Coconut Research Highlights in Kerala Agricultural University

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Introduction

Coconut is a versatile crop having varied uses. It is a source of food, drink, shelter and raw material for industrial exploitation. India is the largest producer of coconut in the world. It is grown in eighteen states and three Union Territories in the country. The area under coconut has increased from 0.626 million hectares in 1950-51 to 1.89 million hectares in 2008-09 and the production from 3281 million nuts to 15730 million nuts. The increase in productivity during the last decade was about 54 per cent. The crop has considerable significance in the national economy in view of rural employment and income generation potential. In Kerala, about 90 per cent of the crop is rainfed and is generally affected by the long dry spells of three to four months a year. The number of unproductive and senile palms is high in Kerala. The crop is affected by major pests like rhinoceros beetle, red palm weevil, black headed caterpillar, cockchafer beetle, coreid bug eriophyid mite and disease like bud rot, leaf rot, stem bleeding and Mahali.

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Coconut and coconut-based farming research received a further fillip when the Kerala Agricultural University came within the fold of the National Agricultural Research Project (NARP). Subsequently, the coconut research stations at Pilicode and Kumarakom were elevated to the status of the Regional Agricultural Research Stations with the mandate for research on coconut and coconut-based farming systems including integrated coconut-livestock-fishery systems, respectively.

Crop Improvement

The introduction of coconut types for yield evaluation was started as early as 1923 at Pilicode with the

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ultimate objective of identifying elite types having high yield. The station has an excellent collection of coconut germplasm consisting of exotic (35) and indigenous (40) types.

Earlier studies on the performance of the introduced types revealed that Lakshadweep Ordinary, Lakshadweep Small, Andaman Ordinary, Philippines and Cochin China were promising. Among the exotic varieties, Cochin China and Philippines were outstanding in quality for their tender nuts.

Out of the seventy five cultivars maintained at Pilicode, fifty one have reached the steady bearing stage and they are being studied in detail for the number of nuts, mean copra content and copra out turn.

High yielding coconut hybrids

Exploitation of heterosis to enhance production and productivity has been the major objectives in coconut research. The first hybrid coconut was developed prior to the formation of the Kerala Agricultural University as T x D (Tall x Dwarf) which became very popular throughout the State.

Realising the importance of hybridization as a potential tool for genetic improvement of coconut, a number of hybrids involving different parental combinations have been produced and tested at the Regional Agricultural Research Station, Pilicode. In 1947, Gangabondam, a semi tall cultivar of Andhra Pradesh, was used as pollen parent and crossed with six tall cultivars viz., Lakshadweep Ordinary, Andaman Ordinary, West Coast Tall, Java, Lakshadweep Small and Cochin China. Lakshadweep Ordinary x Gangabondam was found to be superior to all other combinations in respect of annual nut production, setting percentage, per palm yield of nuts and copra out turn per year. This hybrid was released as Lakshaganga in 1987. Later in 1988-89, two more hybrids were released based on the studies conducted at the Regional Agricultural Research Station, Pilicode. They were Anandaganga and Keraganga, developed by a cross of Andaman Ordinary x Gangabondam and West Coast Tall x Gangabondam, respectively.

Coconut hybridization work at Pilicode gained momentum in 1973 with the planting of 15 hybrid combinations of tall and dwarf palms for studying the extent of heterosis in coconut. West Coast Tall x Malayan Yellow Dwarf was better than the other cross combinations, based on early flowering, average number of nuts and copra out turn and was released to the farmers as Kerasree.

Another hybrid Kerasowbhagya (West Coast Tall x Strait Settlement Apricot) was released in 1993 based on its uniform performance and high yield.

High yielding coconut cultivars

'Komadan', an ecotype of the southern districts of Kerala was found superior to West Coast Tall and Natural Cross Dwarf in respect of nut yield (163 nuts palm/year),

Kerasree

Kerasowbhagya

weight of husked nut (550 g), copra content (177 g/nut) and oil percentage (65.23). It has been released and recommended for large scale cultivation in the southern region of Kerala. An open pollinated variety Kerasagara was released from RARS, Pilicode during the year 2007 by the State Variety Release Committee. Another exotic coconut variety Kudat is found to be promising among the new introductions.

Development of hybrid coconut with desirable characters such as high yield and short stature is the need of the state. Present day coconut farming become difficult due to the shortage of climbers. Efforts were made to identify suitable parents for the development of hybrids of short stature suitable to the state. The result of the survey conducted in Kannur and Kasaragod districts located Annur Coconut which is having minimum internodal length as compared to ordinary Tall. The seed nuts developed through the crosses were planted at RARS, Pilicode for further studies. Positive results expect from this project that will definitely enhance the productivity of coconut in the state without much difficulties in farming.

Identification of quality seedlings

The criteria for selecting quality seedlings at nursery stage could be standardized based on the time taken for germination, number of leaves, girth at collar and early splitting of leaves. The recovery of quality seedlings was estimated to be about 60-65 per cent.

Table 1. Performance of released hybrids

Hybrid	Nut yield palm/year (No.)	Copra content nut (g)	Copra yield Palm/year (kg)
Lakshaganga	108.3	194	21.06
Anandagana	95.2	216	20.56
Keraganga	100.2	201	20.14
Kerasree	140.0	216	30.24
Kerasowbhagya	130.0	195	25.35

Crop Management

Density of planting

Spacing adopted by the coconut farmers of Kerala varies from 5.6 to 9.0m. Based on the studies on the yield response of the coconut cultivar West Coast Tall, conducted in the various research stations of the Kerala Agricultural University, a spacing of 7.5 x 7.5 m was identified as the optimum under average fertility conditions.

Moisture conservation

Moisture conservation is of vital importance in coconut, especially in the northern districts of Kerala with prolonged spells of drought from December to the end of May. Surface mulching of coconut basins with waste coconut leaves (12 basin^{-1}) or burying of coconut husks in linear trenches of 1.80 x 0.45m in between rows of coconut palms helped moisture conservation and increased nut yield. The beneficial effect of burying husks was observed to last for six years.

Soil and nutrition

Research on nutritional aspects and fertilizer requirements of coconut was started in 1923 at the Coconut Research Station, Pilicode. Some of the early experiments gave important information on nutritional requirements of the palm. At present, accent is given not only on the fertilizer requirement but also on several fundamental aspects of nutrition to bring out clearly the major nutritional constraints in Kerala.

Fertilizer requirement

At the Coconut Research Station, Balaramapuram a fertilizer trials involving three levels of N, P and K in factorial combination (3^3 confounded design; confounding NPK^2 and NP^2K^2) with two replications has been in progress since 1964. This particular experiment was designed to test only inorganic fertilizers, viz. ammonium sulphate as N source, single superphosphate as P source and muriate of potash as K source right from the seedling stage. During the past 25 years the palms have not received any organic matter application. In this respect, the experiment is unique and is perhaps the only one of its kind in the world being continued after two decades. The levels of N were 0, 340 and 680g, those of P were 0, 225 and 450g and those of K were 0, 450 and 900g palm/year. The study made so far indicates that potassium can independently influence the nut yield. Nitrogen influences the yield only in combination with phosphorus or potassium.

The NPK requirement of an adult palm in red loam soil was found to be 0.68:0.23:0.90 kg year. Study on the effect of interaction between spacing and manuring on the growth and productivity of coconut indicated that NPK @ 0.68:0.45:0.90 kg palm/year and the spacing 7.5 x 7.5 m were the best with respect to per palm yield. However, NPK @ 0.68:0.45:0.90 kg/palm/year and the spacing 5.0 x 5.0 m recorded the maximum yield/ ha in the red loam soils of Kerala.

Trials conducted at Pilicode indicated that irrigated coconut hybrids require a fertilizer dose of 0.5:0.5:1.5 kg NPK palm/year in two split doses. For reclaimed clayey soil as in Kuttanad, a fertilizer dose of 0.25:0.35:0.90 kg NPK palm/year has been recommended.

The response of magnesium, a secondary element has been tested in two different soil types viz. laterite and alluvial. In laterite soil, the yield of coconut increase due to magnesium application.

However, this trend was not observed in alluvial soil. Diagnosis and Recommendation Integrated System (DRIS) was found applicable to coconut. DRIS could be used for the nutrient management in conjunction with critical level approach. Routine leaf analysis for the diagnosis of latent deficiencies of N, K and Cl and correction of their deficiencies based on foliar critical levels has been recommended.

An efficient method of fertilizer application was developed from radiotracer studies employing ^{32}P based on the most effective root zone. It was observed that over 80 per cent of active roots of coconut reside in a soil column of radius 2.0 m to a depth of 60 cm. Accordingly, fertilizers and manure are to be applied in a circle of radius 2.0m around the palm for best results. Adoption of this method ensures maximum utilization of the applied nutrients.

Response to irrigation and drainage

Coconut responds well to irrigation during dry months (January to May) from the third year onwards. Irrigating the crop with 500L of water in basins of 1.80 m radius at CPE value of 50 mm (approximate interval of 12 days) is the most economical.

Irrigation at IW/CPE 1.0 and a fertilizer dose of 0.50, 0.50, 1.50 kg NPK palm/year was found to be ideal for Tall x Gangabondam hybrids.

The ratio of consumptive use to pan evaporation (crop co-efficient) was computed under different irrigation regimes and the mean was estimated as 0.75. The water requirement of coconut seedlings could be estimated using this crop co-efficient, if pan evaporation values are known.

The observations on growth characters recorded during 1985 and 1986 indicated that the treatment receiving drip irrigation at IW/CPE 0.50 and a fertilizer dose of 0.50, 0.32 and 1.20 kg NPK palm/year was superior to the rest.

In a study conducted at Nileshwar, it was found that surface drains of 1.5 m depth, provided in between rows of coconut, increased the yield by 84.8 per cent (pre-treatment yield; 35.7 nuts/palm; post treatment yield; 66.1 nuts/palm). The crop was irrigated during summer months.

Impact of drought on coconut yield

The adverse effect of drought on coconut yield was observed in the succeeding year, starting from the eighth month to the twentieth month after the drought, the peak decline being in the twelfth and thirteenth months. The effect of drought during

summer on low yielders of coconut was less, when compared to that of high yielders, including coconut hybrids. However, the number of nuts was high (69.3 nuts palm/ year) in high yielders even in drought years, when compared to that of low yielders (45.2 nuts palm/year).

There is a general belief that the coconut palms will be affected if irrigation is discontinued in the mid summer due to scarcity of water. Hence, the coconut growers are reluctant to irrigate the palms during summer (December to May) even though water is available upto February. Studies have shown that irrigating the palms @ 450 l per/ palm per week during summer, till water for irrigation is available, is not detrimental for crop production. The yield of nuts was found to increase due to summer irrigation even for a few months.

Forecasting coconut production

Using the data from 1949-50 to 1993-94, a multiple regression model could be developed for forecasting the total coconut production of the State seven months ahead, based on agroclimatic indices viz, index of moisture adequacy (Ima) and humidity index (Ih). The R^2 was 0.97.

Micrometeorological studies

Micrometeorological studies were conducted to understand solar and the net radiation profiles in coconut gardens. Relationship was worked out between bright sunshine and net solar radiation.

Quantification of incident light at different developmental stages in coconut garden is helpful for selecting suitable intercrops. Light infiltration in coconut-based homesteads increases with increase in plant height up to 6.4 m (corresponding to the height of nine year old palms). A reverse trend was observed beyond this stage. A prediction technique for light infiltration based on measurements of crop parameters was evolved.

Coconut based integrated farming systems

Farming strategies that ensure sustainable advances in production is a chosen alternative to high technology farming. Such a regeneration farming approach that blends different farming practices through biological diversification and nutrient cycling is the most relevant to the coastal wetlands of Kerala, where coconut is the principal perennial crop. At the Regional Agricultural Research Station, Kumarakom in Kuttanad, the coastal low land of Kerala, long term as well as short term studies have been taken up, focussing on the farming system involving integration of diverse allied enterprises, blending complementary and interactive farming viz., raising of intercrops fodder, livestock, poultry and fish in low lands, wherever possible. Three fundamental models of integrated farming have been evolved and tested viz., (1) coconut-intercrops-livestock-fish, (2) coconut-duck-fish and (3) coconut-livestock-prawn. These facilitated complementary interactions and organic matter recycling.

Economics of homstead farming with and without livestock components showed that livestock enterprise had a healthy and synergistic interaction with crop components in a farm. This could be profitably exploited to form an income generating and employment generating activity in the home garden. The system including livestock was found to be more eco-friendly and also sustainable as it provided scope for better nutrient recycling and minimum use of external inputs.

On-farm research on homesteads indicated that the species diversity was more in farms with crops alone than in farms with crop and livestock, indicating a larger number of crop species in the category of farms with only crops.

Several experiments have been conducted to optimise the intercropping systems in coconut. Root production in banana was found to vary between the plants grown in the coconut garden and in the open. Rainfed banana in the coconut garden developed a spreading root system, while irrigated banana developed a compact root system. When banana and cassava were grown as intercrops, 75 per cent of the fertilizer dose recommended for each crop was found sufficient for obtaining high yield.

The economic feasibility of growing pepper as a component crop of coconut was confirmed in an experiment conducted at the Regional Agricultural Research Station, Kumarakom. Panniyur-I was found to be the best variety for the system. Yams were observed to be suitable intercrops of coconut in the reclaimed alluvial soil.

Ginger collections from Kuravilangad, Nedumangad, Kuruppampady and Kumarakom were found suitable for intercropping in coconut gardens.

Growing the medicinal plant *Coleus vetiveroides* as an intercrop in coconut garden was found to be remunerative. *Piper longum* performed well under 50 x 50 cm spacing with an application of 20 t FYM/ha and 30:30:30kg NPK/ha.

Intercropping in coconut gardens of about 20 years age, using forage grasses and legumes has been standardised and recommended. Crop combinations of grasses like Guinea grass, Setaria, hybrid Napier and *Panicum maximum* and legumes like Cowpea and stylosanthes, as pure and mixture at 3:1 ratio were found suitable.

Among the green manure crops and cover crops tried in coconut basins, *Crotalanria striata* and *Pueraria phaseoloides* produced the greatest quantity of dry matter.

Crop Protection

Disease management

The debilitating and dreaded root (wilt) disease is affecting the production and productivity of coconut in Kerala. The estimated annual loss in yield due to the disease during 1976 was 340 million nuts and during 1984-85, 968 million nuts. Most often death of the palms occurs subsequently, due to the infection by the fungal pathogen, *Helminthosporium haloides* as well as due to infestation by red palm weevil. In case a root (wilt) affected palm not attacked by leaf rot or red palm weevil, the palm can continue to produce fairly good yields for several years. Spraying the foliage with 1.0 per cent Bordeaux mixture before the onset of monsoon and root injection of monocrotophos has been found to be very effective for the purpose.

Concentrations of rare earth elements (REEs) in the leaves of the diseased and apparently healthy palms of the disease-affected tract and healthy palms of the disease-free area covering three major soil types viz., alluvial, laterite and sandy were studied. The results reflect the probable geochemical differences between diseases affected tracts and disease-free tracts. The probable role of soil chemical constituents in the incidence of root (wilt) disease, either as a causative agent or as a pre-disposing factor, implies that the occurrence of the disease should be understood based on its distribution and not on its spread. The presence or absence of the disease delineates two geographical regions in the State based on soil chemical differences.

Stem bleeding, a lethal disease threatening coconut cultivation in the North, could be effectively managed by painting hot coaltar on the cleared surface, applying neem cake @ 5.0 kg palm/year and drenching the soil with 25 ml calixin in 25 l. water at monthly intervals.

A homothallic *Phytophthora* (*P.katsurae*) infecting coconut palm and causing bud rot was identified. This is highly pathogenic and can also cause foot rot disease of pepper. It produces oospores in large numbers in the infected palm.

Pest management

The coried bug, *Paradasynus* rostratus is a serious menace to coconut cultivation in Kerala. It was estimated to cause 24 per cent loss in copra and 35 per cent loss in oil content. Spraying carbaryl 0.1 per cent on the newly opened inflorescence, after the receptive phase of the female flowers, and the entire crown excluding leaves and other bunches, was recommended for managing the pest. Cashew and guava were identified as potential alternate host of this pest.

A severe outbreak of the coconut mite *A. guerreronis* was reported from Kerala during 1998. The reports from other countries have clearly shown that the acarophagous fungus species belonging to the genus *Hirsutella* are the specific fungal pathogens and the promising bio control agent of coconut mite.

Extensive surveys were conducted and nut samples were collected from the mite-infested areas for isolation of fungal pathogens. Accordingly the specific fungal pathogen *Hirsutella thompsonii* var. *synnematosa* could be isolated consistently from the dead mites. The pathogenicity of the fungus was later confirmed under laboratory condition.

Being a newly reported pathogen, further basic studies have been taken up on several aspects including the standardization of laboratory culturing techniques.

Simultaneously a mycoacaricide namely 'mycohit' has been formulated with *Hirsutella thompsonii* from PDBC, Bangalore. Field experiments were conducted with Mycohit (wettable powder formulation) during 2000 and 2001. About 70 to 90 percent mite

mortality could be recorded in the preliminary trials.

Our scientists have also isolated local strains of the *H. Thompsonii* and are now trying to isolate and characterize the strains that are better in their infectivity and adapted-possible routes of administration including utilization of the pollinators are being explored.

Infestation of rhinoceros beetle could be reduced by treating manure pits and other possible breeding sites with carbaryl 0.01 per cent on w/w basis every three months. Leaf extracts and chopped leaves of clerodendron and neem when mixed with cowdung at the rate of 1:10 and 1:20 by weight prevented the normal growth and development of the grubs.

Incidence of the black headed caterpillar of coconut (*opisina arenosella*) could be effectively controlled by liberating parasites (Braconid/Bethylid/Elasmid) in the early stage of infestation. When infestation is very severe and bio-controls is not likely to be effective, spraying the under surface of the fronds with dichlorvos 0.02 per cent or malathion 0.05 per cent is recommended. After the application of the insecticide, larval and pupal parasites should be released from the 21st day to re-establish the host-parasite balance.

The important alternate hosts of the cockchafer bettle, *Leucopholis coneophora*, were observed to be colocasia, tapioca, pepper, arecanut, rose, bhindi, groundnut and casuarina.

Studies on stored products of coconut were conducted. It was observed that even a well preserved and good quality copra was damaged by pests like *Necrobia rufipes* and *Oryzaephilus surinamensis* when stocked for more than five months. Drying of copra to 4.0 per cent moisture level and storing the same in the netted polythene bags was recommended for reducing pest incidence. When stored in gunny bags, the bag should be disinfested by applying 0.4 per cent malathion or 0.8 per cent fenitrothion on the outer surface and dried in the shade. Fumigation of godowns with Aluminium phosphide @ 3.0 g/m^3, with two days exposure period, was effective in saving pest infested copra.

Post Harvest Technology and Product Diversification

Research for processing and product diversification of coconut inflorescence sap (CIS) under NATP/CGP was completed at Pilicode campus. Processing methods have been developed for preservation of coconut inflorescence sap as RTS (CIS RTS), coconut inflorescence sap concentrate (CIS honey) and coconut inflorescence sap granules (CIS granules). The minimum storage life of RTS is 60 days and that of CIS honey is 1 year. Processing methods have been standardized for the preparation of jam and toffee from CIS products. Processing method for the production of palmgur has been improved to enhance the quality and shelf life.

Sap exuding from the coconut inflorescence had a TSS of 17.5° B and pH 7.3. The total sugar present in CIS was 16.33 of which 15.79 was non reducing sugar. Important minerals present in CIS are potassium (89.8 ppm) followed by Calcium (50 ppm) and Phosphorous (13 ppm).

Sap yield varied significantly among the palms 1.36 to 3.14 litre/ day). Seasonal variation in the sap yield was also significant.

Coconut Mission activities

Efforts were made to enhance the production of hybrid coconut seedlings at various centers of KAU. Additional mother palms were identified in the traditionally producing centers viz. RARS, Pilicode and COA, Padannakkad. New production programme was started at IF, Vellayani, ORARS, Kayamkulam and CRS, Balaramapuram. During the season 2010-11 we expect for a production of 21000 hybrid coconut seedlings which will be ready for distribution from the year 2011 onwards. At present the production was about 10000 hybrid coconut seedlings per year.

An RKVY project "Production and distribution of coconut seedlings and other planting materials adopting seed village concept" was sanctioned with a financial outlay of Rs. 35 lakhs. Hybridization work have already started by identifying 400 mother palms in farmer's field at Nileshwar for the production of kerasree and keraganga hybrid coconut seedlings. This will produce an additional 8000 hybrid coconut seedlings by 2012 season onwards. By implementing a project "Development of production units

for hybrid coconut seedlings and other planting materials in three districts of Kerala we will be in a position to produce 80000 hybrid coconut seedlings per year from various centers by 2012.

Machinery Developed

a. Coconut dehusker

A simple and light hand operated coconut husking device, KERAMITRA was developed for domestic use. Consisting of a stationary wedge, a movable wedge, a lever and a pedestal, this device could husk a nut in 8-20 seconds, depending on the variety, maturity etc. The technology was transferred for commercial exploitation. This tool is fast spreading in Kerala.

b. Tender coconut punch

Another tool, useful for punching a hole on tender coconut has been designed and fabricated.

By - product utilization

Coir pith utilization

Large quantities of coir pith - a by-product of coir industry is being wasted and is a serious pollutant. Coir pith can not be used as such for agricultural purpose. Methods could be standardized for coir pith composting utilizing the fungus *Pleurotus* and urea. Coir pith compost has been found to be an excellent potting media for plants. Techniques could be standardized for using coir pith as a substrate for growing edible mushrooms.

Coir based geotextiles are being tested for soil conservation, soil structure improvement and weed management.