Chapter 14
Technology Transfer in Coconut-Global Scenario and Strategies

S. Arulraj, C. Thamban, and D. Jaganathan

Abstract The chapter on 'Technology Transfer in Coconut – Global Scenario and Strategies' covers the field-level experiences of technology transfer initiatives in major coconut-growing countries of the world. Components in technology transfer network, viz. technology generation system, extension system, support system and utilization system in India and other major coconut-growing countries including technology integration for inclusive development, are elaborately discussed. The chapter outlines multinational research organizations with coconut as their mandate crop, coconut research institutions in major coconut-growing countries and improved technologies on coconut varieties and hybrids, production system management and processing in coconut. Details of extension system comprising of extension organizations; innovative extension approaches using community-based organisations, participatory technology transfer module and promotion of self-help groups; farmer-participatory community extension; and farm field school are dealt along with case studies on successful extension methodologies and ICT initiatives in several coconut-growing countries. Adoption of improved technologies by farmers and constraints in adoption are also highlighted. Strategies for strengthening the transfer of technology programmes in coconut are suggested based on field-level experiences of different stakeholders. A rich documentation of literature supports the scientific analyses and the policy implications in each of the sections of this chapter, where different components of technology transfer intersect fruitfully, both at the national and global level.

S. Arulraj
ICAR-IIOPR, ICAR- CPCRI, Krishnagiri, Tamil Nadu, India
e-mail: aruldopr@gmail.com

C. Thamban (✉)
ICAR-CPCRI, Kasaragod, Kerala, India
e-mail: c.thamban@gmail.com

D. Jaganathan
ICAR-CTCRI, Thiruvananthapuram, Kerala, India
e-mail: djaganathtn@gmail.com

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14.1 Introduction

Coconut, one of the most important of all cultivated palms, provides livelihood security to several millions of people across the world. Through the systematic research conducted during the last century, a substantial number of viable technologies related to crop improvement, production, protection and post harvest processing have been evolved for enhancing coconut productivity and profitability. However, farmers are not able to exploit the production potential from these technologies to the extent desirable. Adoption of the recommended practices plays a crucial role in improving coconut productivity. Various organizations involved in the research and development of coconut are streamlining their activities to enable the farmers to make use of the technologies for enhancing the production and productivity.

Technology is defined as application of scientific knowledge for solving problems in a particular field. The term 'technology transfer' can be defined as the process of movement of technology from one entity to another (Souder et al. 1990; Ramanathan 1994). The transfer may be said to be successful if the receiving entity, the transferee, can effectively utilize the technology transferred and eventually assimilate it. The movement may involve physical assets, know-how and technical knowledge (Bozeman 2000). In a very restrictive sense, where technology is considered as information, technology transfer is sometimes defined as the application of information into use (Gibson and Rogers 1994).

The key elements in the technology generation, transfer, support and utilization system in coconut in India are presented as follows:

Technology generation system	Extension system	Support system
International Research Institutes	Front-line extension of research institutes	Input agencies
National Research Institutes	Ministry of Agriculture	Nurseries
Agricultural Universities	Coconut Development Board	Non-governmental organizations
Coconut Development Board	Department of Agriculture/horticulture private agencies	Farmers' organizations
	Non-governmental organizations	Marketing departments
		Financial institutions
Utilization system Coconut farmers, entrepreneurs and policy makers		

14.2 Technology Generation System

Technologies are generated mainly at the research institutes which are spread throughout the coconut-growing countries. Major research institutes which are working on coconut are indicated below.

14.2.1 Multinational Research Organizations

The three main agencies involved in the development of coconut industry, at global level, are Asian and Pacific Coconut Community (APCC), International Coconut Genetic Resources Network (COGENT) and Bureau for the Development of Research on Tropical Perennial Oil Crops (BUROTROP).

14.2.1.1 Asian and Pacific Coconut Community (APCC)

APCC is an intergovernmental organization of coconut-producing countries organized in 1969 under the aegis of the United Nations Economic and Social Commission for Asia and the Pacific (UN-ESCAP). The objectives of the Asian and Pacific Coconut Community are to promote, coordinate and harmonize all activities of the coconut industry which sustains the lives of millions of small farmers as well as those engaged in production, processing and marketing of coconut products.

14.2.1.2 International Coconut Genetic Resources Network (COGENT)

With the endorsement of the CGIAR and its donors, the International Plant Genetic Resources Institute (IPGRI) established the International Coconut Genetic Resources Network (COGENT) in 1992 to promote an international collaborative programme on coconut genetic resources conservation and use.

14.2.1.3 Bureau for the Development of Research on Tropical Perennial Oil Crops (BUROTROP)

BUROTROP is a non-profit-making association registered in France in January 1995. Its mandate is to assist, strengthen and further develop research on tropical perennial oil crops. At present, BUROTROP is non-functional. For details on international organizations, please see Chap. 2.

14.2.2 WTO and Its Impact on Coconut Research Priorities

With globalization, the trade and agriculture are governed by new rules with opportunities and threats which deal with liberalization in market access, export competition and domestic support. India needs improvement in productivity of coconut and its quality through proper policies, technologies, training and development of proper institutions. Exploration and development of value-added products and marketing is another area of concern (Naik 2005). Competitiveness would be determined by the competitive advantages in terms of climate suitability, management strategies and infrastructure. Sanitary and phytosanitary measures would become a barrier, if they are not harmonized and conditions are not 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 aspects to be competitive in the world market. To cut down cost, there is a need to emphasize on adoption of cost-effective inputs like cultural practices, recycling of farm biomass and free play of a host of biocontrol agents. There is also a need to synthesise traditional wisdom with modern scientific technologies. Coconut-based economy can expect a revival from the negative impact of liberalized imports only when the profitability of coconut farming is delinked from the price behaviour of coconut oil. This is possible through full utilization of the land under coconut and also the various products at the on-farm and community levels. As coconut farming has close linkage with other aspects of rural life, coconut is not to be treated in isolation but as a component of integrated rural development, and research strategies are to be modified and strengthened accordingly.

14.2.3 National Level Coconut Research Institutes

ICAR-central plantation crops research institute, state agriculture universities, central food technology research institute (CFTRI) and regional research laboratories under CSIR, etc., India.

Coconut research board-coconut research institute (CRI), Sri Lanka.

Indonesian Centre for Estate Crops Research & development, Bogor, Indonesia.

Coconut for agro-based industry (CABI), Bogor, Indonesia.

Philippine coconut authority (PCA), Davao research Centre, University of Los Banos, Philippines.

Horticulture research institute (HRI), Chumpon research Centre, Thailand.

Malaysia agriculture Research and Development Institute (MARDI), Kuala Lumpur, Malaysia.

Planning and science research department, oil Plant Institute of Vietnam, Ho Chi Minh City, Vietnam.

Chinese academy of tropical agriculture sciences (CRICATAS), Wenchang City, Hainan China and Wenchang coconut research institute, Hainan.
Centre de cooperation Internationale en Recherche Agronomique pour le development (CIRAD), Montpellier, France.
Centro de Investigacion Cientifica de Yucatan (CICY), Merida, Mexico.
Coconut Research Station, Marc Delorme, port-Bouet, Côte d'Ivoire.
Nigerian Institute for oil Palm Research, Benin City, Nigeria.
Coconut industry board, Kinston, Jamaica.
Mikocheni agricultural research institute, Dar Es Salaam, Tanzania.
Coconut Programme, OPRI, Sekondi, Ghana.
CRSC, Seme Podji, Benin.
EMBRAPA, Aracaju, Betume, Brazil.
BARI, Gazipur, Bangladesh.
RS, Islamabad, Pakistan.
Cocoa coconut research institute, Rabaul and Stewart Research Station, Madang, Papua New Guinea.
Ministry of Agriculture, Nuku'alofa, Tonga.
Saraoutou Research Station, Santo, Vanuatu.
Taveuni coconut research Centre, Fiji.
Olomanu coconut seed garden, RS, Samoa.
Research Station, Yandina, Solomon Islands.

These research institutes have evolved many varieties and hybrids and their cultivation technologies as well as developed technologies for product diversification, value addition and by-product utilization.

14.2.3.1 Coconut Research in India

Important organizations conducting research on coconut in India include ICAR-Central Plantation Crops Research Institute (CPCRI) under the Indian Council of Agricultural Research (ICAR) and the State Agricultural Universities.

ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI) is the pioneering research organization in India conducting research on different aspects of coconut cultivation. CPCRI also coordinates research on coconut within the country and executes research programmes through the All India Coordinated Research Project on Palms. Technologies which are generated from ICAR-CPCRI are briefed here:

Crop Improvement Coconut research efforts in India, over a century, have recorded impressive achievements in terms of developing varieties and hybrids, which have the potential to give two-to threefold increase in yield. ICAR-CPCRI and other coconut research organizations in India have released a number of improved varieties and hybrids, capable of producing 2.79–6.28 tonnes of copra ha^{-1} $year^{-1}$ in different parts of the country. Varieties such as Chowghat Orange Dwarf, Kalpa Sree, Kalpa Jyothi, Kalpa Surya and Kalpa Raksha were released for tender nut purpose.

Dual-purpose varieties such as Chandra Kalpa, Kera Chandra, Kalpa Dhenu, Kalpa Prathibha, Kalpa Mitra, Kalpatharu, Kalpa Haritha, Kera Keralam and Kalpa Shatabdi were released for different agroclimatic conditions. Six hybrids, viz. Chandra Sankara, Kera Sankara, Chandra Laksha, Kalpa Sankara, Kalpa Samrudhi and Kalpa Sreshta, were released which are capable of giving high yield and copra out turn. For further details, please refer to Chap. 4.

Crop Production The general recommended dose of fertilizer is 500:320:1200 g of N, P_2O_5 and K_2O $palm^{-1}$ $year^{-1,}$ to be applied in two split doses along with organic manures. Water requirement was worked out as 200 l $palm^{-1}$ with an irrigation frequency of once in 5 days. Drip irrigation and fertigation practices have been standardised. Vermicomposting of coconut biomass using two species of earthworms, *Eudrilus eugeniae* and *Eisenia foetida*, was proved as an efficient method of composting. For maximizing economic returns, high-value medicinal and aromatic crops and flowering plants have been recommended as intercrops in the palm-based cropping system. A number of vegetables (snake gourd, ridge gourd, bottle gourd, amaranthus, coccinia, brinjal and bitter gourd), tuber crops (colocasia and greater yam), spices (ginger and turmeric), etc. are compatible for intercropping in coconut gardens. Various perennials like cocoa, clove, nutmeg, coffee, black pepper, mulberry, jack, bread fruit, mango, sapota, papaya and timber yielding trees were found to be suitable mixed crops in coconut garden. Mixed farming in coconut with various subsidiary enterprises such as dairy, poultry and sericulture integrating nutrient recycling with coconut cultivation was found to be quite advantageous. For further details on crop production technologies, please see Chap. 7.

Crop Protection Integrated pest management practices for insect pests, viz. eriophyid mite, rhinoceros beetle, red palm weevil, leaf-eating caterpillar, white grub, coreid bug, slug caterpillars, mealy bugs, scale insects and termite, have been standardised. Efficient disease management practices for diseases, viz. bud rot, leaf rot, stem bleeding, Thanjavur wilt/*Ganoderma*, leaf blight or grey leaf spot and root (wilt), have been recommended. Judicious cultural, biological, mechanical and chemical methods are emphasized in managing weeds, pests and diseases. For details, please see Chaps. 10, 11 and 12.

Post harvest Processing and Mechanization Agricultural implements/gadgets such as power-operated sprayer, copra dryers using different energy sources and capacities, coconut splitting device, coconut deshelling machine, coconut grating machine, tender coconut cutter, tender nut punching machine, coconut chips slicing machine and a simple and safe coconut palm climbing device have been developed by ICAR-CPCRI. Technologies for making value-added products like snowball tender nut, coconut chips with various flavours, virgin coconut oil, kalparasa, coconut sugar, coconut charcoal, etc. have been developed and are being promoted vigorously among prospective entrepreneurs. Details on these technologies are described in Chap. 13.

All India Coordinated Research Project on Palms In 1970, the ICAR initiated the All India Coordinated Research Project (AICRP) on Palms with its headquarters at CPCRI, Kasaragod. The project provides adaptive research support for coconut through collection, conservation, cataloguing and evaluation of germplasm, evaluation of new hybrids and high-yielding varieties of coconut, standardization of agrotechniques for various agroclimatic regions including development of appropriate farming systems as well as efficient pest and disease management strategies especially for pests like leaf-eating caterpillar and rhinoceros beetle and diseases like Tatipaka and *Ganoderma*/Thanjavur wilt. As in 2018, 15 centres are conducting research on coconut under AICRP on Palms.

State Agricultural/Horticultural Universities State agricultural/horticultural universities which are in the major coconut-growing regions undertake research programmes related to coconut through their academic programmes and also through AICRP on Palms. Results of the studies are regularly incorporated in the location-specific package of practices recommendations for coconut in the respective states. The state universities are implementing a large number of transfer of technology programmes through Directorate of Extension Education, Krishi Vigyan Kendra, Farm Clinic, Agricultural Technology Information Centre, etc.

Research Role of Coconut Development Board (CDB) In order to promote product diversification and by-product utilization of coconut and to create a vibrant coconut-based economy, a Technology Development Centre has been established at the headquarters of the Coconut Development Board. Technology has been developed for the production of nata de coco, coconut cream, spray dried coconut powder and coconut water-based vinegar, process for the preservation and packaging tender coconut water, etc., with the collaboration of CSIR (RRL), DFRL and CFTRI. Transfer of technology and other development programmes undertaken by CDB are described under Sect. 14.5.1.

14.3 Developmental Programmes for Coconut

The main developmental strategies for sustainability of the sector adopted by coconut-growing countries are coconut planting/replanting/rehabilitation, area expansion, technology adoption relating to product diversification, integrated farming system, provision of quality planting materials, institutional credit to farmers, skill training, information dissemination, organization of coconut farmers, market research and development, market promotion, product quality improvement, strengthening of coconut development organizations and extension system, reduction on dependence of copra as the major coconut product and introduction of coconut-based cottage industries, copra price support and strengthening of downstream processing sector.

14.3.1 Role of APCC

The Secretariat of APCC functions as the regional centre for collection, analysis and dissemination of coconut information, realizing the importance of sharing information in the development of the industry. Information is disseminated in various forms through journals (CORD, COCOMUNITY and Cocoinfo International), proceedings of meetings, country studies, technological sheets, directories, statistical yearbooks and video documentaries. APCC, from its inception, has promoted programmes for product and market diversification. Studies have been conducted to identify constraints and potential for expansion of markets for coconut products. APCC with the inputs provided by an expert group of food scientists drew up a set of uniform quality standards for aqueous coconut products which could serve as a basis for the countries to follow. APCC also frequently arranges training programmes to suit the varying needs of the member countries under the technology transfer exercise.

14.3.2 Coconut Development in India

Current Indian coconut production scenario presents a highly encouraging picture, with India reaching the top in coconut production in the world. India produced 23,904 million nuts in the year 2016–17 from an area of 2.082 million ha. Bulk of the coconut production in the country comes from the Western plains and the Ghat region, followed by the Eastern Coastal Plains and hill regions. The islands of Andaman as well as Nicobar and Lakshadweep are the other traditional coconut-growing areas. Coconut cultivation has made progress, in recent years, in certain nontraditional areas also.

Coconut cultivation in the country is mainly in the hands of small and marginal farmers with more than 90% of the coconut holdings being less than 0.40 ha in size. Average productivity in India is 11,481 nuts ha^{-1}, but several coconut plantations in Tamil Nadu and Andhra Pradesh, which are well managed, have a higher productivity ranging from 13,000 to 15,000 nuts ha^{-1}. Thus, the challenge is to improve productivity which would in turn improve the economic returns to the farmers.

14.3.3 Yield Gap

Efforts taken by research institutes and extension agencies in the areas of technology generation and dissemination have immensely contributed to production and productivity of coconut. However, the productivity level remained low in India compared to potential yield. National average of coconut productivity is 11,481 nuts ha^{-1} $year^{-1}$, while that of the best-managed garden is 27,300 nuts ha^{-1} $year^{-1}$. A

yield of 29,225 nuts ha^{-1} $year^{-1}$ has been obtained at ICAR-CPCRI. Globally, the estimated coconut technology gap in terms of nut and copra yield ranges from 33 to 84% (Batugal and Bourdeix 2005). Lack of adoption of scientific cultivation practices is one of the important reasons for such a low productivity. A comparison between the best-managed gardens and national average of productivity of coconut crop will reveal that there still exists a wide gap between the technologies generated and their utilization by the growers in coconut crop sector, especially in small holdings (Rajagopal et al. 2004a). Low level of technology utilization at farmers' fields calls for formulating effective extension strategies suitable to the heterogeneous farming situations.

14.3.4 Technology-Wise Adoption

14.3.4.1 Varieties, Nursery Management and Planting

Knowledge and adoption of nursery practices and correct method of planting in main field were found to be on a higher side, while the extent of cultivation of recommended varieties and hybrids was on the lower side. Bastine et al. (1991) found that only 6.5% of the farmers of Kannur district, Kerala, India, adopted coconut hybrid planting. Internationally 400 hybrids have been released for cultivation. But only 1–14% of farmers adopt planting of hybrids due to various reasons.

Yogananda et al. (1994) found that 50% of large holders and 61.67% of small farmers were not aware of the importance of copra content in selection of seed nut. But majority of them (more than 75%) had knowledge on all aspects of nursery management and seedling selection. Thampan (1999) opined that 95% of coconut farmers adopted planting of West Coast Tall (WCT). Ohler and Griffee (1999) stated that only 6% of the total coconut area was covered with hybrids.

The use of hybrid seedlings for new planting was the lowest adopted recommendation, whereas spacing and filling pits with top soil were highly adopted (Jnanadevan and Prakash 1994). Kalavathi and Anithakumari (1998) reported high level of knowledge and adoption of planting time, depth of planting, pit size for planting as well as seedling and seed nut selection with 80–96% knowledge and 62–96% adoption. However, adoption level of mother palm selection in root (wilt) disease-affected areas was 33%, while knowledge level was 90%. Similar was the trend for spacing (knowledge 65% and adoption 22%). Anithakumari and Kalavathi (2001) in their study in root (wilt) disease-affected areas reported high level of knowledge and adoption of nursery management and main field planting. Majority of farmers used either open well (62%) or bore well (32.7%) as the source of water for drip irrigation (Mathew and Thamban 2011).

14.3.4.2 Production System Management in Coconut

One of the major constraints identified for low productivity in coconut is the inadequate and irregular nutrient management. Studies reviewed indicated low to medium level of adoption of practices like organic manure application, chemical fertilizer application, green manuring, etc. (Thamban and Venugopalan 2002). Bastine et al. (1991) from their study reported low level in adoption of practices like split dose of fertilizer application (2.96%), cultivation of green manure and cover crops (2.96%), irrigation (16.3%), husk burial (nil) and fertilizer and manure application (25–30%).

Thampan (1999) opined that the farmers applied very small quantity of chemical fertilizers. Yogananda et al. (1994) found that more than 80% of the farmers lacked knowledge on farmyard manure application and quantity of chemical fertilizers to be applied. Jnanadevan and Prakash (1994) reported none of the farmers adopted application of fertilizers as per recommendation. However, 40–70% of the partner farmers of CDB programmes adopted recommended fertilizer dosage.

Kalavathi and Anithakumari (1998) reported 50% knowledge and 20% adoption regarding irrigation to coconut, medium level of knowledge (55%) and adoption (25%) for fertilizer application to adult palms, application of lime and salt (45% knowledge and 30% adoption) and mulching (35%). But fertilizer application to seedlings was found to be very low, i.e. 5%. The respondents were neither aware nor adopted the root (wilt) disease management technologies as a package. Level of knowledge (10%) and adoption (10%) of application of magnesium sulphate were low, and modified/improper dosage was adopted by 50% of the farmers. Anithakumari and Kalavathi (2001) reported low level of knowledge for nutrient management (20%) and moisture conservation (10%) with very few farmers adopting recommended nutrient management (12%) and moisture conservation.

Intercrops like cocoa, nutmeg, banana, black pepper, tuber crops, vegetables, fodder crops and lemon are grown by farmers in certain states in India depending on the agroclimatic and socio-economic factors. Mulching is generally practised using residues of coconut, banana, cocoa, etc. to conserve soil and water. Green manure crops like sunnhemp (*Crotalaria juncea*) and Kolinji (*Tephrosia purpurea*); green leaf manure crops like glyricidia, neem leaves, *Calotropis*, etc.; and leguminous crops like *Stylosanthes gracilis*, *Calopogonium mucunoides* and *Vigna unguiculata* are used as cover crops to prevent soil erosion and for enriching the soil fertility (Kalathiya et al. 2007; Jaganathan et al. 2013).

14.3.4.3 Plant Protection in Coconut

Lack of knowledge and practical difficulties resulted in low level of adoption of plant protection technologies as reported by Bastine et al. (1991), Yogananda et al. (1994) and Thampan (1999).

14.3.4.4 Postharvest Technologies

Knowledge and adoption level of palm-climbing device, copra dryer and copra moisture metre were found to be very low (Anithakumari and Kalavathi 2001).

14.3.4.5 Constraints in Improving Coconut Productivity

Many research workers (de Silva 1989; Thampan 1999; Anderson 2007; Kumar and Kapoor 2010; Pathiraja et al. 2010; Anithakumari et al. 2011, 2012; Kalavathi and Anithakumari 2011; Thamban et al. 2011; Anithakumari 2013; Jaganathan et al. 2013; Kerure et al. 2016) have analysed the constraints in adoption of new technologies, and a summary of their findings is presented here:

1. Nonavailability of root (wilt) disease-tolerant seedlings.
2. Lack of expertise on early identification of red palm weevil incidence.
3. Inadequate information base about technologies, limited ability of small enterprises to assess and acquire technology, inadequate technology acquisition, transfer and development to stimulate local firms to use indigenous technology as well as lack of targeted approach to technology development and technology transfer systems.
4. Inadequate investment in R&D.
5. Improper use of land, unscientific use of chemicals, micronutrient deficiencies.
6. Low level of investment due to increasing cost of cultivation, declining trend in yields and decrease in price of coconuts, affecting the profits.
7. Low level of awareness about the bio-intensive practices.
8. Small size of holdings restricting value addition of farmers' own produce.
9. High competition and low skills in marketing techniques, unorganized markets and lack of farmers' cooperatives for marketing.
10. Poor infrastructural facilities for storage and processing.
11. Labour problems (high-wage rates, scarcity of skilled workers and difficulty in community mobilization of labour).
12. High cost for transporting organic inputs to the farm due to the decline in livestock components in coconut-based farming system, lack of standard package of practices, nonavailability of biocontrol agents, biopesticides and organic manures, inadequacy of local certification agencies and lack of specialized markets for organic products.
13. Inadequate government support especially for initial operational funds and subsidies on electricity charges for small-scale units.

14.4 Transfer of Technology Programmes

Timely and sustainable transfer of technologies and extent of adoption of the recommended practices play a critical role in improving the productivity of the crop. It has been demonstrated that a fourfold increase in yield could be achieved by adopting proper cultivation practices as compared to the poor managed palms. Taking into cognizance the problems faced by farmers and the need to improve the coconut production scenario in the country, various development programmes are implemented by different agencies. In India, at national level, the front-line extension programmes of ICAR-CPCRI and programmes of the Ministry of Agriculture and Farmers' Welfare through the Coconut Development Board and Directorate of Extension and, at the state level, agriculture/horticulture departments, private agencies and NGOs play a critical role in the implementation of various transfer of technology programmes for coconut development.

14.4.1 Front-Line Extension Programmes of ICAR–CPCRI

Important front-line transfer of technology activities in coconut implemented by ICAR-CPCRI include training programmes; front-line demonstrations; information communication through mass media like radio, television, newspapers and farm magazines, extension pamphlets, CD ROMs, video cassettes, etc.; exhibitions; seminars; Krishi Melas; and group meetings, providing consultancy through field visits and replying postal queries (Fig. 14.1).

14.4.2 Conventional Extension Approaches

Training Programmes On-campus and off-campus training programmes for farmers and extension personnel on specific topics related to agro-techniques, integrated pest and disease management, nursery management, organic farming technologies, coconut-based cropping systems and post harvest technology form important components of TOT programmes to enhance the users' knowledge and skill for better technology utilization. A study conducted among extension personnel indicated that the training programmes were highly successful in achieving the objectives as reflected by the high Training Effectiveness Index (TEI) values.

Impact analysis of capacity building programme on coconut among subject matter specialists of KVKs during 2016 revealed that training had significant impact on enhancing knowledge level of the respondents in all subjects of coconut technologies. Average gain in knowledge was estimated to be 18.36%. Knowledge gain among youngsters as well as among respondents who had undergone training earlier was higher. Sixty-one per cent of the respondents graded training course as

Fig. 14.1 Transfer of technology programmes of ICAR-CPCRI

excellent. After the training, 38% of KVKs initiated on-farm trials and front-line demonstrations on new coconut technologies (Jaganathan et al. 2016).

Front-Line Demonstrations The institute has been organizing front-line demonstrations in farmers' fields on different coconut cultivation technologies such as coconut-based farming systems, soil and water conservation, management of root (wilt) disease-affected coconut gardens, mixed cropping with cocoa, etc. These demonstration programmes have proved to be effective in convincing the farmers about the technical feasibility and economic viability of the technologies. Through adoption of the proper management practice, average yield of the palms in the

disease-affected gardens increased from 24.17 to 46.3 nuts palm^{-1} year^{-1} after 3 years, recording an improvement of 91.4%. Observations on yield of coconut revealed an increase in productivity of palms from a pre-demonstration yield of 95 nuts palm^{-1} year^{-1} under monocrop situation to 122 nuts palm^{-1} year^{-1} in coconut-based high-density multispecies cropping system.

14.4.3 Innovative Extension Approaches

Besides the conventional extension activities, a few innovative extension approaches have been pilot tested through action research with farmers' participation by ICAR-CPCRI for improving technology utilization. Several studies have indicated that knowledge and adoption of the coconut technologies need to be analysed in terms of risk management faced by the farming community, resources needed for the technology utilization, gaps in research and development needs and social process for evolving refined extension approaches. Alternative extension mechanisms for managing field problems of coconut need special emphasis while considering the following factors:

- Coconut being a perennial plantation crop, cultivated in a contiguous area in small and marginal land holdings (average holding size of 0.2 ha), provides congenial conditions for pest and disease incidence throughout the year.
- Approaches and strategies differ not only with social factors but also with technology features per se, nature of the crop, nature of pests/disease-causing organisms, incidence, severity and potential spread of pests or diseases as well as the observable nature of loss incurred influence the extension mechanisms/approaches required.
- Constraints such as input availability, technical/extension/economic factors, social components, and biophysical constraints require attention for evolving innovative extension approaches or mechanisms.

14.4.4 Paradigm Shift in Reaching Out to Stakeholders

Refinement of extension approaches paves the way for reaching out to the relevant stakeholders more efficiently and effectively. Farming is not an isolated activity by any means. It has the foundations in culture, heritage, experiences, tacit knowledge, knowledge innovations, innovation systems and social process. The possible approaches are:

1. Participatory technology transfer approach (PTTA) for coconut root (wilt) disease management.

2. Clustering coconut farmers – a successful extension approach for enhancing adoption and income from marginal and small holdings of root (wilt) disease-affected areas.
3. Area-wide community extension approaches (AWCA) in bio-management of rhinoceros beetle of coconut.
4. Farmer field Schools (FFS) in coconut.
5. Participatory community approaches in area-wide management of red palm weevil.
6. Information communication technologies (ICT) as interactive platform for technology transfer and field problem-solving for farming community.

Special features of innovative extension approaches are:

(i) Interactive and participatory approach involving relevant stakeholders.
(ii) Shift from individual farmers to farm family approach with gender concerns.
(iii) Inclusiveness incorporated for reaching out to all sections of society.
(iv) Area-wide interventions to overcome the challenges of fragmented holdings and resource base variability of farming community.
(v) Appropriate integration of extension techniques and methods for awareness building, knowledge dissemination and skill upgradation.
(vi) Technology-specific and problem-specific approaches for focused technology interventions, improving the impact of research.
(vii) Utilizing the digital literacy and advances in taking technologies and information, to different strata, of the society.

14.4.4.1 Community-Based Organizations

The livelihood of a substantial number of families in rural poor communities depends on coconut farming. Many a times, the income generated from coconut farming in small and marginal holdings does not provide enough for meeting their family requirements. The fragmented holdings don't render themselves viable for the optimum utilization of resources and adoption of improved technologies. Management of resources by groups helps to overcome the inherent weaknesses of the fragmented holdings and augment the production and productivity of these holdings. The effectiveness of organizing coconut farmers into community-based organizations (CBO) for efficient management of farmers' resources to reduce cost of cultivation and to increase productivity through integration of technologies even in very small farm holdings has been demonstrated by ICAR-CPCRI in selected localities (Thamban 2010).

A study was taken up for developing sustainable coconut-based income-generating technologies in poor rural communities in two selected coconut communities, one each from West Coast region and East Coast region in India. The three-pronged strategy for the project included growing suitable inter/mixed crops in coconut gardens and integrating animal husbandry and other subsidiary enterprises, cultivating high-yielding cultivars of coconut and diversification of coconut

products. Implementation of the strategies, including microcredit, was routed through the CBO. A close linkage was developed between the CBO and scientists, and monitoring and evaluation of the interventions were done through CBO. Coconut clusters were found to possess better group characteristics and capacity development, and their performance is highly encouraging in terms of their increased knowledge and skills, improved behavioural changes and strong and responsible leadership. The coconut groups should be provided with organized markets, adequate long-term government support and a permanent establishment with infrastructural facilities for storage and processing just like the well-established commodity clusters (Thamban et al. 2016).

This innovative extension methodology was subsequently adopted for the implementation of other poverty alleviation and income enhancement projects. The cluster approach has been scaled up by other agencies like Coconut Development Board (CDB). The Board has initiated a massive programme for the formation of a large number of Coconut Producer Societies (CPS) by associating 40–100 coconut growers in a contiguous area with a consolidated minimum of 4000–5000 palms (Thamban 2010). Through 'cluster approach' in the root (wilt) disease-affected coconut area, average yield of coconut was doubled after technology package implementation for 3 years.

Technological interventions on soil and water conservation, soil health management, integrated nutrient management, inter/mixed cropping system and integrated pest and disease management implemented in farmers' gardens coupled with facilitating CBO of farmers and women self-help groups for effective integration of production and processing technologies in coconut holdings were found to be effective in obtaining substantially higher income.

Under the multi-country IFAD project on 'overcoming poverty in coconut-growing communities', participatory planning and implementation of diverse interventions notably intercropping and off-farm activities in small and marginal coconut homesteads were attempted through CBOs along with nutrition education. These efforts brought out significant improvements in the food and nutritional security as well as the income of the family members. Total annual income per homestead enhanced from Rs.25,617 to Rs.59,017 ha^{-1}over the project period. Income from coconut, increased by 50%, intercrops by fourfold, livestock rearing by sixfold and household level processing by 33-fold. At the end of the project, 96% of the members became completely food secure and 72% nutritionally secure (Thamban et al. 2016).

Based on the inferences drawn from evaluation and refinement of community approaches, an integrated model for coconut cluster was developed which was tested subsequently. An increase in knowledge index to the tune of 153% was recorded. Income from coconut recorded 2.4-fold improvement. The area under intercrops increased to double than that of the pre-project period, and the income from intercrops increased by 3.9-fold.

When community-based bio-resource management was adopted for sustaining production and livelihood security under coconut-based farming systems, the efforts resulted in ensuring quality bio-inputs to the farmers along with efficient use of

land, water, sunlight and residue utilization, thereby contributing to sustainable production and productivity. An increase in knowledge level by 117% in case of bioresource management and 76% in case of integrated nutrient management was recorded. Community coconut nursery established by the farmer groups produced seedlings with a recovery of 79.5% good-quality bio-primed dwarf coconut seedlings. Significant improvement in income from coconut and other intercrops resulted in 89.7% improvement in farm income (Thamban et al. 2016).

14.4.4.2 Farmer Empowerment Programmes

When PTTA was adopted for technology assessment with participation of farm families in a contiguous area affected by coconut root (wilt) disease, awareness, knowledge, attitude and adoption level of farmers towards the integrated root (wilt) disease management technologies were improved by 40–85%. Area-wide community extension approach (AWCA) was attempted in another cluster for management of coconut pests. Through this approach, more than 90% of the potential adopters were reached within 2 months, and post-intervention data indicated 75.8% reduction in fresh pest infestation (Thamban et al. 2016). Awareness and knowledge level of farmers improved by 100% when Farmer Field Schools (FFS) were implemented in 15 locations for the integrated pest management of rhinoceros beetle.

Entrepreneurship development was attempted in a group approach format for micro-level interventions on product diversification in coconut such as production of quality copra using copra dryers, coconut kernel-based food products, coconut candies, snow ball tender nut and coconut chips as well as production of oyster mushroom on coconut wastes and vermicompost using coconut leaves. Results revealed that women members of the CBO increased their income by three to five times through the production and marketing of value-added products compared to their previous income from copra. Equally important, the project intervention provided employment opportunities to formerly unemployed and underemployed rural women resulting in enhanced self-esteem and economic and social empowerment (Batugal and Oliver 2003).

Technology assessment and refinement increased the effectiveness of participatory approach in the adoption of various technologies related to high-yielding varieties, intercropping, nutrient management and crop protection (Arulraj et al. 2002; Thamban et al. 2004). In the interphase approach, researchers, extension personnel and farmers were brought together on a common platform which helped in enhancing the awareness and knowledge about the technologies (Rajagopal et al. 2004b).

Mera Gaon Mera Gaurav: This initiative by the Ministry of Agriculture and Farmers' Welfare, Govt. of India, envisages promoting the direct interface of agricultural scientists with the farmers to hasten the lab to land process. Cutting across all disciplines, farm problems are diagnosed and effective solutions delivered and showcased in farmer's fields. National priorities such as secondary agriculture, climate change, good agricultural practices and soil and health management of crops are given importance in this programme (Thamban et al. 2016).

Cyber extension programmes: Cyber extension include effective use of information and communication technology (ICT), national and international information networks, Internet expert systems, multimedia learning systems and computer-based training systems to improve information access to all the players. The video conferencing system installed at the Agricultural Technology Information Centre (ATIC) of ICAR-CPCRI, Kasaragod, facilitates interaction between various stakeholders for enhancing technology utilization in coconut through effective linkages with government institutes, commodity boards and farmers' organizations (Thamban 2010).

14.5 Developmental Agencies

There are various agencies under the government of India and states to transfer technologies at the appropriate level.

14.5.1 Coconut Development Board

The Coconut Development Board is a statutory body established by the government of India for the integrated development of coconut cultivation and industry in the country. The Board which came into existence in 1981 has its headquarters in Kerala state and regional offices and state centres in other states. Activities of the Board include implementing measures for the development of coconut industry; improving marketing of coconut and its products; imparting technical advice; providing financial and other assistance for expansion of area under coconut; encouraging adoption of modern technologies for processing of coconut and its products; taking steps to get incentive prices; recommending measures for regulating imports and exports; fixing grades, specifications and standards for coconut and its products; financing suitable schemes to increase the production of coconut and to improve the quality and yield of coconut; assisting, encouraging, promoting and financing agricultural, technological and industrial research on coconut and its products; maintaining the database on coconut industry; and undertaking publicity activities.

The Board brings out several publications, including a popular journal in several languages, to promote coconut-based technologies. CDB also participates in exhibitions, seminars, workshops and entrepreneurship development programmes, both in India and abroad, and organizes training programmes for coconut farmers and producers on improved methods of cultivation and latest technologies in coconut processing. Lack of availability of labour, especially skilled labour for coconut climbing and high-wage rate, is a serious problem faced by growers in adopting timely crop management practices. To tackle this, a professional group of youth is organized for harvesting and taking up plant protection operations. The Board, as a service organization, popularizes the latest development in coconut industry through mass

media. The extension activities under the Coconut Development Board are planned and executed with the objectives of promoting scientific coconut cultivation and product diversification besides promoting coconut oil as a healthy cooking medium, so that the decreasing trend in the consumption of coconut oil could be arrested. Promotion of tender coconut consumption is also undertaken to divert an increased part of the production to the beverage sector.

Generation of information on wholesale and retail prices and arrivals and analysis of trends in various markets of the country help the farmers and traders. The Coconut Development Board is recognized as the National Information and Documentation Centre for coconut in the country, and it has a nationwide information network using modern information technology.

14.5.2 State Agriculture and Horticulture Departments

The agriculture and horticulture departments in the major coconut-growing states in the country implement various development schemes and extension programmes for the benefit of coconut farmers. Many of the states have been implementing separate programmes for the production and distribution of planting materials and fertilizers as well as distribution of plant protection chemicals and biocontrol agents against coconut pests. Financial incentives are also provided in the form of subsidies for irrigation infrastructure. Organizing coconut farmers at grass root level for group management of coconut production activities, conducting farmers training programmes and organizing other extension programmes are the major activities of these departments. Besides the above, local bodies like grama panchayats also implement location-specific development schemes under the technical guidance of the agriculture and horticulture departments.

14.5.3 District Level Agriculture Technology Management Agency (ATMA) Model

In a country like India where agroclimatic zones widely differ, besides significant variation in socio-economic status of farmers, uniform extension service cannot be the answer for all the regions. ATMA was formed as an alternate public extension institution to place the public extension system in a new decentralized institutional arrangement which is demand driven and farmer accountable adopting a bottom-up farming system approach. It is a registered society of key stakeholders (farmers, line/development departments, nongovernment organizations, input dealers, mass media, agribusiness companies, farmers' organizations, etc.) involved in agricultural activities for sustainable agricultural development in the district. Emphasis has been laid on providing flexible working environment and establishing effective

integration of all the stakeholders at the district level thereby improving input into programme planning and resource allocation, especially at the block level thereby increasing accountability of stakeholders.

Development work plans at block/district level is based on a Strategic Research and Extension Plan (SREP), prepared through participatory appraisal techniques involving all the stakeholders. The SREP contains detailed analysis of the information on existing farming systems in the district and research-extension gaps required to be filled up. It also prioritizes the research-extension strategies within the district.

14.5.4 State Agricultural/Horticultural Universities (SAUs)

The SAUs are also implementing a number of transfer of technology programmes, in the concerned states through the Directorate of Extension Education, Krishi Vigyan Kendras and plant clinics. The basic extension education role of the university is to make available useful research information. The Directorate of Extension, the Krishi Vigyan Kendras (KVK) and the Village Adoption Programme are responsible for the transfer of technology programmes of the university.

Expert Centres and Village Resource Centres are established in collaboration with Indian Space Research Organisation (ISRO) for the interaction of farmers with experts on a variety of agricultural information. Mobile message services and Kisan Call Centres provide timely information to the farming community regarding agricultural technologies, weather data and market information.

14.5.5 Krishi Vigyan Kendra (KVK)

Krishi Vigyan Kendra (Farm Science Centre) is an innovative institution of ICAR established at district level. The first KVK was established during 1974 which has grown to 620. They play a vital role in conducting on-farm trials and front-line demonstrations in farmers' fields to identify location-specific agricultural technologies and demonstrate the production potential of new agricultural technologies in farmers' fields through front-line demonstrations. They also conduct need-based training programmes. Kerure et al. (2016) reported that ICAR-Krishi Vigyan Kendra, Chitradurga, could encourage many unemployed youth to use the coconut tree climber for harvesting and choose it to earn their livelihood. Critical and quality inputs like seeds, planting materials, organic products, biofertilizers and poultry strains are produced by the KVKs and made available to the farmers. Agricultural Knowledge and Resource Centres are set up at KVK to support the initiatives of public, private and voluntary sectors at district level. A number of successful case studies have emerged out of effective implementation of various technological and institutional interventions by KVKs.

14.5.6 Directorate of Extension

The Directorate of Extension functioning under the Ministry of Agriculture and Farmers' Welfare, Govt. of India, sponsors training programmes on various aspects of coconut production technologies for the benefit of extension personnel engaged in the development of coconut in different states. It also funds projects for production of audio and video programmes on coconut cultivation technologies for strengthening the TOT programmes on the crop.

14.6 Transfer of Technology Programmes in Other Countries

All the major coconut-growing countries have established their own research organizations supported by transfer of technology programmes so that the coconut farmers are fully benefitted by the technologies developed.

14.6.1 Indonesia

Coconut not only provides livelihood security to more than 3.5 million farmers but also plays its social role as the second important commodity after rice in Indonesia. Total coconut area is 3.571 million ha with a production of 14,804 million nuts, and smallholders own 98% of the area (APCC 2015). Coconut is largely consumed as fresh coconut. However, in manufacturing industries, coconut is processed into cooking oil, desiccated coconut, coconut milk, nata de coco, coir fibre, activated charcoal, etc. Coconut is an important source of foreign exchange for the country. As in the case of other coconut-producing countries, Indonesia experiences low international prices for its traditional export items, i.e. coconut oil and copra. The situation is aggravated by the defective marketing system in the country with the presence of long channels of marketing intermediaries especially in remote islands resulting in very low prices received by coconut farmers. Low productivity, due to palm senility and poor farm management, also poses as one of the industry's major problems. Recognizing these problems, the government implements the Smallholder Coconut Development Project.

A large number of improved technologies have been developed by several research institutes/university centres including the Indonesian Coconut and Palmae Research Institute (ICOPRI), Manado, which has the mandate for coconut research. Major developmental programmes are focused on enhancing production and productivity by adopting package of agricultural practices, rejuvenation of old and senile palms and regular replanting programme with selected high-yielding talls,

dwarfs and hybrids, adoption of integrated farming system and encouraging farm level processing as a group approach (Novarianto 2004).

Transfer of technology programmes are implemented through the Ministry of Agriculture, National Centre for Agricultural Extension Development, Agricultural Universities, Provincial Agricultural Extension Coordination Offices, private companies, NGOs and farmers' organizations. Farmer's empowerment through agricultural technology and information project was started in 2007 for achieving sustainability.

14.6.2 Malaysia

Coconut industry being the oldest agro-based industry in Malaysia continues to be an important industry involving 70,000–80,000 smallholders, which accounts for 75% of the total area under coconut. Coconut is grown in an area of 82,001 ha with a production of 538 million nuts (APCC 2015). Major exports of coconut products are desiccated coconut, copra, coconut oil, coconut milk powder, activated carbon, etc. Extension programmes are implemented through the Ministry of Agriculture and agro-based industries, Malaysian Agricultural Research and Development Institute (MARDI), NGOs, private companies and farmer-based associations/cooperatives/societies (Fong 2004). Major developmental programmes for coconut in Malaysia are enumerated here under:

- Replanting old, uneconomic coconut palms with high-yielding hybrids like MATAG and MAWA with incentives for cleaning, building of drainage and irrigation infrastructure as well as making available quality seedlings and other agricultural inputs to all the needy farmers.
- Extension services to assist farmers to utilize the land resources.
- Enhancing income of smallholders through crop diversification and integration of cash crops and livestock component.
- Strengthening of technology transfer network through collaboration between the Malaysian Agriculture Research and Development Institute and Department of Agriculture under the Ministry of Agriculture.
- Collection, processing and marketing of coconut and its products through the Federal Agricultural Marketing Authority (FAMA) for the benefit of smallholders.

14.6.3 The Philippines

Coconut is grown in an area of 3.517 million ha with a production of 14,735 million nuts (APCC 2015). Productivity is only 4196 nuts ha^{-1} which is less compared to other countries mainly because the major area is under old/senile palms. Frequent

hurricanes destroying large area of coconut is a constraint peculiar to the Philippines. Major coconut products are copra, copra meal, activated carbon, coco shell charcoal, coconut oil and desiccated coconut. In the Philippines, the Makapuno coconut (yielding nuts with creamy kernel) has a good market through ice cream industry.

Extension programmes are carried out through the Department of Agriculture under the Ministry of Agriculture and Food, Agricultural Training Institute, State Agricultural Universities, private companies, NGOs, farmers' organizations and Philippines coconut farmers' cooperatives. A major extension programme was funded by FAO in 2002 for strengthening agricultural extension through ICT applications for technology management service, farmers' information and technology services, Farmer-Scientist Bureau, Open Academy for Philippines Agriculture, Smart farmer Call Centre, school on the air and web portal as well as mobile Internet bus.

Developmental programmes for coconut include farm rehabilitation, planting, replanting and extension services for greater farm productivity with focus on the small coconut farms' development programme; skills training, information dissemination and organization of the coconut farmers for their economic upliftment and empowerment; intensification of agricultural and industrial research for better crop protection, high-yielding varieties and product processing; market research and development for the expansion of both domestic and foreign markets; and recovery of the multibillion coconut levy assets to be eventually used for the benefit of coconut farmers as well as for improvement of administrative and support services (Coronacion 2004).

14.6.4 Sri Lanka

Coconut, which is the oldest tree crop in Sri Lanka, continues to occupy a significant and eminent place in economic and social spheres in the lives of Sri Lankans. Coconut covers around one fourth of the cultivated area in the country which contributes 2% to the GDP of the country. Sri Lanka produces white edible copra, coconut cake, coconut cream, coconut milk, milk powder and defatted coconut and coconut shell products such as shell charcoal, shell flour and activated carbon. Shipping of fresh tender nuts in refrigerated conditions is a special feature of Sri Lankan market. Coconut Research Institute (CRI) of Sri Lanka develops technology and adapts them at experimental level, while Coconut Cultivation Board (CCB) is engaged in transfer of technology to coconut farmers up to the grass root level through extension officers at field level (Somasiri et al. 1993; Sugathadasa 2004).

Information on new technologies is disseminated to farmers using instruction leaflets and advisory circulars and also by organizing seminars and workshops both for extension workers and farmers. In addition, Coconut Development Authority in Sri Lanka brings out weekly bulletin, monthly bulletin (Coco Market Focus) and yearly bulletin (Sri Lanka Coconut Statistics). Transfer of technology programmes are implemented by the Department of Agriculture under the Ministry of Agriculture,

Agricultural Universities, Horticulture Crop Research and Development Institute, Coconut Cultivation Board, Agriculture Research Institute, Coconut Research Institute, Hector Kobbekaduwa Agrarian Research and Training Institute, NGOs, private companies, coconut triangle milk producers' union and agro-enterprise development and information service.

14.6.5 Thailand

Coconut is widely grown throughout the country, and it is one of the important crops in the southern and central regions of Thailand. Coconut plays an important role in Thai diets and domestic life of Thailand population. Major coconut products are coconut oil, palm sugar, coconut fibre, tender coconut, desiccated coconut, copra and activated carbon (Watanayothin 2004). Aromatic tender nut is unique to Thailand and finds a good market.

The Department of Agricultural Extension under the Ministry of Agriculture and Cooperatives, Kasetsart University, Agricultural Technology Transfer Centres, Lampang Agricultural Research and Training Centre, agricultural extension associations, NGOs and private companies are taking care of dissemination of technologies to the coconut growers. Coconut developmental programmes include replanting and rehabilitation schemes in Southern Thailand, value addition for small holder farmers' groups and Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP) and the development of pre- and post harvest technologies to ensure increase in the production of safe, high-quality produce, making these technologies available to the small farmers and industrialists.

14.6.6 Vietnam

Vietnam has an area 0.162 million ha with a production of 1434 million nuts (APCC 2015). Major coconut products are coconut oil, desiccated coconut and shell charcoal (activated carbon). Coconut sugar is one of their unique products. Vietnam strengthened its coconut development programmes by establishing the Union of Vegetable Oil Manufacturers in 1984, having a wider scope covering all aspects of coconut research, development, processing and marketing (Nga 2004). The country also has in place an extension system at the national level and at the provincial level. In 1986, support was obtained from the USSR and East Germany for coconut development in the form of loans for the establishment of new plantations and rehabilitation of existing plantations.

Coconut developmental programmes include intercropping models through specific programmes/policies and mixed farming with shrimp, fish, livestock and honeybee, providing planting materials of new varieties to enhance productivity and training of farmers on scientific cultivation, harvesting and preservation.

14.6.7 Papua New Guinea

The executing agency of Papua New Guinea's national coconut research programme is the Cocoa and Coconut Research Institute (CCRI). Coconut research and development programme include a number of components designed to address the major problems faced by the coconut industry (including poor farm management, declining productivity and increasing number of senile trees), support price for copra, research on coconut breeding and embryo culture, encouragement of intercropping and value addition.

14.7 Technology Utilization Pattern in Coconut Sector

The process of research could be considered as successful only when the results reach the ultimate users. However, acceptance of a new idea by the members of a social system is rather slow and difficult. Each individual technology has to pass through different stages of adoption process. Various communication channels used by research and extension systems help the farmer to pass through these stages in a rapid and positive manner. Input agencies involved in the supply of fertilizers and plant protection chemicals, nurseries in public and private sector involved in the production and distribution of quality planting materials of coconut, financial institutions such as banks and cooperative societies who provide financial assistance to coconut growers and marketing organizations, who intervene in coconut marketing, are the major actors in the support system in coconut sector. Through their specific functions, they contribute to the strengthening of transfer of technology in coconut. Non-governmental organizations, farmers' organizations and input dealers in private and cooperative sector also play a critical role in the process of transfer of technologies.

It is often presumed that the innovations would sell themselves or the benefits of a new technology would be widely realized by its potential adopters, and therefore the technology would diffuse rapidly. Unfortunately, this is seldom the case because of a factor of uncertainty when the superior alternative is put forth. As a first step to understand the components of this complex situation, an effort was made to review the level of adoption of recommended coconut cultivation technologies, which would serve as a feedback to the coconut research and development community. Technologies which are successfully adopted and not adopted worldwide as reported by Hazelman (1994) are described below.

14.7.1 Successfully Adopted Technologies

- Nursery planting and management techniques have generally been adopted as long as they are coordinated or implemented by the national government or private plantations but are generally not followed if passed directly to small producers.
- Intercropping with different crops such as cocoa, coffee, banana, taro, vanilla and root crops and to some extent the use of cattle under coconut. Benefits from increased output per unit area is a favourable factor for adoption.
- Weed control where bioagents are relied upon (e.g. Lantana weed control in Niue and Solomon Islands and that for *Mimosa* in Cook Islands), as they are more self-sustaining with almost no further contact needed with researchers once bioagents are established, indicating the simplicity of the technology and its appropriateness to farmers' context.
- Pest control especially those which require minimum farmer input has largely been adopted.
- Processing of commodities that fit local eating habits and lifestyle such as coconut cream products and various cosmetics, which fit for both export and local market demands, has been readily adopted especially if market prices are favourable.
- Use of local cultivars which are already familiar to farmers and also have adapted to local conditions with low demand for management and environmental requirements.
- Use of various copra driers has been generally accepted since it ensures product acceptability in the market.
- Use of coconut wood for furniture, for fence posts and for carvings has positive acceptance due to good market potential.

14.7.2 Unsuccessful Technologies

- Planting of hybrids, since they more often require a higher level of management than the one most of the small farmers are accustomed to.
- Inorganic fertilizers, which have received much attention by researchers, are hardly adopted due to cost considerations.
- Replacement of senile palms, which is strongly advocated, but is resisted due to both economic and cultural considerations.
- Harvesting systems of various types have largely been avoided by farmers as they rely on traditional systems for collecting nuts after they are dropped.

The Asian and Pacific Coconut Community launched a project in the late 1980s to assess the farmers' receptivity to new technologies in coconut in several countries. The assessment covered a range of technologies that have been researched

upon and recommended for implementation. By and large, adoption of new technologies has been very poor.

14.7.3 Country-Wise Status of Adoption of Technologies

14.7.3.1 Indonesia

The APCC conducted a study covering a range of technologies including improved planting material, fertilizer application and moisture conservation. Adoption was found to be very low, and the two main reasons for the disappointing level of adoption were that a great majority of farmers were not convinced about the technology. Awareness on the new technologies was also poor (Amrizal 1988).

14.7.3.2 Malaysia

The survey included two technologies, namely, the use of hybrids and intercropping in coconut farms. While there was some response to intercropping, the level of adoption of hybrids was dismal (Shahar 1988).

14.7.3.3 Papua New Guinea

The survey in Papua New Guinea covered a package of technologies including hybrids, fertilizers, cover crops, soil and moisture conservation and intercropping. Except for intercropping, none of the other technologies has been adopted by the farmers (Yarbro 1988).

14.7.3.4 The Philippines

The survey covered a range of new technologies including hybrids, fertilizers, agrochemicals, intercropping, soil conservation, cover cropping and scientific copra making. The survey revealed that only 4.2% of the farmers implemented any one or more of the above technologies. Reasons for non-adoption included lack of finance (66%), negative perception on relative advantage (12%), lack of awareness (4%) and non-conviction of the technology (18%) (Arancon 1988).

14.8 Strategies for Effective Transfer of Technology

Low level of technology utilization, at farmers' fields in coconut sector, calls for formulating effective extension strategies, suitable to the heterogeneous farming situations in coconut farming. Some of the strategies in this direction are discussed below:

14.8.1 Farmers' Participation in Research and Extension

Extent of adoption of technologies in coconut is not at a satisfactory level, as has been discussed earlier, and the main factor hindering adoption of technology is farmers' lack of knowledge regarding appropriate techniques for improving his farming. But in many other situations, the reason behind the low acceptance of technologies may be that the technologies are not economically viable, not technically feasible, not matching with the farmers needs and not compatible with the farmers' overall farming system. Recommending technology based on the results at the research station without adequate and proper testing in the farmers' fields under the farmers' resource and risk situation leads to inadequate technology integration. An active participation of the beneficiaries in the generation of technology can ensure that the technology is user-friendly. In the farmer participatory technology generation efforts, conducting on-farm trials is envisaged, wherein trials are conducted in the fields of participating farmers who will be allowed to manage the trials by themselves in collaboration with researchers and extension agencies. Farmer participation in agricultural technology development and dissemination should begin from diagnosis to planning and designing technological solutions, to implementation and to evaluation and feedback into dissemination. The experience in India endorses the view that the farmer participatory technology generation and dissemination in coconut could yield fruitful results, which will be worthy to be emulated by other agencies involved in the development of coconut.

14.8.2 Need-Based Training Programmes

Training programmes with appropriate methodologies are to be organized for farmers on various aspects of crop production, protection and post harvest processing technologies. Participatory methods could be effectively employed to unearth the areas of improved technologies in which farmers require exposure. Training programmes are also required for the extension personnel engaged in the development of coconut to keep abreast with the latest technological advances in coconut cultivation.

In the farmer empowerment programmes, special emphasis is to be given on the following aspects, as recommended by different workers.

- There is a need for popularizing production and use of organic manures including use of vermicompost and also encouraging the cultivation of green manure crops in coconut garden.
- To enhance the profitability of coconut cultivation especially in the present context of wide fluctuation in coconut prices, it is necessary to have programmes for popularizing optimum methods of inter/mixed cropping/mixed farming in coconut gardens. Suitable crop combinations are to be suggested depending on the farmers' preferences and his resource endowment and prevailing agroecological features of the locality.

Efforts are required to provide extension support to educate farmers about the scientific pest and disease management and also to implement location-specific schemes to provide incentives for the need-based plant protection measures.

Special training programmes are to be organized on new technologies such as climbing devices for the benefit of farmers.

14.8.3 Targeting the Extension Service

Often it is observed that the resource-rich farmers make use of the technologies in a better way than the resource-poor small and marginal farmers. Extension service obviously benefits these elite farmers better. Reaching resource-poor farmers with small and marginal holdings requires a different approach. The cropping system models such as high-density multispecies cropping system can be adopted by farmers who can afford to have a well laid-out irrigation unit. In the marginal holdings, which are often rainfed, choice of the cropping system and other production technologies would have to be different. The research and extension system is to work for the resource-poor farmers and low potential areas with appropriate technology, and active utiliser systems are to be generated. Transfer of technology model of innovation dissemination has to target heterogeneous situations.

14.8.4 Promoting Group Approach

Group approach helps to overcome the limitation of small size of holding in utilizing resources and improved technologies and also to provide opportunities for better social integration among farmers. Group approach programme could be implemented through local level farmers' associations. In the post harvest processing of coconut, there is immense potential for organizing cultivators with small and marginal holdings into viable groups to overcome the limitation of scale of cultivation. Apart from the efficient management of resources, these farmers' groups could be

effectively utilized for organizing educational programmes for the benefit of member cultivators. Moreover, these groups could act as an effective link between various systems engaged in the technology generation and dissemination.

14.8.5 Producer-Driven Value Chain system

The study conducted by Jayasekhar et al. (2014) has integrated the concept of sectoral system of innovation and value chain theory to find the regional dynamics of an evolving commodity chain. It has captured the reflections of tender coconut sector from the comprehensive study conducted in Kerala, India. The tender coconut value chain of Kerala has been found middleman -driven, which offers only a meagre value share to the producer/farmer. For upgradation of position in the chain, the producers should proactively function in a group mode and should integrate the domestic value chain. According to the study, for ensuring a bargaining position to the producer, the chain should be restructured from the middleman-driven one to producer-driven. The study has argued that the support of an effective sectoral system of innovation is inevitable for the development of the sub-sectoral commodity chains.

14.8.6 Experiential Learning Through 'Satellite Farms'

Owing to the perennial nature of the crop, the scope for setting up and maintenance of demonstration plots in coconut is limited compared to field crops. In this context, encouraging farmer-farmer extension, by way of model farms/satellite farms, assumes significance. A farmer who is already maintaining his farm with the improved technologies of coconut farming who is cooperative and well accepted by his neighbouring farmers could be identified for group meeting, field visits, demonstration and discussion in his farm. His farm could act as a 'satellite farm' from where the concept of improved methods of farming radiates to neighbouring farmers.

14.8.7 On-Farm Adaptive Research Trials

These trials with the active participation of the growers would be very useful in assessing the suitability of technologies. Approaches may differ from country to country. Field trials are to be made very simple with minimal replicates. Guidance and close involvement of the concerned researcher are necessary during the establishment of the trials and subsequent monitoring. Grower too should contribute, at least by way of labour, other material inputs being provided by the researcher. In Sri Lanka, on-farm adaptive research trials to demonstrate the farming systems approach (with intercropping and animal husbandry) have been a priority activity in the

research programme of the Coconut Research Institute of Sri Lanka. These have been becoming quite successful as centres of technology transfer and sources for planting material.

14.8.8 Participatory Demonstrations

Participatory demonstrations strive to demonstrate the technology with the active involvement of farmers and research stations. These should be easily accessible to the public and visible. Relevant information should be displayed in very simple language. In Sri Lanka, during the 1980s, over 200 demonstrations were established to popularize the use of fertilizers. This exercise was, by and large, successful with a significant number of smallholders being sensitized on the beneficial use of fertilizer, as was evident from the records available to the farmers on increased nut production (Rezania and Jayasekera 1992).

14.9 Future Strategy

Coconut research institutions have developed a number of technologies by the use of which remarkable improvement in the coconut productivity levels has been achieved within a short span of time. However, the wide gap that exists between the recommended practices and their actual level of adoption in various holdings indicates major barriers in improving the productivity levels. In order to change this scenario, the development efforts implemented by various research and development organizations are needed to be strengthened which should form one of the primary tasks towards achieving the targets for improving coconut productivity and profitability levels. As farmer participatory technology generation and dissemination in coconut could yield fruitful results, it will be worthy to be emulated by various agencies involved in the development of coconut. In the farmer empowerment programmes, special emphasis is to be given on popularizing production and use of organic manures and cultivation of green manure crops in coconut garden and optimum methods of inter/mixed cropping in coconut gardens depending on the farmers' preferences, his resource endowment and prevailing agroecological features of the locality. Efforts are required to provide extension support to educate farmers about the scientific pest and disease management and also to implement location-specific schemes to provide incentives for the need-based plant protection measures. Special training programmes are to be organized on new climbing devices for the benefit of farmers. The research and extension system is to work for the resource-poor farmers and low potential areas with appropriate technology, and active utiliser systems are to be generated. Transfer of technology model of innovation dissemination has to target heterogeneous situations. The producers should proactively function in a group mode and should integrate the domestic value chain coupled with creating storage facilities and market intervention to ensure a bargaining position for the producer.

Coconut plays a vital role in the agrarian economy of many countries. The present scenario of technology adoption in coconut calls for strengthening the technology generation and dissemination programmes based on a viable extension strategy with the active participation of beneficiaries. Effective linkage is to be established among different research and development agencies and coconut farmers through well-coordinated participatory research and extension programmes for ensuring a meaningful technology generation and transfer system in coconut.

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Dr. S. Arulraj served as Scientist (Agricultural Extension) and subsequently as Principal Scientist and Head of Division (Social Sciences); Project Coordinator, All India Coordinated Research Project on Palms at ICAR-CPCRI; as well as Director, ICAR-Indian Institute of Oil Palm Research in Andhra Pradesh, India. His major areas of research and development are participatory technology development, participatory technology transfer, documentation of indigenous technical knowledge, public-private sector partnership for agricultural development, policy research and use of information technology for transfer of technology. aruldopr@gmail.com

Dr. C. Thamban is working as Principal Scientist (Agricultural Extension) at ICAR-CPCRI, Kasaragod. He has also worked as Agricultural Extension Officer in the Department of Agriculture, Kerala State. His areas of interest include research on participatory technology transfer and community extension approaches in plantation crop sector with special emphasis on coconut. He has published 40 research papers and has edited 5 books. c.thamban@gmail.com

Dr. D. Jaganathan is a Scientist in agricultural extension at the ICAR-CTCRI, Trivandrum, Kerala, India. He has 8 years of experience in coconut while working at ICAR-CPCRI, Kasaragod, Kerala, India. He is a recipient of IARI Gold Medal for outstanding academic performance. His expertise is on human resource management, farmers' participatory research and innovation system analysis. He has published 20 research papers, 3 books and 10 chapters in books. djaganathtn@gmail.com