Good Agricultural Practices for coconut in India: Technological options, field scenario and strategies

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Introduction

Good Agricultural Practices (GAP) are a collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability (FAO, 2016). It has been well documented that implementation of GAP encourages promotion of the optimum use of resources such as pesticides, fertilizers, water and eco-friendly agriculture. In addition, implementing GAP also helps promote sustainable agriculture and contributes to meeting national and international environmental and social developmental objectives. Coconut (*Cocos nucifera L.*) is an important plantation crop of India with a profound influence on the rural economy by supporting the livelihoods of substantial number of farm families. It not only contributes to the national agrarian economy, it also supports the subsidiary industrial development. In India, the coconut palm is mainly grown in ecologically sensitive geographical areas such as coastal belts, hilly areas and areas with high rainfall and humidity. Coconut is highly amenable for product diversification and is mostly used as a food crop and hence, apart from ensuring sustainable on farm production practices, efforts are also needed for adopting recommended post production practices to achieve food safety standards for the production and marketing of coconut products. In these circumstances, it is highly relevant to evolve and put into practice the set of recommendations on Good Agricultural Practices pertaining to coconut. Research carried out by ICAR- CPCRI and State Agricultural/Horticultural Universities has resulted in substantial number of technologies for coconut aimed at increased productivity, sustainability and increase in income which could finally improve the socio economic status of the farmers and other stakeholders. Recommended coconut production technologies appropriate to the agro-ecological situations in line with the GAP requirements are to be promoted among the farming community. Similarly, post production practices as per the GAP requirements also need to be evolved and applied to the coconut based enterprises to ensure safe and healthy food and non-food coconut products, while taking into account economic, social and environmental sustainability.

Coconut palm is a perennial crop which is committed to land for more than 60 to 100 years and thus it is important to promote sustainable production and processing technologies ensuring conservation and utilisation of natural resources without any exploitation to withstand both biotic and abiotic stress in an uninterrupted longer period of time in the existing climate change scenario. Hence the good agricultural practices for coconut would ensure holistic approach taking into account the plant, animal, environment and human health aspects in an integrated manner.

This paper broadly discusses technological options, field scenario and strategies for promoting Good Agricultural Practices for coconut in India which includes, cropping /farming system, pest and disease management, harvesting and product diversification.

Coconut based multiple and integrated farming systems

Major objective of good agriculture practice is to utilize the available natural resources more effectively. Mono cropping of coconut leads to poor utilization of available resources. Coconut based cropping system is good agriculture practice which helps in effective utilization of natural resources and sustainable production.

Coconut based cropping systems by raising compatible subsidiary crops and/ or integrating with livestock enables to increase the productivity and net returns from unit area of coconut plantations. Farm resources like land, labour, sunlight, water and nutrients can be effectively utilized in such a system and higher productivity could be achieved as a result

of synergistic interaction among the crop and crop-livestock components. Crop diversity involving a number of annual, biennial or perennial crops as inter/mixed crops in perennial stands of coconut also promote the productivity and sustainability of the system. Coconut as a monocrop does not fully utilize the basic resources such as soil and sunlight available in the garden. The growth habit and planting methods of coconut make it highly suitable for intercropping in the interspaces of the coconut garden. Coconut palm like all monocots has a typical adventitious root system. Under favourable conditions, as many as 4000 to 7000 roots are found in the middle-aged palms. About 74 per cent of the roots produced by a palm under good management do not go beyond 2 m lateral distance and 82 per cent of the roots were confined to the 31 to 120 cm depth of soil. Thus, in a coconut garden the active root zone of coconut is confined to 25 per cent of the available land area and the remaining area could be profitably exploited for raising subsidiary crops. The orientation of leaves in the coconut crown helps penetration of sunlight into the soil and provides opportunities for exploitation of land and solar energy for inter/mixed cropping. Inter/ mixed crops are to be selected based on the age of the palms, size of the crown, availability of sunlight in the garden and agro climatic condition of the growing region.

Coconut offers scope for intercropping in the initial stage of the growth of palms and mixed cropping in the later part of life of palms. A variety of intercrops like tubers and rhizomatous speices (tapioca, elephant foot yam, sweet potato, greater yam, lesser yam, chinese potato, colocasia, ginger and turmeric), cereals and millets (paddy, sorghum, maize, pearl millet and finger millet), pulses and oilseeds (cowpea, green gram, black gram, red gram, ground nut, soybean, bengal gram and sunflower), vegetable crops (pumpkin, ash gourd, chillies, potato, french bean, snake gourd, amaranthus, brinjal, bottle gourd, ridge gourd, *Coccinia sp.*, Dolichos bean, annual moringa, curry leaf and tomato), fruit crops (banana, pineapple, and papaya), flowering crops (*Heliconia sp., Anthurium sp.* and *Jasminum sp.*) and fodder grass and legumes can be raised in coconut gardens upto 5 to 7 years. During the second growth phase of palms, *i.e.*, 5-20 years of age, growing of other crops in the interspace may be difficult due to poor sunlight availability. However, crops like colocasia, some varieties of banana like Palayamkodan etc., fodder grass, shade loving medicinal plants etc. which can tolerate shade can be cultivated in this phase. After the palms attain a height of 5 to 6 metres (above 20 years) *i.e.*, in older plantations, the crops mentioned in the initial stage and perennials like cocoa, vanilla, black pepper cinnamon, clove and nutmeg, sapota and medicinal and aromatic crops like Chittadalodakam (*Adhatoda beddomei*), Karimkurinji (*Nilgirianthus ciliatus*), Nagadanthi (*Baliospermum montanum*), Vetiver (*Vetiveria zizanioides*), Indian long pepper (*Piper longum*) can be grown as mixed crops along with the intercrops. Perennials are recommended as intercrops in the third stage only when the spacing adopted is 7.5 to 8.0 m. However, perennials can be grown as intercrops from the initial stage onwards by planting in coconut at a wider spacing of 10 m and above. In places where rainfall is not well distributed, irrigation is necessary during summer months. However, these crops are to be adequately and separately manured in addition to the manures applied to the coconut palms. Package of practices of intercrops should be followed as per the recommendation by Agricultural Universities of the region.

High Density Multispecies Cropping System

High density multispecies cropping system (HDMSCS) involves growing a large number of crops to meet the diverse needs of the farmer such as food, fuel, timber, fodder and cash. This is ideally suited for smaller units of land and aims at maximum production per unit area of land, time and simultaneously ensuring sustainability. This system includes annuals, biennials and perennials. The crops selected include cash crops, food crops and fodder crops. The biomass other than the economic part is recycled within the system. From the experimental plot on HDMSCS maintained at CPCRI Kasaragod, which involves coconut and other crops like banana, pineapple, pepper, clove and nutmeg, it is observed that an average annual net income of 5 to 6 lakh rupees can be obtained per ha. Besides, 25 tonnes of organic wastes are also made available per ha which can be recycled and applied to the crops as vermicompost. In HDMSCS if organic recycling is effectively carried out, we can reduce the chemical fertilizer input for coconut to two third of the recommended dose.

Coconut based integrated farming system

Coconut based integrated farming is an ecologically sustainable system which helps the farmer to realize more income. Sustainability is the objectivity of the integrated farming system

where production process is optimized through efficient utilization of inputs in safeguarding the environment with which it interacts. Mixed farming by raising fodder grasses such as hybrid Napier or guinea grass along with leguminous fodder crops such as *Stylosanthes gracilis* in coconut gardens has been found to be profitable. Raising the above crops in one hectare of coconut garden can support five to six dairy animals. However, if Hybrid Bajra Napier (Co 3, Co 4 and Co 5) is grown as intercrop in coconut garden about 120 tonnes of green fodder per hectare per year can be obtained through which 12 animals can be maintained. In addition to cattle, poultry, pisiculture, goattery and apiculture may also be integrated depending upon the farmer's interest. The cattle and poultry manure generated from the system when applied to coconut garden improves the soil fertility considerably. Maintaining milch cows and other components in coconut garden helps the farmer to enhance his income and provide additional employment to the family. A net income of 6.0 to 6.5 lakhs rupees per year can be obtained from one hectare coconut based mixed farming unit comprising of components such as 10 milch cows, 6 batches of poultry birds of 100 per batch and Co 3 Hybrid bajra Napier fodder grass, 1000 fingerlings and goattery unit. Employment generated from such a unit is about 900 man days per year. By maintaining one coconut based integrated farming system more than 70 tonnes of FYM is produced from the system and cow urine more than 1 lakh liters and these if recycled in to the system can result in improvement of soil physical, chemical and biological properties and ensure the sustainability of the system. More than 75 per cent of the N and K requirement can be substituted through on farm resources and entire phosphorus requirement can be met internally.

Pest and disease management

The basis of pest and disease management in GAP is minimum use of chemical pesticides and ensuring use of eco friendly practices including use of bio control agents. The natural enemies are insect predators (insects that consume part or all of pest insects), parasites (insects that use other insects to produce their offspring, thereby killing pest in the process), and pathogens (diseases that kill or decrease the growth rate of insect pests). Predatory insects include lady bird beetles, lace wings and spiders. Parasitic insects include wasps and flies which lay their eggs on pest insects, such as larvae or caterpillars.

The emphasis on GAP for plantations should ideally be on the use of varieties tolerant to pest and diseases. Neem-based pesticides produced from neem kernel extracts can also be used to repel pests. The extracts derived from the aerial parts (leaves and stem) of *Artimisia vulgaris, Urtica dioica*, Polygonum and *Eupatorium glandulosum* which are profusely growing in the plantations can be used for their anti-feedant action against some leaf eating pests of coconut.

Careful management in both time and space of planting of inter crops not only prevents pests, but also enhances population of natural predators that have natural capability to control insects, diseases and weeds. Other methods that can be generally employed are- clean cultivation, improving soil health to resist soil pathogens and promote plant growth; crop rotation; encouraging natural biological agents for control of diseases, insects and weeds; using physical barriers for protection from insects, birds and animals; modifying habitat to encourage pollinators and natural enemies of pests; and using semi chemicals such as pheromone attractants and trap pests.

About 150 Biopesticides including micro organisms, parasites, predators and natural plant based pesticides from neem and garlic are effective in managing pests of coconut and other intercrops. There are several examples of use of effective bio control agents for suppression of pest and diseases of coconut and other component crops. The important pests and diseases as well as their management practices that are to be followed under GAP is given in Table 1. It will be most ideal if community approach is adopted in the management of various pests and diseases of coconut. Many plants are suitable as botanical pesticides and can be incorporated in the cropping system. Chemicals should be used judiciously and should be applied when the insect population reaches higher than economic threshold level. Spraying should done with utmost care. Workers should wear proper masks and gloves. Correct type of chemical, correct dosage of chemicals and correct type of nozzle should be used. The wind velocity should be minimum when spraying undertaken, preferably during early morning hours or evening hours. Good quality water should be used for mixing with chemical pesticides. Close monitoring and systematic scrutiny of palms for timely detection of pests are critical to execute the correct approaches in pest suppression and reduce crop loss.

Name of pest	Management practices
Rhinoceros beetle (*Oryctes rhinoceros)*  *Fig . Metarhizium majus*	1. Field sanitation 2. Routine palm scrutiny and hooking out the beetle from the infested site reduces the floating pest population. 3. Shielding the spear leaf area of juvenile palms with fish net could effectively entangle alighting rhinoceros beetles and placement of perforated sachets containing 5 g chlorantraniliprole `(0.4 %) / 3 g fipronil or one botanical cake (2 g) developed by ICAR-CPCRI on top most three leaf axils evade pest incursion. 4. Prophylactic treatment of top most three leaf axils with either botanical cake [(Neem cake /marotti cake (*Hydrocarpus sp*) / pongam cake (*Pongamia pinnata* -250 g)] admixed with equal volume of sand or placement of 12 g naphthalene balls covered with sand 5. Incorporation of the weed plant, *Clerodendron infortunatum* in to the breeding pits caused hormonal irregularities resulting in morphogenetic transformational aberration in the immature stages of the pest. 6. Treat the manure pits with green muscardine fungus, *Metarhizium majus* @ 5 x 1011 /m3 to induce epizootics on the developing grubs of rhinoceros beetle 7. Release *Baculovirus oryctes* infected adults @ 10-15 I ha 8. Area-wide farmer participatory approach in technology adoption could reduce the pest incidence very effectively and forms an eco-friendly approach in pest suppression.
Red palm Weevil *Rhynchophorus ferrugineus*	1.Field sanitation is very critical and all residual population in crown toppled palms should be destroyed. Prophylactic leaf axil filling suggested for rhinoceros beetle is very essential as this pest pave way for red palm weevil. 2. Avoid causing injury to the palms, as they would attract the weevil to lay eggs. Mechanical injury if any, caused should be treated with coal tar 3. While cutting fronds, petiole to a length of 120 cm is to be left on the trunk to prevent the entry of weevils into the trunk 4. Timely and targeted spot application of imidacloprid 0.002% (1 ml per litre of water) or indoxocarb 0.04% (2.5 ml per litre of water) on infested palms would kill the feeding grubs and induces recovery of palms by putting forth new spear leaf. 5. If damage occurs in the crown, the damaged tissue has to be removed and insecticide suspension, imidacloprid (0.02%) @1 ml/L of water may be poured in. In case of entry of weevil through the trunk, the hole in trunk may be plugged with cement/tar and the top most hole is made slanting with the aid of an auger and the insecticide solution is poured through this hole with funnel 6. Set coconut log traps with fermenting toddy or pineapple or sugarcane activated with yeast or molasses to attract weevil 7. Use of pheromone trap for attracting and killing adult weevils (this should be adopted at community level)
Leaf eating caterpillar *Opisina arenosella*	1. Removal and burning of heavily infested 2-3 outer fronds 2. Regular monitoring of palm fronds for pest occurrence in endemic zones. 3. Augmentative release of stage specific parasitoids viz., the larval parasitoids *Goniozus nephantidis* (Bethylidae) @ 20 parasitoids/palm, *Bracon brevicornis* (Braconidae) @ 30 parasitoids/ palm, the prepupal parasitoid, *Elasmus nephantidis* (Elasmidae) @49/100 pre-pupae, and the pupal parasitoid *Brachymeria nosatoi* (Chalcididae) @32/100 pupae at the appropriate time was found effective in the sustainable management of the pest. Combined release of the parasitoids is required in multistage prevalence of the pest in the field. 4. Before releasing, the parasitoids are adequately fed with honey and exposed to host odours (gallery volatiles) for enhancing host searching ability.

Coried bug *Paradasynus rostratus*	1. Spraying of neem oil-soap emulsion (0.5%) on the pollinated bunches. The emulsion can be prepared by adding 5 ml neem oil and 8 g bar soap in one litre water 2. Collect and destroy all the fallen buttons of the affected palm 3. Crown cleaning to destroy eggs and immature stages of the pest 4. Spraying of azadirachtin 300 ppm (Nimbecidene) @ 0.0004% (13 ml / l) reduced the pest incidence at the highest level. Two rounds of azadirachtin spray on young coconut bunches 1-5 months old during May-June and September-October are quite essential for satisfactory control of the pest in the field 5. Among the natural enemies, the weaver ant, Oecophyllas maragdinais found to be the most efficient predator of coreid bug in the field 6. Two egg parasitoids, namely *Chrysochal cissaoviceps* and *Gryonhomeoceri*, were identified as potential egg parasitoids. Forty per cent parasitism was observed in the egg mass collected from the field due to these parasitoids 7. Spraying cholrantraniliprole 0.3 ml/litre or lambda cyhalothrin @ 1.0 ml/litre on the pollinated bunches was found effective.
Coconut eriophyid mite *Aceria guerreronis*	1. Removal and destruction of dried spathes, inflorescence parts and fallen nuts to subdue the pest population 2. Spraying on the terminal five pollinated coconut bunches with neem oil garlic soap mixture @ 2 per cent concentration (neem oil 200 ml, soap 50 g and garlic 200 g mixed in 10 litres of water). 3. or spraying neem formulations containing 1 per cent azadirachtin @ 4 ml per litre of water 4. or spraying palm oil (200 ml) and sulphur (5g) emulsion in 800 ml of water 5. Root feeding azadirachtin 10,000ppm @ 10 ml + 10 ml water is also effective 6. Spraying of talc-based preparation of acaropathogen, *Hirsutella thompsonii*@ 20 g / litre/ palm containing 1.6 x 108cfu three times in synergy with neem formulation on the bunches immediately after pollination 7. Predatory mites, *Neoseiulus baraki* and *Amblyseius sp.* do encourage natural suppression of the pest 8. Kalpaharitha (a selection from Kulasekharam Tall) was found field tolerant to mite damage 9. Application of recommended dose of fertilizers, recycling of biomass, raising of green manure crops in palm basin and incorporation during flowering, summer irrigation including soil and water conservation measures improve the palm health and reduce the pest attack.
Rugose spiraling whitefly (RSW) *Aleurodicus rugioperculatus* .  Fig . *Leiochrinus nilgirianus*	1. Application of 1% starch solution on leaflets to flake out the sooty moulds. 2. In severe case, spray neem oil 0.5% and no insecticide is recommended 3. Installation of yellow sticky traps on the palm trunk to trap adult whiteflies 4. Using the aphelinid parasitoid, *Encarsia guadeloupae* and the chrysopid predator, *Apertochrysa sp.*, lady beetles *Jauravia pallidula*, *Serangium parcesetosum* and *Menochilus sexmaculatus*, cybocepahlid predator, *Cybocephalus sp.* as well as *in situ* preservation of the sooty mould scavenger beetle, *Leiochrinus nilgirianus Kaszab* 5. Use of yellow sticky traps @ 5 per acre 6. In juvenile palms, spraying of water with jet speed could dislodge the whitefly and reduce the feeding as well as breeding potential of the pest 7. Habitat preservation of the sooty mould scavenger beetle, *Leiochrinus nilgirianus* could eat away all the sooty moulds deposited on palm leaflets and cleanse them reviving the photosynthetic efficiency of palms.

Root grub Leucopholis coneophora	1. Soil application of aqua suspension of entomopathogenic nematode, *Steinernema carpocapsae* in the interspaces at 5-10 cm depth @ 1.5 billion IJ/ha and need based repeated application 2. Repeated summer ploughing to expose the immature stages of predation 3. Handpicking of adult beetles during evening of two weeks commencing from the onset of monsoon. 4. Application of neem cake in the palms basin @ 5 kg /palm for regeneration of roots.
Coconut scale, *Aspidiotus destructor*	1. Use of aphelinid parasitoid, *Aphytis sp.* is very successful 2. The lady beetles, *Chilocorus nigritus*, *Sasajiscymnus dwipakalpa*, *Pharoscymnus horni (Coccinellidae)* were found as effective predators
slug caterpillars *(Darna nararia)*	1. Complete destruction of affected palm leaflets with caterpillar at early stages of infestation should be made immediately so that the pest build up is suppressed. Care should be taken as the caterpillars cause extreme itching when contacted with human skin due to the presence of poisonous scoli. 2. Establishment of light traps and spraying *Bacillus thuringiensis* 5 g/litre was found effective along with inundative biological control using the eulophid larval parasitoid, *Pediobius imbrues*
Nut borer *Cyclodes omma*	1. Crown cleaning and removal of immature stages of the pest 2. Application of the entomopathogen, *Bacillus thuringiensis* @ 20 g per litre or neem oil 0.5% (5 ml per litre with 10 g soap powder) using hand sprayers would reduce pest incidence.
Rodents *Rattus rattus wroughtoni*	1. Rats can be controlled by providing mechanical barriers (bands), poison baits and traps. Wrapping the trunk of coconut trees using polythene sheets was found to reduce the damage by rats 2. G.I sheet bands, 40 cm wide, fixed around the trunk of palms at a height of 2 m from the ground serve as mechanical barriers for rats. 3. Planting coconut seedlings in correct spacing as well as destruction of fallen fronds and other palm residues at regular intervals to ward off the rat activity from coconut gardens.

Diseases

Name of disease	Management practices
Bud rot	1. Regular cleaning of the crown and prophylactic spraying of Bordeaux mixture (1%) to the crown just before the onset of monsoon and one more spray after 35-40 days help in reducing the bud rot incidence 2. Phytosanitation by removing severely affected palms. 3. Placement of two Trichoderma (*Trichoderma harzianum* CPTD28 isolate) enriched coir pith cakes in the inner most leaf axils just before the onset of monsoon and again after every two months as prophylactic measure 4. Remove the infected tissues of the spindle completely. Two or three healthy leaves adjacent to the spindle may have to be removed, if necessary, for easy removal of all rotten portions and thorough cleaning. After removing the affected tissues apply 10% Bordeaux paste and cover the wound with a polythene sheet to prevent entry of rain water. The protective covering has to be retained till normal shoot emerges. 5. Spray 1% Bordeaux mixture to the surrounding palms 6. Destroy the infected tissues removed by burning or deep burying in the soil 7. Provide adequate drainage in gardens and avoid overcrowding. 8. For the newly planted seedlings also prophylactic spraying of Bordeaux mixture (1%) can be given to avoid infection. 9. In localities where heavy wind is experienced and leaves of coconut palms got damaged, spraying of Bordeaux mixture (1%) is essential to prevent infection by Phytophthora.

Leaf rot	1. Remove rotten portion of the spindle leaf and 2-3 successive leaves and pour fungicide solution containing 2 ml hexaconazole 5 EC in 300 ml water/ palm or talc based formulation of Pseudomonas fluorescens or *Bacillus subtilis* @ 50 g in 500 ml water/palm into the well around the base of the spindle leaf 2. Undertake prophylactic measures to prevent rhinoceros beetle attack
Stem bleeding	1. Remove water stagnation and apply recommended doses of organic manure to make the palms healthy. 2. Avoid burning of trash and palm residues near the trunk to avoid trunk/root injury 3. The affected tissues should be completely removed using a chisel and smear the wound with 5% hexaconazole (5 ml in 100 ml of water) and drench the basins @ 25 lit. of 0.1% solution 4. Smearing paste of talc based formulation of *Trichoderma harzianum* on the bleeding patches on the stem (The paste can be prepared by adding 50 g of Trichoderma formulation in 25 ml of water) 5. Apply neem cake enriched with *Trichoderma harzianum* @ 5 kg per palm in the basin along with other organics. 6. Use *Trichoderma hamatum* and *Trichoderma harzianum* enriched coir cake for the management of the disease 7. Application of paste of Trichoderma harzianum talc formulation on the bleeding patches on the trunk was also found effective in preventing the spread of stem bleeding
Basal stem rot disease *Ganoderma spp.*	1. Removal of dead palms and palms in advanced stage of the disease as well as destruction of the boles and root bits of the diseased palms to remove disease inoculums 2. Isolation of diseased palms from healthy palms by digging isolation trenches of 2 feet depth and one feet width around the basin 3. Avoiding flood irrigation or ploughing in infected gardens to prevent spread of the inoculum. 4. Application of neem cake (5 kg) fortified with *Trichoderma harzianum* (CPTD 28) talc formulation (50 g) per palm per year at six monthly intervals reduced the disease intensity 5.Root feeding of hexaconazole @ 2% (100 ml soluti oner palm) or soil drenching with 0.2% hexaconazole / 1 % Bordeaux mixture @ 40 litre soluti on per palm

Harvesting

Usually 11-12 month old nuts are harvested. Coconuts are harvested at varying intervals in a year. The frequency varies depending upon the yield of palms. Usually, the nuts are harvested 6 to 10 times in a year. In well maintained and high yielding gardens, bunches are produced regularly and harvesting is done once in a month. Nuts which are 11 months old give fibre of good quality can be harvested in the tracts where husk is utilized for manufacture of coir fibre. Skilled personnel are traditionally employed for climbing palms for harvesting nuts. Nowadays, lack of availability of skilled climbers for harvesting operations is a serious problem experienced by coconut farmers. A simple palm climbing device invented by a farmer from Kannur district of Kerala is gaining popularity and that is the device used by vast majority of climbers. Reducing operational hazard is one of the aspects of GAP which is more applicable for coconut. Harvesting is one of the major operations being done manually. Of late climbing devices have been developed to reduce the drudgery and ensure safety of climbers. However, old generation climbers still prefer manual climbing without using climbing devices. There is always risks involved in the life of climbers since the 60 years old coconut palms of tall varieties attains a height of 15 to 18 m. Hence the climbers need to be sensitized about the risks involved and measures have to be taken to train them to use mechanical climbing devices with safety attachments. Owners of the garden should help to insure them. The young generation climbers need

to be properly trained about the proper usage of mechanical climbing devises.

GAP for post harvest processing

Value addition through product diversification is the important strategy for enhancing income from coconut farming. A variety of food and non food products are prepared by utilizing different parts of coconut palm. Coconut products can be broadly classified as tender coconut based products, inflorescence sap based products, coconut milk based products and mature coconut based products. Adoption of farm level processing of coconut for value addition is very low in India mainly because of the predominance of small and marginal holdings which suffer from various resource constraints to take up processing enterprises. In order to overcome the challenges due to the resource constraints in fragmented holdings group approaches are facilitated and large number of FPOs are formed in coconut sector out of which many are managing enterprises on production and marketing of value added coconut products. Many of the coconut products, especially food products, have quality standards as set by the agencies concerned with regulatory measures. Good Agricultural Practices pertaining to the post harvest processing and marketing of coconut are to be formulated by taking into account the available quality standards and by evolving quality standards for those products which do not have standards fixed. Production protocol for each coconut product including compliance on maintenance of personal hygiene of work force, hygiene to be ensured within the production centre as well as the premises, packaging unit etc are to be compiled and guidelines for GAP for post harvest processing are to be formulated for adoption and certification. Capacity building initiatives to create awareness about GAP pertaining to post harvest processing in coconut are to be conducted at regular intervals to benefit the entrepreneurs, labour and other stakeholders to ensure safe and healthy coconut products.

Field level adoption of GAP in coconut

Though a substantial number of technologies have been evolved by coconut research institutions which are in tune with the principles of GAP, studies conducted by ICAR-CPCRI in Kerala state have indicated that the extent of adoption of recommended production technologies is not at a satisfactory level (Thamban et al, 2021). Optimum spacing for planting is followed only in 30% of the coconut gardens. Similarly, adoption of water conserving irrigation methods such as drip irrigation in coconut holdings is very low. Vast majority of the farmers (99%) do not apply micronutrients to their coconut palms despite the fact that there is widespread deficiency of micronutrients adversely affecting coconut productivity. Coconut based inter/mixed cropping system is followed in about less than 50% of the gardens only which indicates the scope for popularising coconut based inter/mixed cropping through appropriate development/extension interventions, especially in small and marginal holdings. Utilisation of the potential for multiple cropping in coconut gardens to enhance food production assumes much significance. Integrated farming is adopted in 15.73% coconut holdings only. Pest and disease incidence in coconut gardens is very high in farmers' field. However, IPM is adopted in less than one third of coconut gardens and IDM in less than 10% of orchards. Similarly, farm level processing for value addition of coconut is also very low. The low level of adoption of sustainable production technologies by growers indicates the necessity for implementing interventions to promote adoption of GAP in coconut.

Strategies for promoting GAP in coconut

Coconut growers and entrepreneurs experience various technological and socio-economic constraints which result in low level of adoption of recommended practices pertaining to production and processing. Problems experienced by coconut farmers include price crash/fluctuations for coconut and its value added products in the market, fragmentation of holdings, absentee landlordism, lack of awareness/knowledge about GAP for coconut, lack of labour and high wage rate, lack of irrigation facilities, lack of processing infrastructure etc. Hence, it is imperative to implement policies and programmes to support farmers and entrepreneurs for enhancing adoption of GAP in coconut for enhancing productivity and sustainability and to ensure safe and healthy food and non-food coconut products.

Primarily there is a need to map the available technologies in line with principles of GAP for sustainable coconut production in different coconut growing regions in the country so that agro-ecological zone-wise guidelines for adoption of GAP can be evolved. Similarly, protocols made available for production and marketing of coconut products also need to be mapped for formulating guidelines for adoption of GAP to ensure safe and healthy coconut products.

Coconut research institutions, development agencies, FPOs, entrepreneurs, fabricators, input agencies, certification agencies, marketing agencies, credit institutions, and other relevant stakeholders need to be brought together on a common platform to formulate the guidelines for adoption/certification of GAP. Coconut Development Board, the main agency mandated for the integrated development of

coconut industry in the country can be the champion organisation for coordinating the activities to inventorize the recommended technologies and also for evolving policies and programmes to incentivise adoption of the same. Once the guidelines for GAP in coconut is formulated and framework for action prepared for its promotion, suitable agencies for certification of GAP in coconut are to be identified and accredited.

There is a need to strengthen research on GAP with emphasis on climate resilient practices for sustained productivity of coconut. Research intervention is also required to evolve soil health management recommendations to suit agro ecological zones. The need for developing equipments and machinery for tillage/cultural operation/ plant protection/climbing appropriate to fragmented coconut holdings is another area for strengthening research.

Since coconut is predominantly a small holder crop in India, suitable support mechanism is required to empower the resource poor growers to adopt GAP in coconut through group approaches. Organising capacity development programmes for farmers, labourers, entrepreneurs and other stakeholders to create awareness/knowledge about GAP in coconut. Farmers and entrepreneurs are to be made aware about the benefits of adopting GAP in coconut production and processing especially about the potential of realising premium price in marketing GAP certified coconut and its products.

A congenial policy environment is to be created for promoting decentralised community coconut nurseries managed by Farmer Producer Organisations (FPOs) in coconut sector to enhance availability of quality seedlings of suitable varieties. Formulate and implement development/extension interventions for restructuring coconut orchards overcrowded with coconut palms for the maintenance of optimum palm density for sustainable coconut production.

Appropriate interventions are required to promote water conserving irrigation methods such as drip irrigation in coconut holdings. Development/ extension interventions are also needed for evolving and popularising adoption of AEU- wise technology package for soil health management for coconut. FPOs in coconut sector are to be supported for production and marketing of customized fertilizer inputs for coconut and the trained FPOs are to be linked to the Agro-Service Centres. Similarly, interventions are needed to encourage women SHGs/ farmer collectives for production and marketing of organic / bio inputs for sustainable coconut production.

FPOs in coconut sector and women SHGs can be facilitated to take up interventions on inter/mixed cropping with focus on food crops like tuber crops in coconut gardens. Front line demonstration of various coconut based integrated farming system models developed at the research institutions and also successful models adopted by coconut farmers needs to be organised by Krishi Vigyan Kendras and field level units of State Department of Agriculture/ Horticulture with the active involvement of FPOs.

A paradigm shift from individual farmers to group/community based decentralised participatory approach is required for improving efficiency of extension support to enhance adoption of IPM/IDM practices in line with GAP to avoid crop loss. Farm level processing for value addition of coconut is very low and hence, interventions are to be implemented to facilitate FPOs in coconut sector for taking up coconut based enterprises for production and marketing of value added coconut products in line with GAP to enhance income from coconut farming.

Conclusion

Adoption of Good Agricultural Practices for production and post harvest processing is highly relevant under the present climate change scenario to ensure sustainability and safe and healthy coconut food and non-food products. Substantial number of technologies in line with GAP for sustainable production and post-production processing of coconut have been made available by coconut research institutions in the country. Research initiatives on GAP for coconut are to be further strengthened with emphasis on climate resilient practices for sustained productivity, evolving soil health management recommendations to suit agro ecological zones and for developing equipments and machinery appropriate to fragmented coconut holdings. Interventions are needed for creating a congenial policy environment for promoting GAP and for implementing suitable development/extension interventions to benefit growers and entrepreneurs. Effective coordination of activities by research and development/extension institutions, FPOs/SHGs, entrepreneurs/processors and other stakeholders in coconut sector is a pre-requisite for evolving and implementing appropriate guidelines for adoption/ certification of GAP in coconut.

References

- Thamban C, Anithakumari P, Kalavathi S and Jaganathan D. 2022. Innovative extension approaches for sustainable coconut development. In : Vanaja.T., Balakrishnan, P. C. and Satheesan, K. N. (Eds.). Compendium on coconut. Regional Agricultural Research Station Pilicode, Kerala Agricultural University. pp: 356-375