Production technology for sustainable coconut cultivation

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A number of low cost production technologies suitable for coconut cultivation have been developed and there are ample evidences that application of appropriate technologies in the right combination can help to enhance the productivity

Abstract

The national average productivity of coconut in India, which is predominantly cultivated by small and medium growers, is very low (around 40 nuts/palm/year) on account of many reasons. Lack of adoption of scientific cultivation practices that can enhance the productivity and at the same time bring down the cost of production can be mentioned as the main factor for the low productivity. A number of low cost production technologies suitable for coconut cultivation have been developed and there are ample evidences that application of appropriate technologies in the right combination can help to enhance the productivity.

Integrated approach in nutrient management by way of recycling crop biomass (in situ vermi-composting); raising green manure legumes (in coconut basins) and green leaf manure plants such as Glyricidia (in and around the plantation) and their incorporation and the use of biofertilizers are some of the effective low cost production technologies developed at CPCRI. Conversion of coconut wastes to valuable organic manures has become possible by the low cost vermicomposting technique developed utilizing local epigeic earthworm belonging to the Eudrilus *sp. Coir pith, a problematic waste in coir defibering units, can be used as a valuable input in coconut cultivation by converting it to organic manure by a composting process involving biopolymer degrading fungi or earthworms with various amendments. Another approach for recycling of coconut wastes is by utilization of lignocellulosic biomass for oyster mushroom cultivation and further conversion of the spent substrate to organic manure by composting or vermicomposting processes.*

Soil and water conservation measures helped in the utilization of natural resources more efficiently in crop production. Mulching with coconut husk, coir dust and coconut leaves was effective in reducing soil temperature and evaporation from soil surface. Contour planting on slopy land, combined with contour tillage, ridging or bunding of soil has been found to be effective in reducing soil erosion. Close growing of erosion resisting crops such as pineapple in long and narrow strips across the slope reduced the eroding

*Director, CPCRI, **CPCRI, R.S. Kayamgulam *power of water by forming obstruction to run off and helped retain the soil. Adoption of organic and biological resources-based agrotechnologies had positive impact on soil health and fertility parameters, which enabled to achieve higher productivity on sustainable basis.*

Introduction

Being a small holder's plantation crop grown in 1.89 m ha area in the tropical belt of the country extending through out the peninsular India comprising of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Goa, parts of Maharashtra and north eastern regions, the coconut palms play a very vital role in the livelihood of millions of people. The major socio-economic features in which this crop is cultivated include predominance of small and marginal holdings, medium to resource poor farm environment and less marketable surplus.

The national average productivity of coconut in India is very low (around 40 nuts/palm/year) on account of many reasons. Lack of adoption of scientific cultivation practices that can enhance productivity and at the same time bringing down the cost of production is a major factor contributing to low productivity. Nutrients and water are limiting factors in crop production in most of the coconut based small holdings. Declining productivity is attributed to the exhaustion of nutrients from soil due to continuous mining of nutrients by the palm without sufficient nutrient inputs. Hence, in order to sustain economic yield, soil nutrient management with application of organic inputs and soil and water conservation measures are of paramount importance. A number of low cost production technologies have been developed at Central Plantation Crops Research Institute and there are ample evidences that application of appropriate technologies in the right combination can help to enhance the productivity. Integrated approach in nutrient management by way of recycling of crop biomass (*in situ* vermicomposting), raising green manure legumes in coconut basins and green leaf manure plants such as Glyricidia in and around the plantation and their incorporation and use of bio-fertilizers for soil fertility build up and mulching, husk burial, half moon bunding, catch pit preparation, etc are some of the effective low cost soil and moisture conservation measures standardized at this Institute which are effective in the utilization of natural resources for enhancing coconut production in a sustainable manner.

Fig. 1 Coconut leaf stalk being converted to vermicompost by *Eudrilus* sp.

Recycling of crop residue biomass

The coconut palms produce large quantities of waste biomass in the form of dried leaves, bunch wastes, husk, coir pith, etc which can be effectively utilized by composting process for production of organic manure. The availability of waste biomass from a well managed coconut garden with 175 palms has been estimated as 14 tonnes/ha/year. The natural decomposition of these wastes and nutrient release are very slow due to the high lignin content and the nature of lignocellulose complex of the coconut waste materials. The organic wastes can be directly utilized as mulch or converted into compost by employing earthworms or microbial cultures.

Vermicomposting for conversion of biodegradable wastes into compost

Vermicomposting is an appropriate technology for bioconversion of biodegradable wastes into quality organic manure by the activity of selected species of earthworms. Earthworms have been identified with capability to convert various types of organic wastes and produce vermicompost on a commercial scale. Studies conducted at Central Plantation Crops Research Institute, Kasaragod have resulted in isolation from coconut plantation of an epigeic local earthworm, *Eudrilus* sp., efficient in bioconversion of lignin rich coconut materials. This tropical compost worm has the unique ability for fast growth rate, high reproductive potential and higher rate of feeding on coconut leaves including the petiole portion. A low cost technology has been standardized for converting the weathered coconut leaves to acceptable organic manure utilizing the local earthworm species (Prabhu *at al.*, 1998). Though vermi-composting in large cement tanks was found to be ideal, *in situ* vermicomopsting in coconut plantations is possible by the pit method or heap method with very low investment. The pit method can be practised in the interspaces of four palms and the heap method enables production of vermicompost right in the basin of coconut palms and in the interspaces. Utilization of whole coconut leaves without chopping helps to keep the labour requirement to the minimum. Though the length and breadth of composting pit, heap or tank can be altered based on the availability of organic wastes, the height of the heap and depth of the tank or pit should not exceed one meter. Pretreatment of coconut leaves with cow dung at the rate of 100 kg per tonne of coconut leaves and maintenance of moisture are necessary to achieve partial decomposition of the organic wastes to make it suitable for earthworm action. The earthworms are released at the rate of 1000 numbers per tonne of coconut leaves after two to three weeks of cow dung treatment. Mulching with dried grass or coconut leaves after the release of earthworms and maintenance of moisture by regular watering are necessary to maintain earthworm activity at an optimum level. The bioconversion of most of the organic waste biomass is achieved within a period of 60-75 days. The organic waste turns into tea powder like granular form as it passes through the digestive tract of earthworm. On an average, 70 percent recovery of vermicompost can be obtained.

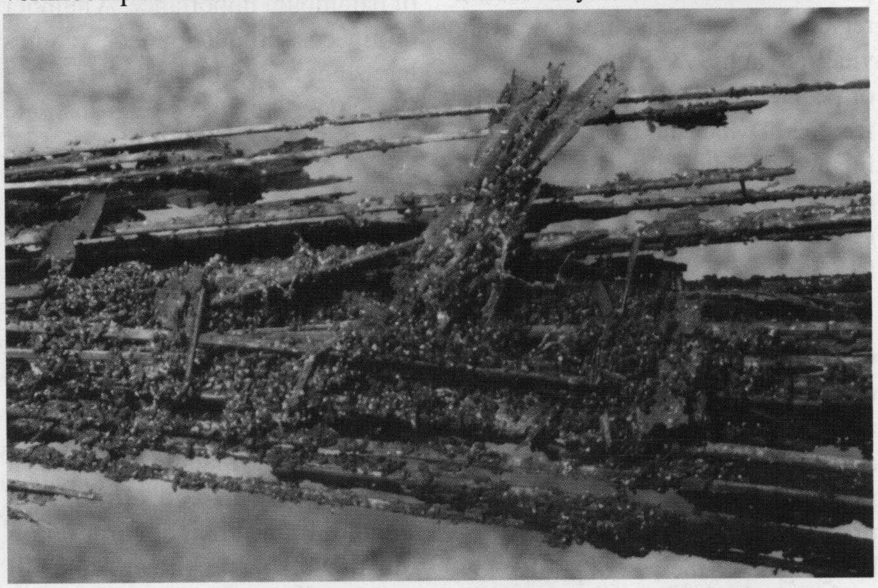

Fig. 2 Partly vermicomposted coconut leaf

The vermicompost produced from coconut leaves was found to be a good source of plant nutrients in available form. The average nutrient composition of the vermicompost recovered from coconut leaves was: Nitrogen (N) – 1.8 per cent, Phosphorus (P) – 0.22 per cent, Potassium (K) – 0.16 per cent, organic carbon 17.84 per cent and Carbon: Nitrogen (C:N) ratio of 9.9. Total microbial counts and beneficial microbial population were also more in the compost compared to the base material. Two types of active nitrogen fixing bacteria not commonly isolated from soils have also been found to be associated with the vermicasts. The efficiency of vermicompost to enhance the growth and vigour of polybag raised coconut seedlings have been demonstrated. The application of vermicompost has improved the physical, chemical and biological properties thereby enhancing the fertility of soil.

Considerable success has been achieved in the popularization of this technology among the farming community. Distribution of seven lakh earthworms of the local *Eudrilus* sp. as nucleus culture to farmers of different states is an ample evidence for the acceptance of this technology among small and large farmers. Large scale distribution of earthworm has become possible due to the standardization of a simple and faster method for mass multiplication and maintenance of the earthworm. The species can be multiplied very fast in a 1:1 mixture of cow dung and decayed leaves, mulched properly with grasses. The use of earthworm for waste management has successfully promoted vermicompost production in rural areas in a manner that is suited to local conditions.

Conversion of coirpith into bio-organic manure

Coir pith is a variable organic resource obtained as a byproduct in the coir processing industry during the extraction of coir fibers from coconut husk. It is a non-fibrous, fluffy and high weight corky material, which constitutes about 50-70 percent of the husk. With high C:N ratio of above 100:1 and higher contents of lignin and polyphenols, raw coir pith is not an ideal organic input in crop production. Coir pith can be made suitable for use in agri-horticulture after stabilization by proper composting process by employing suitable organisms capable of degrading lignin and polyphenols and bringing down C:N ratio. Several studies showed that coir pith can be degraded by artificial inoculation of efficient lignin degrading micro-organisms.

One of the initial attempts on biodegradation of coir pith was in the application of the basidiomycete fungus, *Pleurotus sajor caju* along with the amendment of urea (Nagarajan *et al.,* 1985). Further studies resulted in the utilization of different biopolymer degrading fungi such as *Pleurotus platypus, Pleurotus djamor, Trichoderma harzianum,* etc. Studies conducted at Central Plantation Crops Research Institute resulted in the isolation of efficient ligninolytic and cellulolytic fungi such as *Marasmiellus troyanus, Lepista* sp., *Lentinus squarrosulus, Schizophyllum commune* from naturally decopmosing coconut wastes.

Large scale composting of coir pith can be done either in cement tanks or by the heap method in a shaded place. Initial treatment with lime and rock phosphate at the rate of 0.5 per cent and legume biomass or cow dung at 10 per cent make the coir pith amenable for microbial actions. Inoculation of coir pith after 15 days with the fungal cultivars at 0.2 per cent and maintenance of moisture facilitate microbial degradation of the biopolymers. The raw coir pith with a C:N ratio of 108:1 would turn into compost with a C:N ratio of 15:1 within a period of 40-50 days. Microbial enrichment of coir pith compost with N_2 fixing bacteria and phosphate solubilizers enabled production of good quality compost with better manurial value.

Coir pith can also be converted into acceptable organic manure by vermicomposting process utilizing the local epigeic earth worm belonging to the *Eudrilus* sp. Pretreatment with lime and rock phosphate at 0.5 per cent each and incubation under moistened conditions are necessary to achieve partial degradation and to create conditions for earthworm actions in the compost. Amendments with pre-treated coir pith with cow dung at the rate 10 per cent, and fresh vermicompost at the rate 10 per cent encourage faster earthworm action. This mixture has to be layered with uncut coconut leaves at the rate of 20 per cent to facilitate aeration in the bed. Earthworm has to be introduced at the rate of 1000 numbers per tonne of organic materials and the bed should be mulched and moisture to be maintained by regular supply of water. A granular vermicompost with 1.2 per cent nitrogen and a C:N ratio of 16.7:1 can be obtained in two months (Thomas *et al.,* 2001a).

A number of trials have revealed that decomposed coir pith can be used as organic manure in crop

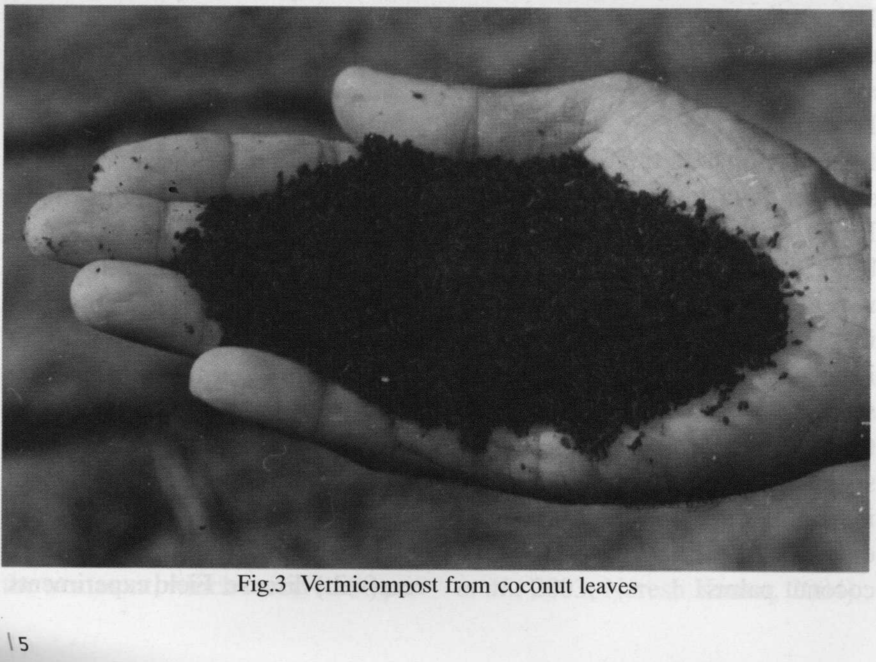

Fig.3 Vermicompost from coconut leaves

production. It can also be used as a cheap but effective substitute for peat because of its peat like characteristics. Decomposed coir pith has very high moisture retention capacity and its wettability is much better than peats (Evans and Stamps, 1996). The decomposition of lignins present in coir pith results in the formation of humic fractions (Kadalli *et al.* 2001), which imparts coco peat high nutrient retention capacity.

Biomass recycling along with mushroom cultivation

Mushroom cultivation on organic waste biomass of coconut provides twin benefits of production of edible fruiting bodies for human consumption and at the same time provides organic manure from the spent substrate. The efficiency of biological conversion of waste biomass to protein rich fruiting bodies was in the range of 55-70 per cent. Coconut leafstalk and bunch waste are better substrates for oyster mushroom production (Thomas *et al.*, 1998). *Pleurotus* species such as *P.florida, P.sajor caju, P. flabellatus* and *P.eous* are suitable for cultivation on coconut wastes. Fermented coir pith was also found to be a suitable substrate for production of oyster mushrooms. The spent substrate obtained after the cultivation of mushrooms formed acceptable organic manure when it was composted by the heap method. The composted spent substrate had enhanced plant nutrient status, higher level of micronutrients and low C: N ratio.

Biofertilizers as low cost eco-friendly inputs

Beneficial micro-organisms such as nitrogen fixing bacteria, phosphate mobilisers and plant growth promoting bacteria can be used as low cost ecofriendly inputs in coconut cultivation. Bacteria efficient in biological nitrogen fixation including *Azospirillum* spp., *Herbaspirillum* sp., *Burkholderia* sp., *Arthrobacter* sp. and *Bacillus* sp. have been isolated from coconut roots and *Beijerinckia indica* from root region soils (Thomas and Prabhu, 2003). Phosphate solubilizing microbes of coconut soil include *Pseudomonas* sp., *Bacillus* sp. and *Micrococcus* sp. Production of biofertilizer formulations of the short listed strains have been standardized. Inoculation trials with the biofertilizer of indigenous strains revealed the positive beneficial influence of the biofertilizers in improving the vigor of coconut seedlings raised in polybags. Field trials with nitrogen fixers and P-solubilisers also gave some indications that these bacteria can enhance the nut yield of adult coconut palms.

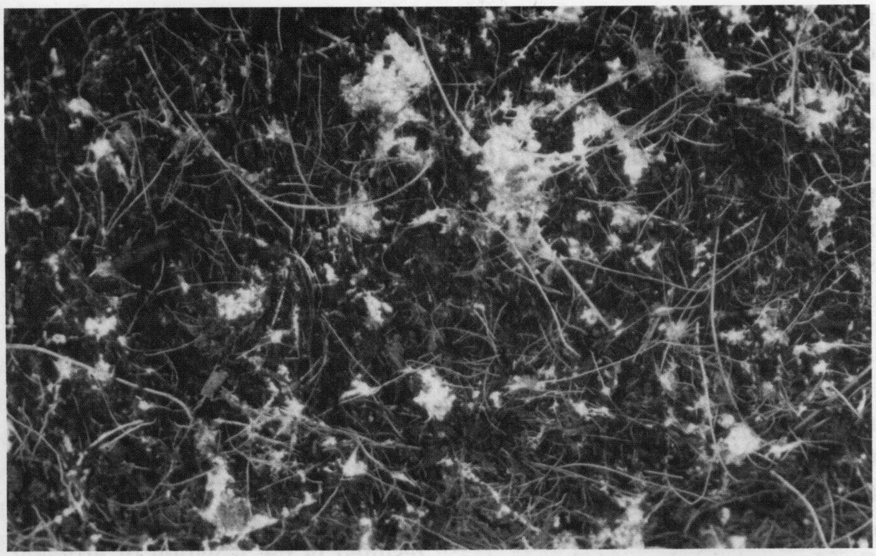

Fig.4 Fungus colonizing coir pith converting to compost

Basin management with green manure legumes

Basin cultivation and incorporation of leguminous green manure crops is a simple and low cost agro-technique, which can be easily practised by farmers for generation of organic manure at the site of need itself. Among the several legumes tested in coconut basins, *Pueraria phaseoloides, Mimosa invisa* and *Calopogonium mucunoides* were superior in biomass production and contribution of biologically fixed nitrogen (Thomas and Shantaram, 1984). Sowing of legumes in coconut basins with the onset of monsoon in May and harvest of the above ground portion of legumes after 140-150 days of growth resulted in the generation of 15-28 kg of biomass and 102-197 g of nitrogen in the basin of a coconut palm. The benefits conferred by this practice include the improvement in soil fertility and biological parameters and increase in the yield of coconut palms affected by the debilitating root(wilt) disease. Field experiments with adult coconut palms revealed that 50 per cent of the inorganic nitrogen could be substituted with the nitrogen contributed by the green manure legumes (Thomas *et al.*, 2001b). Recent studies showed that cowpea can also be grown as a green manure crop to generate large quantity of biomass in coconut basins.

Glyricidia as alley crop in coconut gardens

The fast growing leguminous crop, *Glyricidia sepium* has been found to be an ideal alley crop for coconut plantations. Biomass generation to the extent of 8t/ha is possible in littoral sandy soils if the legume is grown in three rows in between two rows of coconut palms (Subramanian *et al.*, 2000). Biomass yield was more when pruning was done three times in an year during February, June and October. In the field trials on fertilizer nitrogen substitution with Glyricidia green leaf manure, with adult coconut palms, highest yield was obtained in the treatment, which received 50 per cent of recommended nitrogen through Glyricidia green leaf manure.

Soil and water conservation

Soil and water conservation assumes particular significance as a low cost cultural practice in situations where the rainfall is not distributed throughout the year and where there are no irrigation facilities. In most of the coconut growing regions, the rainy period is confined to a few months during the monsoon season. The palm experiences moisture stress for varying periods extending upto 6 months in an year. Utilization of the available water in most effective manner by adopting soil moisture conservation practices will help to increase the productivity of the palms. A number of practices including mulching, agronomic and bioengineering measures for soil and water conservation suitable for coconut plantations have been developed at Central Plantation Crops Research Institute (Dhanapal *et al.*, 2003; Naresh Kumar, 2004)

Fig.5 Oyster mushroom cultivation on fermented coir pith

Mulching with different materials

Mulching of coconut basins with organic crop residues is advantageous to maintain higher moisture level, reduce evaporation loss and soil temperature, control weed growth and supply organic matter and nutrients to the soil. The waste materials available from coconut farming can be effectively utilized as mulch materials as they undergo degradation slowly.

Coir pith mulch

Coir pith, the by-product of coir processing industry can be used as mulch in coconut basin. The mulch may be applied to a thickness of 15 cm during the end of the rainy season. Coir pith can hold moisture five times of its weight. Further by spreading coir pith in the basin, the increase in soil temperature and evaporation are arrested. Use of composted coir pith rather than raw coir pith provides dual benefit of soil moisture conservation and serves as a nutrient source. If applied as raw coir pith, it may last for about four to five years.

Husk mulch

Husk burial is a common practice in coconut garden. Approximately 250 to 300 husks are required for mulching in a coconut basin. Two layers of husk may be buried in the coconut basin with the concave side facing upwards for the lower layer to facilitate to absorb more moisture. The top layer can be placed with the convex side facing upwards to arrest the evaporation. The benefit of husk burial will last for about 5-7 years. It can hold moisture 3 to 5 times of its weight and also supplies the palm with small amount of potash present in them.

Leaf mulch

Approximately 20 coconut leaves are required to spread in the basin area as mulch. Unlike the husk and coir pith, leaves cannot hold any moisture. Leaf mulch prevents the top soil from getting heated up and this reduces the evaporation from the basin area. The leaves may last for 1 to 2 years only.

Half moon bund with pineapple border

Half moon bund can be made on the down slope in a sloppy terrain with a slope ranging from 5 to 15 per cent. The bund height can be 30 cm and more. To avoid bund damage, one to two rows of pineapple can be planted on the bunds. This half-moon bund conserves water, soil and nutrients *in situ*. This kind of conservation practice helps to achieve higher productivity under rainfed conditions. It was observed that with in a period of two years, there was 200 per cent increase in coconut yield. Further there was additional income from pineapple.

Catch pit

Staggered catch pit in coconut garden with a slope of 12-14 per cent in the heavy rainfall zone of western ghats has improved the coconut yield by conserving the soil and water which other wise would have been lost through runoff water. Pits of size 2 x 0.5 x 0.5 m can be opened across the slope. With the dug soil, bund can be formed on the down slope and planted with pineapple.

Fig.6 *Calopogonium mucunoides* in coconut basin

Trench filled with coconut husk

In sloppy land, long trench of size 4 x 0.5 x 0.5 can be opened (across the slope) in the middle of two rows of coconut garden. The trench should be positioned in such a way that it would not come in line with the basin area i.e. the water that flows down the slope in between the basin area is trapped in the trench. This trench is to be filled with coconut husk. The top layer of husk should have the convex side facing up wards. The bund, which is formed in the down slope may be planted with pineapple to avoid damage to the bund.

Fodder grass intercropping

Co-3 fodder grass can be grown in coconut gardens with slope ranging from 14 to 16 per cent. The grass is planted in rows across the slope. Growing grass serves dual purposes of fodder production and as well as soil and moisture conservation. The grass yields fodder to the level of 100 t/ha in the coconut garden in the western ghat region. The cultural operations should be avoided during the heavy rain fall season to avoid soil and nutrient loss.

Conclusion

Lot of opportunities exist for biological management of soil fertility in coconut plantation. Technologies based on bioresource management are cost effective, environment friendly, easily adoptable and makes efficient utilization of local resources. Agro techniques based on local resources can make positive impact on coconut production and sustainability in farming. Soil and water conservation structures are vital to conserve natural resources for enhanced productivity. Adoption of these various low cost production technologies is a feasible option for small holders to maintain sustainability of land resources and to develop the farm holdings as a viable unit.

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