Research Highlights

1995 – 2005

DIRECTORATE OF RESEARCH
KERALA AGRICULTURAL UNIVERSITY
KAU POST - 680 656, THRISSUR, KERALA, INDIA

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FOREWORD

The research outcome emanated from the four faculties of Kerala Agricultural University, Viz., Agriculture, Veterinary and Animal Sciences, Agricultural Engineering and Fisheries Science for the decade (1995-2005) are compiled and presented succinctly in the Research Highlights. During this period, 103 crop varieties were released and a good number of useful technologies were developed. The main thrust areas of research addressed were on solving location specific problems, focusing on resistance breeding, plant protection measures, biotechnological interventions, molecular biology, water technology, biofertilizers, post harvest technology, captive breeding in fisheries, mechanization, animal production, poultry science, quality milk and meat production, value addition and epidemiological aspects. Homestead garden, backyard poultry, inland brackish water fishery, crab, prawn, lobster and high value fish culture have received attention during the period.

Due to technological interventions, the productivity of various crops in the State have increased in spite of the fact that the agriculture in Kerala is recently not a paying main avocation and there is shift from food crops to plantation crops.

Food and nutritional security associated with livelihood security are the key factors which would ensure welfare of the State and the people for which agriculture and the allied fields remain to be the mainstay.

I congratulate the Director of Research, Associate Directors and the Scientists who have contributed so nicely and so well to bring out this compilation 'Research Highlights of KAU, 1995-2005.' The publication will be a pointer to future research goals in the State. I wish success, satisfaction and a sense of attainment to all the Scientists who toiled with commitment to produce this very valuable document.

Sd/-
Prof. K.V. Peter
Former Vice Chancellor
Kerala Agricultural University

Vellanikkara
27-2-2007

PREFACE

This report is the gist of Research Achievements made during the period from 1995 to 2005. These research findings have been disseminated to the farming community for adoption through the Package of Practices Recommendations published by KAU from time to time.

This compilation is pertaining to advances made in research taken up at 36 research stations of the University and its 10 constituent colleges falling under various faculties viz., Agriculture, Veterinary and Animal Sciences, Agricultural Engineering and Fisheries. The significant role played by various research co-ordination groups in mediating and co-ordinating the research activities deserve high appreciation.

The report specifically highlights the crop varieties developed and released, the technologies transferred and patents obtained/applied during the period.

The support obtained from various funding agencies like ICAR, KSCSTE, Government of Kerala, Government of India, CDB, DBT, DST, BARC, NHB and UGC is gratefully acknowledged.

I congratulate all Zonal Associate Directors and Scientists for their contributions made. The remarkable efforts rendered by the Associate Directors of Research and the scientists at the Directorate of Research are lauded wholeheartely.

Sd/-
Dr. D. Alexander
Director of Research
Kerala Agricultural University

Vellanikkara
27-2-2007

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1. AGRICULTURE

1.1.Varieties released

Crop	*Variety*	*Year*	*Special feature*	*Station*
Rice	Mangala Mashuri	1998	Photo insensitive, tall, red kernelled, long duration variety tolerant to flood and iron toxicity.	Regional Agricultural Research Station, Pattambi
	Karuna	1998	Weakly photosensitive, tall, red kernelled, long duration variety with low fertilizer requirement.	
	Harsha	2000	Photo insensitive, semi-tall, red kernelled, short duration variety with excellent cooking quality.	
	Varsha	2002	Photo insensitive, semi-tall, red kernelled, short duration variety.	
	Swetha	2002	Photo insensitive, semi-tall, white kernelled, long duration variety resistant to gall midge and stem borer.	
	Ranjini	1996	Photo insensitive, dwarf, red kernelled, medium duration variety resistant to BPH, blast, sheath blight and sheath rot.	Rice Research Station, Moncompu
	Pavithra	1998	Photo insensitive, dwarf, red kernelled, medium duration variety resistant to BPH and gall midge biotype 5.	
	Panchami	1998	Photo insensitive, dwarf, red kernelled, medium duration variety resistant to BPH and gall midge biotype 5.	

Crop	*Variety*	*Year*	*Special feature*	*Station*
Rice	Remanika	1998	Photo insensitive, dwarf, red kernelled, short duration variety resistant to BPH.	Rice Research Station, Moncompu
	Uma	1998	Photo insensitive, dwarf, red kernelled, medium duration variety resistant to BPH and gall midge biotype 5.	
	Revathy	1998	Photo insensitive, dwarf, red kernelled, short duration variety resistant to BPH.	
	Karishma	1998	Photo insensitive, dwarf, red kernelled, medium duration variety resistant to BPH.	
	Krishna-njana	1998	Photo insensitive, dwarf, red kernelled, short duration variety resistant to BPH.	
	Gouri	2002	Photo insensitive, semi-tall, red kernelled, medium duration variety moderately resistant to major pests and diseases.	
	Makaram	1998	Photosensitive, tall, red kernelled, long duration variety tolerant to major pests and diseases.	Onattukara Regional Agricultural Research Station, Kayamkulam
	Kumbham	1998	Photosensitive, tall, red kernelled, long duration variety tolerant to major pests and diseases and lodging.	
	Chingam	2002	Photo insensitive, semi-tall, red kernelled, short duration variety suitable for dry sowing.	
	Dhanu	2002	Photosensitive, semi-tall, red kernelled, long duration variety.	

Crop	*Variety*	*Year*	*Special feature*	*Station*
Rice	Vyttila 5	1996	Photo insensitive, tall, white kernelled, medium duration variety.	Rice Research Station, Vyttila
	VTL 6	2004	Photo insensitive, semi-tall, red kernelled, medium duration variety tolerant to salinity, acidity and water stagnation.	
	Ahalya	1998	Photo insensitive, dwarf, red kernelled, short duration variety with good cooking quality.	Agricultural Research Station, Mannuthy
	Deepthi	1998	Photo insensitive, semi-tall, red kernelled, long duration variety.	Regional Agricultural Research Station, Ambalavayal
	Kunjukunju Varna	2002	Photo insensitive, semi-tall, red kernelled, short duration variety with purple leaf sheath.	College of Horticulture, Vellanikkara
	Kunjukunju Priya	2002	Photo insensitive, semi-tall, red kernelled, short duration variety.	
Vegetable crops				
Cowpea	KMV-1	1996	Trailing plants with long light green pods and reddish brown seeds and suitable for inter cropping in coconut gardens of Kuttanad.	Regional Agricultural Research Station, Kumarakom.
	Vyjayanthi	1998	Trailing plants with red coloured extra long pods and brown seeds.	College of Horticulture, Vellanikkara
	Lola	2000	Trailing plants with long light green pods and black seeds.	

Crop	*Variety*	*Year*	*Special feature*	*Station*
Cowpea	Bhagya-lakshmi	2000	Bushy, early flowering plants with light green, medium sized pods and mottled seeds and suitable for fringe cropping.	College of Horticulture, Vellanikkara
	Kairali	2000	Semi- trailing, mosaic resistant plants with pink coloured medium long pods and reddish brown seeds.	
	Anaswara	2002	Semi-trailing plants with light green, medium long pods and cream, bold seeds.	
	Varun	2002	Semi-trailing plants with pink coloured long pods and purple brown plumpy seeds.	
Bitter gourd	Preethi	1996	White, spiny medium long fruits.	College of Horticulture, Vellanikkara
	Priyanka	1996	White, large spindle shaped fruits with smooth spines, thick flesh and less seeds.	Sugarcane Research Station, Thiruvalla
Snake gourd	Kaumudi	1996	White, long and stout fruits.	Sugarcane Research Station, Thiruvalla
	Baby	2002	Small white fruits.	College of Horticulture, Vellanikkara
	Manusree	2004	Early variety with medium long white fruits, suitable for summer rice fallows	Agricultural Research Station, Mannuthy
Brinjal	Swetha	1997	Bushy, early maturing bacterial wilt resistant variety with white, medium to long fruits	College of Horticulture, Vellanikkara

Crop	*Variety*	*Year*	*Special feature*	*Station*
Brinjal	Haritha	1998	Spreading, long duration bacterial wilt resistant variety with light green, long and fleshy fruits.	College of Horticulture, Vellanikkara
	Neelima (Hybrid)	1998	Spreading, long duration bacterial wilt resistant hybrid with large, oval to round, glossy violet fruits.	
Tomato	Mukthi	1998	Determinate, bacterial wilt resistant plants with round medium sized white fruits.	College of Horticulture, Vellanikkara
	Anagha	2002	Semi-determinate, bacterial wilt resistant plants with round medium sized white fruits.	
Pumpkin	Suvarna	1998	Medium sized, flattened fruits with thick, orange flesh.	College of Horticulture, Vellanikkara
	Saras	2002	Medium sized, elongated fruits with thick, orange flesh.	
	Sooraj	2002	Medium sized, globular fruits with thick, orange flesh.	
Oriental Pickling Melon	Soubhagya	1998	Less spreading, early variety with small to medium sized, oblong, golden yellow fruits.	College of Horticulture, Vellanikkara
	Mudicode	2000	Long, oval, golden yellow fruits.	
	Arunima	2000	Trailing plants with large, cylindrical, orange yellow fruits.	Regional Agricultural Research Station, Pilicode
Bhindi	Susthira	2002	Long duration variety with light green fruits and resistant to YVMV.	College of Horticulture, Vellanikkara
Ash gourd	KAU Local	2000	Medium sized oval to oblong fruits with high flesh thickness.	College of Horticulture, Vellanikkara
	Indu	2000	Medium sized, round fruits.	Regional Agricultural Research Station, Pattambi

Crop	*Variety*	*Year*	*Special feature*	*Station*
Chilli	Ujwala	2000	Determinate, bushy, bacterial wilt resistant plants with erect, highly pungent fruits in clusters of 8-10.	College of Horticulture, Vellanikkara
	Anugraha	2002	Short, spreading, bacterial wilt resistant plants with light green, long pendant, medium pungent fruits.	
Ridge gourd	Haritham	2000	Plants with broad leaves and large sized fruits with typical ridges and tapering towards the base.	Regional Agricultural Research Station,Pilicode
	Deepthi	2004	Medium duration, mosaic resistant variety with ovate leaves and medium sized fruits having finely wrinkled surface.	College of Horticulture, Vellanikkara
Winged bean	Revathy	2000	Pole type, photosensitive, short day plants with medium sized fruits and dark brown seeds.	College of Horticulture, Vellanikkara
Amaran-thus	Mohini	2002	Medium branching, thick green stem with red colour at basal parts and dark green leaves.	College of Horticulture, Vellanikkara
Ivy gourd	Sulabha	2004	Perennial plants with three lobed leaves and long, pale green fruits having continuous striations.	College of Horticulture, Vellanikkara
Sugar and Tuber crops				
Sugar-cane	Madhurima	1996	Mid-late variety with purple, erect cane.	Sugarcane Research Station, Thiruvalla
	Madhu-mathi	1998	Reddish, erect cane resistant to red rot disease and with high sugar content.	
Cassava	Kalpaka	1996	Short duration, non-branching variety suitable for intercropping in coconut gardens of Kuttanad	Regional Agricultural Research Station, Kumarakom

Crop	*Variety*	*Year*	*Special feature*	*Station*
	Vellayani Hraswa	2002	Dwarf, branching, short duration variety with very good cooking quality.	College of Agriculture, Vellayani
Greater yam	Indu	1998	Shade tolerant variety with digitate tubers at a shallow depth.	Regional Agricultural Research Station, Kumarakom
Coleus	Nidhi	2000	High yielding, short duration variety with large sized tubers having good cooking quality.	Regional Agricultural Research Station, Pattambi
Fruit crops				
Banana	BRS -1	1998	Medium duration variety with medium sized fruits; highly resistant to sigatoka leaf spot and Panama wilt and resistant to rhizome weevil and pseudostem borer.	Banana Research Station, Kannara
	BRS -2	1998	Plants with purple mid rib and medium sized bunches having short, plump, bottle necked, medium sized fruits.	
Pineapple	Amritha	2004	Medium sized plants with golden yellow fruits rich in aroma, high TSS and low acidity.	Pineapple Research Centre, Vellanikkara
Spices and Plantation Crops				
Pepper	Panniyur-5	1996	Purple-pigmented shoot tip with oval leaves.	Pepper Research Station, Panniyur
	Panniyur-6	2000	Faint pink shoot tip and bold attractive berries.	
	Panniyur-7	2000	Hardy variety with purple-pigmented shoot tip, cordate leaves with wavy margin and long straight spikes.	

Crop	*Variety*	*Year*	*Special feature*	*Station*
Carda-mom	PV- 2	2002	A vazhuka variety with long, bold capsules and high dry pod recovery. Dried capsules are ovoid to elliptical with parrot green colour.	Cardamom Research Station, Pampadumpara
Turmeric	Kanthi	1996	Medium duration variety with medium bold fingers having closer internodes and high curcumin content.	College of Horticulture, Vellanikkara
	Sobha	1996	Big mother rhizomes, bold fingers having closer internodes, more tertiary rhizomes and high curcumin and oleoresin content.	
	Sona	2002	Medium duration variety with orange yellow, medium bold rhizomes having high curcumin content and no tertiary fingers.	
	Varna	2002	Tall plant with long and broad leaves; bright orange yellow rhizome with tertiary fingers.	
Cinnamon	Sugandhini	2000	Semi-compact canopy, medium to large leaves with purple coloured new flush.	Aromatic and Medicinal Plant Research Station, Odakkali
Cashew	Dharasree	1996	Moderately spreading trees with yellowish pink apples and bold nuts.	Cashew Research Station, Anakkayam
	Sulabha	1996	Moderately spreading trees with orange apples and export grade nuts.	
	Anagha	1998	Compact canopy, orange red apples and export grade nuts.	
	Akshaya	1998	Compact canopy and yellow apples.	
	Priyanka	1996	Spreading canopy and Jumbo nuts.	Cashew Research Station, Madakkathara

Crop	*Variety*	*Year*	*Special feature*	*Station*
Cashew	Amrutha	1998	Spreading canopy, yellow apples and export grade nuts.	Cashew Research Station, Madakkathara
	Damodar	2002	Golden yellow apples and export grade nuts.	
	Raghav	2002	Golden yellow apples and export grade nuts.	
Cocoa	CCRP 1	1998	Medium pods with light constriction at the base, small blunt beak at the tip and moderately deep ridges and furrows.	College of Horticulture, Vellanikkara
	CCRP 4	1998	Large, purple, beaked pods with deep ridges and furrows and high bean weight.	
	CCRP 5	1998	Large, elliptical pods with moderately deep ridges and furrows.	
	CCRP 6	1998	Very big, almost elliptical pods with shallow ridges and furrows.	
	CCRP 7	1998	Large, elongated, beaked pods with moderately deep ridges and furrows.	
	CCRP 2	2000	Smooth, large sized, almost spherical pods.	
	CCRP 3	2000	Large number of medium sized, elliptic pods having moderate ridges and furrows.	
	CCRP 8	2002	Hybrid with very vigorous growth and medium pods.	
	CCRP 9	2002	Hybrid with very vigorous growth and medium pods.	
	CCRP 10	2002	Hybrid with very vigorous growth and medium pods.	
Pulses and Oilseeds				
Cowpea	Shubra	2000	Suitable for summer rice fallows.	College of Agriculture, Vellayani

Crop	*Variety*	*Year*	*Special feature*	*Station*
Black gram	Sumanjana	2000	Suitable for summer rice fallows.	College of Agriculture, Vellayani
Sesame	Thilathara	1998	High yielding variety.	Onattukara Regional Agricultural Research Station, Kayamkulam
	Thilarani	2002	Semi-tall, early maturing variety with dark brown seeds and suitable for summer rice fallows.	
Ground-nut	Sneha	1998	High yielding, short duration variety with medium sized pods having prominent beak.	College of Agriculture, Vellayani
	Snigdha	1998	High yielding, short duration variety with medium sized pods having prominent beak.	
Medicinal and Aromatic Plants				
Long pepper	Viswam	1996	High yielding, medium duration variety with prolonged flowering phase, stout and short spikes.	College of Horticulture, Vellanikkara
Kacho-lam	Kasthuri	2002	Robust plants with more number of leaves, which are larger in size and light brown rhizomes.	College of Horticulture, Vellanikkara
	Rajani	2002	Leaves fewer in number and small in size. Rhizomes are creamy white and more in number.	
Mush-room	Ananthan	1996	High yielding, pest and disease resistant, short duration variety with milky white sporocarp.	College of Agriculture, Vellayani

Harsha

Panchami

Uma

VTL-6

Vyjayanthi

Bhagyalakshmi

Preethi

Baby

Haritha

Anagha

Sooraj

Indu

Susthira

Anugraha

Sulabha

Deepthi

Madhumathi

Vellayani Hraswa

Nidhi

BRS-1

BRS-2

Amritha

Panniyur-7

PV-2

Sona

Varna

Damodar

Raghav

CCRP-8

CCRP-9

CCRP-10

Thilarani

Kasthuri

1.2.Technologies developed

1.2.1.Crop improvement

Rice

- Pusa Basmati – 1 and IET 12606 are found suitable for Wayanad.
- In the farm trials conducted at Palakkad with rice hybrids, KAURH-2 recorded maximum yield of 8500 kg/ha.
- Two short duration cultures *viz.*, M 75-34-1 (M 66 B 45-1/TN) and M 86-148-1 (CR 266-407-4, MO 6) and two medium duration cultures *viz.*, M 71-4-1 (Mahaveera MO 5) and M 75-26-1-1 (M66 B 45-1/TNI) performed better in MLT compared to the check variety Jyothi at RRS Moncompu. These cultures were resistant to GSV & RTV under lab screening.
- Three cultures OM 2, OM 3 and OM 4 evolved for tall high yielding rice variety were resistant to salinity and flood in Oorumundakan tract of Onattukara.
- Two cultures *viz.*, CIRJ-7 and CIRJ-9 from R.R.S. Vyttila showed good performance in yield.
- A promising dwarf photoperiod sensitive rice culture, Cul. 20-D1, a mutant of Chitteni (Ptb- 20) was found to be the third best entry in national testing trials.
- Cul. C3-2 –KM has shown consistency in yield compared to traditional first crop component *viz.*, Chenkayama in the Kootumundakan system of cultivation.
- Njavara genotypes had wide variations with respect to qualitative and quantitative characters. The maximum range being in spikelet awning, lemma and palea colour, brown rice colour, duration, grain yield and straw yield. The extra short duration nature of the Njavara cultivar makes it ideal for cultivation in drought prone areas and as a donor parent for evolving extra short duration high yielding rice varieties.
- Multilocational trials showed that the high yielding, disease resistant cultures, KAUM 87-5 and KAUM 95-1 were on par with Jyothi and outyielded KAUM 87-1 during Kharif season.
- MLT with short duration cultures indicated that the cultures, KAUM Mo 108-262-1 and KAUM Mo 870 KR were on par with Jyothi and superior to KAUM MO 103- 104- 1 and KAUM MO 610KR during Kharif season. The straw yield from the culture KAUM Mo 108-262-1 was the highest and the other cultures and the variety Jyothi were on par.
- K_{18} rice culture was the best among the varieties tested in Kari soils under subsurface drainage conditions.

Coconut

- Among the 51 steady yielding cultivars of coconut, Andaman Giant and Philippines ordinary out yielded the other cultivars by producing 15.13 kg and 17.96 kg copra per palm per year respectively.
- A unique germplasm of coconut consisting of 40 indigenous and 35 exotic cultivars is maintained at Pilicode
- KAU maintains the first ever planted coconut hybrid in the world, planted during the year 1936.
- Among the 15 new introductions in coconut germplasm planted during 1976, the cultivar Seychelles was found to be promising and recommended for release by XXV zonal workshop.
- The hybrid WCT x CGD ranked top in all the four locations in cumulative nut production and was on par with Kerasree.
- The annual nut production was the highest in the hybrid COD x WCT followed by WCT x COD and LO x GB. In general, the hybrids were superior to WCT and other varieties in nut yield.
- Screening coconut cultivars for tender nut purpose showed that the quantity of nut water varied among the cultivars. The quantity was maximum at 180 –190 days after inflorescence emergence (DAIE). The optimum physiological maturity having maximum quality and consumer acceptance was at 210 DAIE.

Vegetables

- Shade tolerant lines of *Capsicum annuum* (CA 58), *C. frutescence* (CF 51) and *C. chinense* (CC 63) were identified to suit the homesteads of Kerala. High LAI, CGR and RGR were found as the physiological basis whereas high amount of chlorophyll, proline and total phenol content acted as the biochemical basis imparting shade tolerance.
- From twenty genotypes of bird pepper *(C. frutescens)* collected from different parts of Kerala, the genotype CF 51 was identified as the highest yielder both in shade and open.
- Genotype CA 38 of *Capsicum annuum* was identified as a high yielding superior genotype in the comparative yield trial and was proposed for release.
- Leaf blight resistance was located in amaranth lines A 22, A 26, A 29 and A 61. Green amaranth lines Amt. 105 and Amt. 237 of *Amaranthus tricolor* were identified as promising with high nutritive value and low anti-nutrient factors.

- The tomato line LE 45 was identified as superior in yield and bacterial wilt resistance in the farm trials conducted at different locations in Thiruvananthapuram, Kollam and Pathanamthitta districts.
- A yard long bean line VS 3 was identified as superior in yield and bacterial wilt resistance in the farm trial conducted at different locations in Thiruvananthapuram, Kollam and Pathanamthitta districts.
- Five superior landraces of ivy gourd have been located from Alappuzha, Kanhangad, Thirunelli, Manjeshwaram and Nangikadappuram through genetic analysis. CG 73 was identified as high yielder and fruits have maximum length.
- Culinary melon *(Cucumis melo L.)* types *viz.*, CM 5 (Kattakada, Thiruvananthapuram) CM48 (Peria, Wayanadu) and CM6 (Aryanadu, Thiruvananthapuram) were identified as elite types with superior yield, yield attributes and tolerance to mosaic disease.
- A slicing cucumber line CS 11 superior in yield was found suitable for cultivation in Kerala.
- Breeding for mosaic resistance in bitter gourd resulted in the identification of three genotypes *viz.*, VKB 135, VKB126 and VKB 140 with field level of resistance.

Sugar and Tuber crops

- Sugarcane culture Co88017 was recommended for release as the variety Madhumathi by State Seed Sub Committee.
- Among the genotypes evaluated, cul.no.16/95 had recorded maximum cane and sugar yield.
- Performance of CoT1 1153 and CoT1 1358 was superior to other varieties under AVT (Mid late) first plant crop and recorded an average yield of 116.6 t/ha and 129.2 t/ha respectively. For AVT (Early) first plant crop, CoM 9516 was found to be superior with an average yield of 133 t/ha. CoT1 527/85 performed better under AVT ratoon and AVT first plant crop of mid-late group.
- Among the early maturing sugarcane cultures of 1998 -99 series, the overall performance of CoSi 91012 was found better than other test varieties.
- Among the midlate maturing sugarcane cultures of 1998-99 series, performance of Co.9419 was found better than other test varieties.
- Overall performance of Co 97001 was found better than other test varieties among 1999 - 2000 early maturing series.

- Among the 1999-2000 midlate series, overall performance of CoJn 86-600 was found better than other test varieties.
- Coleus entries CP-74 and CP-79 were identified as promising ones and proposed for release.
- Coleus mutants, 352 and 641 were found well adapted to different locations, such as Malappuram, Palakkad, Thrissur and Ernakulam district.
- Evolved two photoinsensitive coleus mutants, TC 9 and M 131, which have the potential of higher tuber yield of 20-25 t/ha and can be grown throughout the year.

Fruit crops

- In papaya varieties, male plants of Pusa Nanha and Pusa Dwarf yielded one specific band with primer OPA – 03. The hermaphrodite plants of Sunrise Solo and Coorg Honey dew yielded one specific band with primers OPA – 13, OPB – 04 and OPB –17.
- Based on anatomical features, the variety Vellaikolamban could be placed in low growth potential (LGP) group while Moovandan was in high growth potential (HGP) group.
- Among the exotic banana hybrid introductions evaluated FHIA 1, FHIA 3, FHIA 23, FHIA 25, TMB 5295/1, FHIA 21 and CRPB 39 were found superior in terms of bunch weight and resistance to sigatoka leaf spot.
- The first plantain based hybrid progeny resultant from the cross Nendran x Calcutta-4 was evaluated. It had a bunch weight of 13 kg with 8 hands and 90 fruits. It also exhibited very high resistance to sigatoka leaf spot.
- Established a field gene bank of 256 accessions comprising indigenous (cultivars, land races, endangered varieties and wild Musa spp.) and exotic material, which is considered as one of the best field collections of banana germplasm in the country.
- Seventeen improved hybrids and several exotic banana and plantain cultivars have been introduced through National Bureau of Plant Genetic Resources, New Delhi, and were evaluated.
- Based on the evaluation work carried out to locate superior clones, twenty cultivars belonging to different genomes were identified for large-scale cultivation in Kerala.

- Tissue culture plants of Dwarf Cavendish and Robusta revealed their superiority over sucker-derived plants with respect to vegetative and bunch characters.
- Tissue culture plants of banana var. Nendran proved superior to sucker derived plants in respect of growth and yield.
- Tissue-culture plants of Dwarf Cavendish, Robusta and Nendran were found superior to sucker-derived plants for higher productivity, earliness and uniformity in harvest.
- Banana varieties of AAA genome are more susceptible to nematodes. Most of the tolerant varieties belonged to AAB and AB genomes.
- Standardised the hybridisation techniques and *in vitro* propagation techniques in banana and pineapple.
- Three distinct types of pineapple var. Mauritius were identified, of which the promising type VKMS-1 with fruit characters of Kew and leaf characters of Mauritius gave fruits in 12 months.
- About 20000 seedling accessions,, 500 seedling mutants, 200 sucker mutants and 2000 in vitro mutants of pineapple are under evaluation for developing a 'dual purpose' pineapple variety.
- Papaya hybrids such as Pusa Dwarf x Coorg Honeydew, Pusa Nanha x Coorg Honey dew, Coorg Honey dew x Sunrise Solo, Sunrise Solo x Pusa Dwarf and Pusa Nanha x Pusa Dwarf were found promising for Kerala conditions.
- About 135 types of passion fruit collected from different states are under evaluation. Among them two yellow types and one purple type are found promising.

Floriculture

- Good cross compatibility was observed between different varieties of *Dendrobium*. *In vitro* mutation using low levels of gamma rays proved possible for producing mutants in Dendrobium.
- Four flowering grex combinations belonging to the sympodial orchid genus '*Dendrobium*' were registered with the Royal Horticultural Society, England. Morphological characterization – vegetative and floral - and genetic studies including heterosis for floral characters of the registered grexes were done.
- Standardised the hybridisation techniques and *in vitro* propagation techniques in orchids and bougainvilleas.

Spices and Plantation crops

- Investigations to evaluate the important cultivars of black pepper in central Kerala revealed that Karimunda is the best variety suited to Kothamangalam, Muvattupuzha, Thodupuzha and Meenachil taluks of Kerala with respect to yield and regular bearing habit. The following varieties were suggested for large-scale cultivation in the respective taluks:

Kothamangalam	-	Karimunda and Kaniyakkadan
Muvattupuzha	-	Karimunda, Chengannurkodi and Panniyur-1
Thodupuzha	-	Neelamundi, Karimunda and Kaniyakkadan
Meenachil	-	Karimunda, Jeerakamunda and Perumkody

- Multilocational trials in black pepper revealed the superiority of Panniyur 5 with 1051 g green berry/standard during the fourth year of planting. Panchami was found superior over other released varieties in Wayanad area followed by Panniyur 4 and Panniyur 5.
- Evaluation of open pollinated progeny of Kalluvally showed that the culture 1558 was high yielding with 4.20 kg fresh green berries/vine. It produced very long spikes of 19.4 cm with 133 berries/spike. The piperine content was also high (5.57%). It was a very hardy type and tolerant to adverse climatic conditions. This culture was released as Panniyur 7.
- Germplasm collection and evaluation of pepper genotypes carried out at PRS, Panniyur and College of Horticulture, Vellanikkara found that Valiyaramundi, Chendayar, TMB IV and TMB X were promising genotypes.
- In the germplasm collection, Karimunda II recorded the maximum green berry yield of 4.41kg/vine. Panniyur 4 is found to be the best variety for growing as bush pepper.
- For the first time in the history of black pepper cultivation, an amphidiploid, partly fertile, inter specific hybrid was developed through hybridization between cultivated species of black pepper and *P. colubrinum*, the wild species which is completely resistant to *Phytophthora* foot rot disease.
- In the germplasm collection of black pepper, Angamali recorded the maximum green berry yield of 4 kg / vine followed by Chendayar (2.540 kg) and Valiyaramundi (2 kg).
- One dry ginger type viz. PGS-35 and one dual-purpose ginger type V2E5-2 are recommended for farm trial.
- Ginger accession 204 and IISR-Varada were ideal for intercropping in coconut garden with high yield and tolerance to soft rot.

- Three turmeric varieties viz., VK-29, VK-31 and PCT-19 were found promising and were recommended for farm trial.
- Cinnamon types SL 203 and SL 53 recorded higher yield and found suitable for Wayanad. Maximum leaf oil of 4% was obtained in SL 44 and bark oil of 2% was obtained in SL 53.
- Two promising cashew hybrids viz., H7 and H 1593 have been proposed for release.
- The cashew varieties were grouped into 4 different clusters based on the physico chemical and nutritional composition of cashew apple. Fourteen varieties were selected for preparing candy and tutty fruity.
- Evaluation of germplasm showed that the top yielding clones of cocoa were G VI 35, G VI 44, G VI 50 and G VI. The cocoa clone G VI 35 consistently recorded the highest yield for the last thirteen-year period in the germplasm evaluation.
- In breeding depression in cocoa varied with genotype.

Pulses and Oilseeds

- Culture 502-2-2-2 was found as a superior grain cowpea for southern region in farm trials conducted in summer rice fallows.
- Cowpea variety GC-3 with a yield potential of 1955 kg/ha was found as the best variety suited to grow under moisture stress condition (IW/CPE-0.4) at Pattambi.
- Continuous evaluation of green gram germplasm from 1991 onwards has resulted in the identification of high yielding variety namely Pusa 8973 for the summer rice fallows of Onattukara region.
- The green gram hybrid IIPRM.3 X CO.2 was the best specific combiner for yield in the process of evolving high yielding and shade tolerant varieties
- Culture 4 and 15 of sesamum were found to be promising at Kayamkulam and recommended for farm trial.
- Two varieties of sesamum viz: CSGT-785 and OMT-1165 were recommended for cultivation in Onattukara in the summer rice fallows and kharif uplands respectively.
- BC6 generation developed using wild species of sesamum was found to be with abiotic stress tolerance.

Forage crops

- Two promising bajra-napier hybrids with high fodder yield and quality and one elite guinea grass with high fodder yield and adaptability for partial shade were recommended for release by the XV Zonal Research Extension Advisory Committee Meeting held at Vellayani.
- Evaluation of stylosanthes accession for yield and disease resistance for three years indicated that *Stylosanthes scabra* 9311 and *Stylosanthes seabrana* 2523 have recorded high yield as well as low anthracnose score.

Aromatic and Medicinal plants

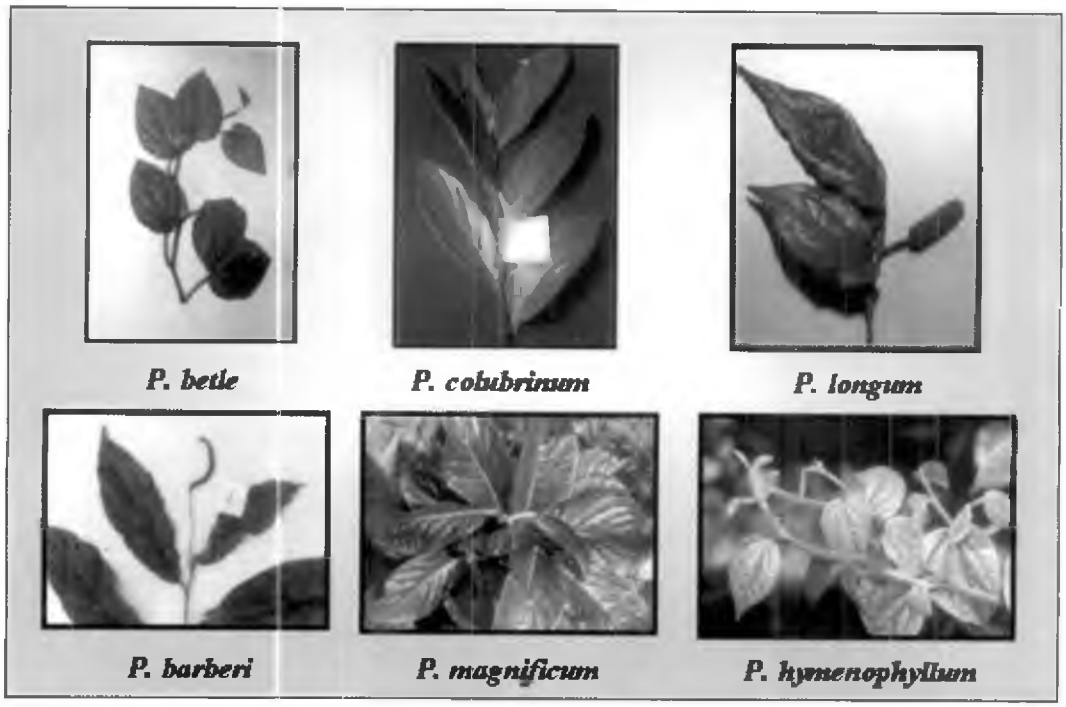
- Lemongrass accessions OD23 and OD 307 were found to be with high yield and quality oil and promising for commercial cultivation.
- More than 400 species of tropical medicinal plants that are used in ayurveda, tribal and folklore medicines as well as other indigenous systems of medicine and homeopathy are catalogued and maintained at AMPRS, Odakkali.
- Identified Ac.10 and 5 as better genotypes for higher root yield in *Plumbago rosea.*
- In *Piper longum,* Ac. 8 was found superior for spike yield whereas Ac.4 was better in terms of piperin content.

1.2.2.Crop production

Rice

- Line sowing of rice under puddled condition using the 8-row drum seeder is more advantageous for crop stand establishment and yield, over the conventional practice of broadcasting sprouted seeds and even transplanting. The grain yield was significantly higher in drum seeding and that too with a significantly lower seed rate.
- Direct seeding of rice showed increased crop stand and improved yield levels under the pokkali ecosystem if adequate water regulation is ensured.
- Permanent manurial trial in rice conducted at RRS, Moncompu for the seventeenth year, showed that there was no response to potash in the intensive double crop rice in Kuttanad where straw recycling was practiced, whereas the response to nitrogen was 2.3 tons/ha. Skipping phosphorus reduced rice yield.
- Kasturi and Haryana Basumati recorded the highest grain yield when transplanted during the second week of October with a fertilizer dose of 90:45:67.5 kg NPK ha^{-1} with 50 per cent N as FYM and 50 per cent N as chemical fertilizer.

Hybrid rice – KAURH-2



Gene bank of Piper nigrum and related species

- Low yielding rice varieties viz., Cul 7005-6-1, 7004-3-1 and 7004-2-1 showed increased yield in Onattukara soils at potassium doses (22.5 kg K_2O/ha) which was less than package of practices recommendations.
- Analysis of the available sulphur content of more than 800 samples collected from 22 villages in Thrissur and Palakkad districts of Kerala, revealed that sulphur status is low in 70% of the area and medium in remaining 30% area. Application of Sulphur at the rate of 15 kg ha^{-1} along with the recommended N, P&K level was sufficient for realizing higher yield from rice in soils low in S content. Application of S also improved the straw yield.
- The long-term study of zinc management in irrigated rice based cropping system showed that the residual effect of soil applied zinc lasts for more than three years.
- Micronutrient status study of Kuttanad soils showed zinc deficiency in Karuvatta, Pallippad, Thottappaly and Purakkad soil series, copper deficiency in Manjoor, Mannar and Muthur and the combined deficiency of zinc and copper in the soil series of Thakazhy, Ambalapuzha, Changanacherry, Vechoor and Kurichi. The available zinc status was adequate (ie. more than 0.5 ppm DTPA extractable zinc) in the Champakulam, Ramankari, Edathua, Mannar and Muthur series. The available copper status was adequate (ie. more than 0.2 ppm DTPA extractable copper) in the Karuvatta, Pallippad, Ramankari and Edathua series. The iron and manganese content was high in all the series.
- The profitability of zinc sulphate application in zinc deficient soils @ 25kg Zn SO_4/ha is high due to the residual (carry over) benefits of a single application to succeeding crops. It will last for 8 to9 years and hence soil application of zinc is not required for every season.
- Magnesium can be recommended for rice in the form of magnesium sulphate (16% MgO) or magnesite (40% MgO) or dolomite (10%MgO) @ 20 Kg MgO per hectare. On per unit MgO basis, magnesite application was cheaper than magnesium sulphate and dolomite.
- Field experiments in rice reveal that yield of 4-5 t/ha could be obtained under single cropped high fertile Pokkali area without any additional fertilizers.
- Soaking seeds in Penshibao + Azospirillum, foliar spray with Penshibao at 20 and 30 DAT improved almost all growth characters and grain yield in rice.
- The low yield of rice from laterite soils was found to be not only due to nutrient deficiency alone but also due to nutritional constraints from excesses, imbalances or metabolic unavailability of elements.

- On farm trials conducted at 1142 units in command areas of ten irrigation projects throughout Kerala revealed that higher levels of potassium (120 kg ha-1) and silica (sodium silicate 250 kg ha-1) along with normal production practices can curtail the ill effects of iron and manganese and improve the yield of rice substantially in laterite soils.
- Amelioration with ash and lime at 300 kg.ha^{-1} each with subsequent change in the N: K ratio to 1:1 enhanced productivity of rice in green-manured laterite soil with a benefit cost ratio of 2.25.
- Substitution of a major quantity of inorganic fertilizers is possible by the use of organic manures. However, considering the mineralization patterns, a better option would be a combined use of inorganic and organic manures. Incorporation of organic manure can be carried out along with final ploughing for reducing the cost of cultivation.
- Substitution of either 25 percent or 50 percent Recommended Dose of Fertilizers (RDF) with organics during kharif season is beneficial for sequential cropping of rice. Skipping phosphorus continuously for years significantly reduced crop growth and yield in rice.
- Compaction of coarse textured soil along with application of coir pith improved physical properties of soil and yield of rice in Onattukkara soils. Vermicompost @ 2.5 t/ha can substitute FYM @ 5t/ha
- Summer rice fallows could be profitably used for taking up a vegetable or green manure crop depending on the availability of irrigation water. Bhindi was the most profitable vegetable crop in the summer rice fallows at Karamana. If the crop growth period is more than 120 days a short duration cassava can also be taken. This type of crop intensification reduced the weed population and enhanced subsequent rice yields.
- Maximum net return from upland rice was obtained by application of 90 kg ha^{-1} nitrogen, 50 per cent of which was substituted with farmyard manure. However, the benefit-cost ratio was maximum when 35 per cent of nitrogen was applied as farmyard manure.
- Nutrient management of upland rice varieties in coconut garden revealed that among the varieties, Harsha and Mattatriveni performed better under partial shade situations. Benefit cost ratio for upland rice was maximum at 80 kg N ha^{-1} and 45 kg K_2O ha^{-1} along with the recommended dose of 30 kg P_2O_5 ha^{-1}.
- Upland rice intercropped with cowpea in 2:1 proportion can be recommended as an economically viable, biologically suitable and sustainable intercropping system for the kharif season.

- Studies on rice cultivation exclusively with organic inputs revealed no significant difference in pest damage due to leaffolder, planthopper and rice bug. Grain yield in organic farming was on par with conventional farming.
- Mechanical transplanting of paddy can be adopted for economic production of rice with low labour input and cost.

Coconut

- KAU has developed technology to store coconut inflorescence sap for one year under ambient condition.
- Seasonal variation in coconut neera yield was noticed and the highest yield was recorded during the month of July followed by June.
- Maximum volume of tender nut water was found at 190 days after inflorescence emergence whereas sugars, reducing sugars, ascorbic acid and potassium were found maximum at 210 DAIE.
- Long term fertilizer experiments conducted at Balaramapuram have shown that in the absence of potash, nitrogen application had antagonistic effect on coconut.

Vegetables

- The ideal spacing for bittergourd and snakegourd was found to be 2m x 2m. The optimum fertilser schedule was to the tune of 100 percent and 150 percent of the recommended dose of NPK respectively in riverine alluvium.
- A basal dose of 25 t ha^{-1} of FYM and application of poultry manure to supply the recommended dose of 75 kg N ha^{-1} was the best economic organic nutrient schedule for bittergourd.
- Drip irrigation @ 1.5 l day^{-1} pit^{-1} with 35:12.5:12.5 kg NPK ha^{-1} gave higher yield in bitter gourd var. Priya.
- Bubbler method of irrigation at 50, 75 and 100 per cent Eo was superior to drip irrigation at similar levels both in terms of water economy and yield of bittergourd in the sandy soils of Chalakudy.
- Maturity periods of 24, 33 and 16 days after anthesis were found optimum to harvest the fruits for seed purpose in bittergourd (Preethi), melon (Mudicode) and in yard long bean (Lola) respectively.
- Application of nutrients as 50% neem cake and 50% chemical fertilizers was ideal for getting higher marketable yield in brinjal. Among organic manures, poultry manure registered the highest marketable yield and returns.

- Application of poultry manure equivalent to 100 kg N/ha produced maximum plant height, yield and mucilage content in okra. Vermicompost application equivalent to 75 kg N per ha resulted in more starch content.
- Vermicompost as organic source along with full-recommended dose of inorganic fertilizers produced 105 per cent more yield than POP recommendation in summer bhindi. For the monsoon season, the same treatment recorded 43 per cent increase in yield.
- Integrated plant nutrient studies with different organic mannures and recommended dose of chemical fertilizers in bhindi revealed that 12.5t ha^{-1} of vermicompost along with 75% recommended dose of fertilizer gave maximum yield in the laterite soil of Velloor watershed in Kottayam.
- Performance of bacterial wilt tolerant tomato (*Lycopersicon esculentum* Mill.) genotype LE45 & LE34 under shade revealed that tomato can be grown under mild shade of 25 per cent.
- Drip irrigation @ 3 l $plant^{-1}$ day^{-1} gave the highest fruit yield and benefit-cost ratio in culinary melon.
- A basal dose of 25t ha^{-1} of FYM and application of poultry manure or glyricidia or vermicompost or neem cake to supply the recommended dose of 75 kg N ha^{-1} (on N equivalent basis) in combination with Azospirillum @ 1 kg $ha^{-1}$was the best economic organic nutrient schedule in chilli. Vermicompost applied treatments recorded the highest keeping quality of fruits.
- Under rain shelter, capsicum produced three to five fold higher yield with assured quality and reduced the incidence of bacterial wilt and stem rot diseases. However, the attack of mites and fruit borer and the diseases like blight and anthracnose were found more.
- Gherkin *(Cucumis sativus L.)* produced maximum marketable fruits and marketable yield under pandal system of planting with a population of 5333 plants/ha.
- Sustainable nutritional practices for bittergourd-amaranthus intercropping system revealed a markedly higher per plant and total yield of fruit due to combined application of poultry manure and chemical fertilizers. Vermicompost application registered maximum keeping quality of fruits, ascorbic acid, and iron content. B: C ratio and net profit were higher when chemical fertilizer was substituted with poultry manure in 1:1 ratio.
- A basal dose of 50t ha^{-1} (N equivalent basis) in combination with Azospirillum @1kg ha^{-1} was the best economic organic nutrient schedule for increasing the productivity and quality of amaranthus.

- Dual inoculation of amaranth (*Amaranthus tricolor* L.) with *Azospirillum* and arbuscular mycorrhiza along with the application of chemical fertilizers at the rate of 75 per cent of the POP recommendation (NPK @ 50:50:50) and the use of organic manure either as FYM or vermicompost (@ 50 t/ha) resulted in marked increase in yield and quality of amaranth under field conditions.

Sugar and Tuber crops

- Application of full dose of N along with pressmud 2.0 t/ha or 75 per cent N along with pressmud and *Azotobacter* @ 4.0 t and 5.0 kg per ha respectively are effective in increasing the yield of sugarcane.
- Double row planting at 30:60 cm registered the highest cane yield and sugar yield.
- Among the early groups, Co93028 was found to be promising and it required NPK at 165:82.5:82.5kg/ha for maximum cane growth and yield
- Application of N at 150% of recommended dose had increased the cane and sugar yield, which was on par with N application at 125% of recommended dose. The above planting has recorded highest values for CC% of the juice as well as sucrose content.
- Ethrel application at 250 ppm is sufficient for controlling the flower initiation in sugarcane and improving juice quality.
- Integration of CSPM + Biofertiliser or FYM + Biofertiliser along with mineral nutrition at 75% of recommended dose of NPK sustains the productivity and soil health in sugarcane cropping system.
- Cultural practices like stubble shaving, trash mulching in alternate rows, dismantling the ridges and gap filling with setts were very critical for enhancing the cane and sugar yield of ratoon crop of sugarcane.
- The short duration cassava varieties when grown under low lands, needed application of FYM @ 12.5t/ha or poultry manure @ 5t/ha along with 75:50:100 kg NPK/ha.
- The present recommended dose of NPK for cassava can be reduced upto 50% (25:25:25kg./ha.) if khondolite @ 1 ton ha^{-1} and FYM @ 12.5 tons ha^{-1} are applied along with chemical fertilizer. Full substitution of chemical fertilizers with khondolite is possible when the katter is applied at a the rate of 2 tons $ha.^{-1}$
- Substitution upto 50 per cent of potassium of MOP by Na as common salt was found to increase the tuber yield in cassava to the tune of thirty one per cent as compared to MOP alone. Tuber quality improved considerably. Shelf life of tubers in moist soil could be extended upto one month.

- Use of vermicompost either as a seed inoculant or as an organic source resulted in better biometric characters and yield of tapioca.
- Soil application of bio-fertilizers *viz*, azospirillum and VAM mixed with small quantity of cowdung recorded good yield of cassava.
- White yam (*Dioscorea rotundata*) var. Sree Priya was found to be a profitable intercrop in coconut garden. The optimum size of planting material was 200 g. with a spacing of 90x90 cm and NPK recommendation of 80:60:80kg/ha. FYM (10t/ha) could be substituted with either coir pith compost @ 5 t/ha or by the *in situ* incorporation of green manure (sunhemp).

Fruit crops

- In a monthly planting experiment in banana, planting during November to July was found to be the best, with respect to yield.
- Spacing of 1.2 x 1.5 x 2.0 m accommodating 4,761 plants per hectare is feasible for realizing the highest net returns in Nendran and Palayankodan, as against the conventional spacing of 2.0 x 2.0 m, with 2,500 plants per hectare.
- The trial on high-density planting and sucker arrangement in banana revealed that in both Nendran and Robusta, planting of three suckers per pit spaced at 2 x 3 m (1,667 pits x 3 = 5,001 plants /ha) was the best treatment with higher B:C ratio.
- Shallow planting and spraying Ethrel 350 mg/l at fortnightly interval resulted in more sucker production in banana cv. Nendran.
- Application of 3/4th level of the recommended dose of phosphorus along with posphobacteria, farmyard manure and mulch has produced significantly higher yield in banana var. Nendran.
- Cowpea as an inter crop in banana was found to be economical.
- Placement of 30 g urea at the cut end of the rachis, three weeks after complete emergence of the bunch increased yield in Nendran.
- Spraying of 3% potassium sulphate 2 weeks and 4 weeks after bunch emergence was found to increase the bunch weight and finger characteristics in Nendran banana. Soil application of commercial formulation of micronutrients enabled to improve bunch yield.
- In Nendran, the optimum dose of nitrogen was 200 g applied as 150g + 50 g in 4 + 3 splits. In Poovan, application of 200g N + 150 g N in 4 + 3 splits resulted in the highest bunch weight (13.8 kg). Application of nitrogen in the post-bunching period was found to be beneficial as indicated by higher bunch yield. In Palayankodan, the best treatment was 400 g N + 100 g N in 4 + 3 splits, with regard to bunch weight.

- Application of 150 g nitrogen per plant through drip increased the number of hands and fingers in banana var. Nendran. Irrigation once in three days using basin system was the most beneficial. Irrigation at 20 CPE yielded the highest bunch weight.
- Covering the bunches with polythene paper decreased bunch maturity period and increased bunch weight in banana var. Nendran. Covering the bunches immediately after initiation with blue polythene sleeves reduced the number of days from bunching to harvest. Uncovered bunches took more days to ripen. Covered bunches showed a marked improvement in bunch appearance.
- By using earthworms in situ, the application of inorganic fertilizers for Nendran could be reduced to half.
- The results of a fertilizer trial proved that for obtaining high returns, potassium application should be done in the vegetative phase.
- In Palayankodan,the highest bunch weight was obtained for 100g + 200 g K_2O in 2 + 2 splits. Application of K_2O 400 g per plant in two equal splits 60 and 120 days after planting was the best treatment for obtaining high yield (bunch weight - 13.17 kg) in banana var. Poovan.
- The optimum ratio of organic to inorganic nitrogen is 1:3 and the best source of organic N is either a combination of FYM + green leaves or FYM alone for different varieties of banana. Application of 25 per cent of nitrogen in organic and 75 per cent in inorganic form gave high bunch weight in banana var. Poovan.
- Application of a combination of bio-fertilizers (*Trichoderma harzianum* + *Azospirillum* + PSB + VAM) along with 100% recommended dose of fertilizers gave heavier bunches. Use of vermicompost either as a seed inoculant or as an organic source resulted in better biometric characters and yield of banana
- VAM inoculation was found to improve the overall growth of tissue culture plantlets of banana.
- Application of N, P and K @ 250: 250: 500 g / plant in six split doses improved growth, yield and quality of papaya.

Floriculture

- Eighty per cent shade level was found optimum for anthurium.
- Topping in *Anthurium andreanum* increased lateral shoot production. GA_3 750 mg l^{-1} in topped plants produced the highest number of lateral shoots per plant among all the treatments.

- In anthurium, the effect of nutrients on the number of days taken for the first flower to appear, interval of flower production and flower characters like size of spathe, spadix and length of stalk was significant. The plants sprayed with 20:20:40 NPK, 0.25 percent, at weekly interval were found to be performing better.
- River sand as well as coconut pith along with cow-dung was found to be the superior media for early flowering and improved floral characters in anthurium.
- In the anthurium variety Tropical, NPK @ 30:10:10 as well as NPK @ 0.2 per cent along with GA 200 ppm gave superior growth and flowering.
- Anthurium flowers harvested with 1/3rd of the true flowers opened on the spadix retained maximum longevity after harvest
- The vase life of anthurium flowers was increased by two weeks by pulsing with BA 150 ppm for 8 hours. Plugging of cut ends of flowers with BA 50 ppm also increased the vase life of flowers.
- Maximum vase life in anthurium was observed in BA 25 ppm solution followed by 50 ppm, showing the significant effect of BA in extending vase life.
- In anthurium varieties Nitta, Agnihotri, Sunset Orange, Lima and Meringue, 2 to 8 percent sucrose was found to be very efficient for pulsing.
- Anthurium flowers packed in boxes with the spathe kept in polythene sleeves and with $KMn0_4$ in boxes lasted longer without any senescence symptoms
- Standardization of techniques for quality enhanced production and value added post harvest handling in Anthurium indicated that the medium containing sand and leaf compost in the ratio 1:1 was superior to the media containing sand and coir pith compost, media containing granite and coir pith and that containing granite and leaf compost in the ratio 1:1.
- Developed protocol for post harvest handling of orchid and anthurium from harvest to the final consumer by a combination of treatments including pre-harvest nutrient management, harvesting at the correct stage of maturity, pre cooling, pulsing, plugging, waxing, packing, keeping in holding solution and storage at low temperature.
- Maximum number of spikes per year (12.98) and number of florets per spike (10.50) in *Dendrobium* 'Sonia 17' were produced by NPK 10:20:10 at 0.2 per cent weekly twice + BA 100 ppm. Spike length was significantly superior (55.40 cm) for NPK 10:20:20 at 0.2 per cent applied weekly twice + GA_3 20 ppm.

- In 'Sonia 17' the plants treated with *Azospirillum* at the time of planting and sprayed with fertilizer solution 20:10:10 @ 0.2 percent recorded earlier flowering and improved floral characters.
- In *Dendrobium* 'Sonia Bom Jo' a treatment combination of tile bits + charcoal as media improved flowering and the floral characters.
- Pulsing with warm water at 50-60°C for 5 seconds was a practically easier and economic way of enhancing vase life in *Dendrobium* 'Sonia 17'
- *Dendrobium* var. Sonia 17 flowers harvested at 1 or 2 bud stage can be kept fresh in vase upto four weeks by giving a pulsing treatment with a combination of HQ 500 ppm and 5 per cent sucrose for 12 hours and adding HQ 400 ppm, $AgNO_3$ 50 ppm and sucrose 5 per cent to the holding solution.
- In *Dendrobium* flowers plugged with BA 125 ppm and HQC 200 ppm showed the longest vase life. This could be extended from 15 days (control) to 32 days by holding in a solution containing 8 HQC 300 ppm + sucrose 6 per cent.
- In *Dendrobium* studies conducted using $_{32}P$ revealed that translocation occurred from back bulb to younger shoots.
- In gladiolus, treatment of the corm with GA3 (50 and 100 mg/l) and Ethrel 200 mg/l produced early sprouts and application of paclobutrazal induced reduction in height of plants.
- The monthly planting studies in tuberose revealed that the best planting time was March/April and October/November.
- Nutritional studies in tuberose indicated that nitrogen application brought about early flowering and at higher rates, produced maximum spike length and number of florets.
- Spikes of tuberose kept in $AgNo_3$ 40 mg/l HQ 40 mg/l solution after pulsing with $ZnSO_4$ 7.5 nM for 6 hours recorded maximum vase life (10.5 days).
- Tuberose spikes kept in $AgNo_3$ 25 ppm + sucrose 2 per cent as well as in citric acid 300 ppm + sucrose 2 per cent gave good vase life.
- Techniques of dehydration of flowers of rose, carnation, gerbera, golden rod, zinnia, aster, globe amaranth and various grasses and tree species were standardized.
- The technique for preserving foliage by different methods, *viz.* airdrying, microwave oven drying, press drying, skeltonizing, and glycerining were also developed.

- Vase life studies on cut flowers of *Arachnis* Maggie Oei 'Red Ribbon' showed that the stages of development of the inflorescence at harvest influenced the percentage of bud opening during the vase life period. Inflorescences having more number of opened flowers and less number of unopened buds (2 nos.) at harvest recorded greater bud opening (71.92 %) on the 6th day of vase life.
- Gamma radiation was found to be effective in increasing vase life of cut flowers.

Spices and Plantation crops

- Dipping of pepper cuttings in culture solution of *Trichoderma harzianum* recorded minimum rotting in the nursery (3.0 per cent) followed by dipping in *T. viride* (4.5 per cent) and spraying and drenching with one per cent BM (13 per cent).
- Substitution of 50 per cent of the recommended inorganic fertilizer dose with FYM on equivalent N basis and the remaining 50 per cent of the dose met through inorganic N and P recorded the highest yield in pepper.
- Input use in pepper can be reduced by 50% in respect of mineral fertilizers and lime without sacrificing yield, either by growing cowpea in the interspace and basins or by applying composite cultures of *Azospirillum, Phosphobacterium* and VAM.
- Pepper plants irrigated @ 10 litres per vine per week by basin method up to March showed 48 per cent enhancement in dry yield per vine compared to un-irrigated plants.
- Studies on the influence of soil moisture regimes on growth and yield of bush pepper showed that among the varieties studied, Panniyur 5 possessed morphological, physiological, biochemical and anatomical adaptations to tolerate water stress and Panniyur 1 has the poorest adaptations. Irrigation may be scheduled for field grown bush pepper considering the root zone as 30 cm around and 60 cm deep from the plant and the optimum depletion of available moisture as 50%. Drip irrigation @ 8 l/day from Oct-May was better in bush pepper than pot watering @ 10 l/day/plant.
- Morphological, physiological, biochemical and anatomical character studies showed that varieties Poonjarmunda, Panniyur 5 and Padarpan are water stress tolerant, Kalluvally, Uthirankotta and Kumbakodi are moderately tolerant and Panniyur 1 as sensitive.
- The active root zone of bush pepper for irrigation and fertilizer application is at 30 cm radius and 40 cm depth from the base of the plant.

- Optimum percentage of allowable depletion of soil moisture for irrigating bush pepper is 50 per cent.
- Panniyur 4 is the most suitable variety among Panniyur varieties for growing as bush pepper.
- Drip irrigation @ 2 litres/ day/ vine from January-April contributed more towards spike number, green berry yield and spike length of pepper.
- Irrigating the vines at IW / CPE ratio of 0.25 (@100 l /vine) from December to March at an interval of 8-10 days increased pepper yield substantially.
- Reported the occurrence of somaclonal variations in pepper with respect to phytophthora foot rot disease for the first time in the world.
- Supply of *Azospirillum* @ 2.5 kg/ha along with 75 per cent N and full P and K recorded a dry ginger yield of 4.1 t/ha with an increase of 16.94 per cent over the control.
- Neem cake was effective in reducing the incidence of soft rot disease in ginger.
- In ginger, the cultivar Ernadan was found to give consistently good yield with lesser incidence of bacterial wilt. Field trials conducted during the last three years have revealed that application of neem 1.0 t/ha 45 days after planting significantly reduced the nematode population and increased the yield in ginger.
- A fertilizer schedule of 100:100:175 kg NPK ha^{-1} gave highest number of panicles and yield in cardamom. Neem cake application had not much influence on yield.
- Treatment of cardamom with Azospirillum was found to improve number of tillers, plant height, number panicles and yield.
- Side grafting and softwood grafting on garcinia rootstock were found to be the successful vegetative propagation methods in garcinia giving 90.0 per cent and 82.5 per cent success, respectively. Seeds sown after removing seed coat gave 83 per cent germination on the 25^{th} day after sowing.
- The application of nitrogen @ 1kg per tree significantly increased the tree height, canopy spread, number of flushes per m^2 and nut yield in cashew. Phosphorous application at 250 g per tree reduced the number of days to flowering and improved the ascorbic acid content of the apple and protein content of kernels. Potassium application at 250 g per tree resulted in improving the kernel weight and apple yield.
- Irrigation was found to significantly influence the nut yield of cashew.

- A procedure for topworking in cocoa was standardised which is used for the rejuvenation of old and unproductive trees. Top worked cocoa trees registered yield decline after a very high yield during the initial years.
- The results of studies on crop weather relations of cocoa showed that the pod yield is highly sensitive to environmental factors. A decline (39%) in annual yield was noticed during 2004 due to severe drought during 2003.
- Budded plants of cocoa were low yielders when compared to mother plants.
- Standardised the in-situ budding technique in nutmeg and modified forkert budding technique in cocoa.
- The influence of seedling height and girth on yield characters of cocoa was more pronounced in the case of seedlings one year after sowing than with those of 4 MAS, 5 MAS and 6 MAS. The vegetative vigour measured by the height and diameter of the trunk was found to be better correlated with precocity.

Pulses and Oilseeds

- Among the varieties, Kanakamani was found to be the best for summer rice fallows as it produced a comparatively stable yield followed by GC-3 and V-240.
- Seed yield in cowpea was significantly influenced by irrigation levels and frequent irrigation level of IW/CPE = 0.8 recorded higher yield compared to lower level.
- The yield of cowpea as well as blackgram in acid soil regions was significantly influenced due to liming. Application of 50% NPK+ lime + FYM recorded the highest yield.
- Use of vermicompost either as a seed inoculant or as an organic source resulted in better biometric characters and yield of cowpea.
- Seed treatment with Rhizobium and soil application of phosphobacteria (20/pit) along with 75% recommended dose of N, P_2O_5 and full K as per POP recorded the highest yield in cowpea.
- Soaking of cowpea seeds in 500 ppm thiourea followed by two sprays (500 ppm) at vegetative and flowering stages increased the yield of cowpea by 26 per cent and net return by 50 per cent.
- The seed coat thickness was found to be a major factor in providing resistance to bruchid attacks in cowpea. Genotypes having bruchid resistance could be effectively utilized in recombination breeding programme for producing hybrid derivatives possessing both bruchid resistance and high yield.

- In sesame, application of NPK 40:30:20 kg / ha along with Zn SO_4 15 kg/ha and NPK @ 40:30:20 kg/ha along with $ZnSO_4$ 15 kg/ha + organic matter 1 ton/ha recorded the highest seed yield of 486 and 484 kg/ha respectively.
- Application of 50% N in the organic form (FYM) and the remaining 50% N and full P&K as inorganic fertilizers recorded the highest yield of sesame.

Forage crops

- Application of FYM 10 t ha^{-1} significantly improved the fodder yield of guinea grass in the first two years whereas FYM 10 t ha^{-1} or vermicompost 5 t ha^{-1} were equally effective in the third year along with the application of 100 per cent recommended fertilizers. The biofertilizers did not influence the yield.
- Guinea grass *(Panicum maximum J.)* variety Hamil was a high yielder in open and shaded conditions. Application of potassium @150 kg ha^{-1} significantly increased the yield and uptake of potassium under shade. Economic yield was obtained in shade intensities upto 50 percent.
- The fodder production potential of hybrid napier was higher by the application of 75 per cent recommended fertilizer dose along with 10 t ha^{-1} of vermicompost. This treatment also improved the water holding capacity, porosity, available nitrogen phosphorus and potassium content of soil after the experiment.
- Guinea grass and gamba grass recorded the highest green (117.17 and 121.14 t ha^{-1}) and dry fodder (50.26 and 50.73 t ha^{-1}) yields when irrigated at 30 mm CPE and 40 mm CPE.
- Application of 150:30:150 kg NPK ha^{-1} produced the highest fodder yield and 200:30:150 kg NPK ha^{-1} produced the highest seed yield in signal grass. Seed collection after two cuts of fodder was found to yield the maximum seed yield.
- The seed yield of signal grass (*Brachiaria decumbens*) was the highest when potassium @ 150 kg ha^{-1} was applied.
- Application of FYM, vermicompost or glyricidia leaves @ 5 t ha^{-1} along with 100 percent recommended dose of fertilizers (150:50:50 kg NPK ha^{-1}) recorded the highest fodder yield in congosignal *(Brachiaria ruziziensis)*.
- Irrigating congosignal grass at 45 mm CPE produced highest fodder yield and B: C ratio. For obtaining optimum fodder yield, congosignal requires 5t ha^{-1} of FYM and 100% of the fertilizers as per the package of practices recommendations (150:50:50kg NPK ha^{-1}).
- The fodder legumes, viz., cowpea and dolichos bean are good intercrops for hybrid napier and 75 per cent of the recommended fertilizer dose for the sole crops is sufficient for the hybrid napier- legume combination.

- The highest green fodder yield, dry fodder yield, crude protein content and lowest crude fibre content were obtained when hybrid napier variety CO-2 were grown under paired row along with a lablab bean as the intercrop and supplemented with 100 per cent nitrogen.
- *Stylosanthes hamata* was found to be the best perennial legume and cowpea the best annual legume for intercropping in hybrid napier cv. CO-2
- Silver leaf desmodium *(Desmodium uncinatum)* and pigeonpea *(Cajanus cajan)* are ideal intercrops for signal grass (*Brachiaria decumbens*) and gamba grass (*Andropogon gayanus*). The protein yield was the highest for the combination of gamba + desmanthes *(Desmanthus virgatus).*
- In a fodder maize-cowpea intercropping system, fertilizer dose of the component crops could be reduced to 50 per cent using bioinoculants, *viz.* VAM for maize and *Rhizobium* for cowpea.
- Application of organic manures, viz. FYM or vermicompost @ 5 t ha^{-1} along with a fertilizer dose of 20:80:30 kg NPK/ha and inoculation of seeds with rhizobium culture resulted in significantly higher fodder yield of legumes, *viz.*, pigeon pea *(Cajanus cajan)* and cowpea *(Vigna unguiculata).*
- In summer rice fallows, application of 5 t ha^{-1} of vermicompost and 100 percent of chemical fertilizers as per package of practices recommendation recorded highest green fodder and dry fodder yield in fodder bajra, fodder sorghum, *Sesbania rostrata* and fodder cowpea.
- Intercropping fodder maize and fodder cowpea in 3:1 combination yielded maximum green and dry fodder yield under rainfed conditions.
- The fodder cereal and legume combinations, maize + cowpea and fodder bajra + fodder cowpea were found to be performing well in rice fallows.
- Suitability of forage grasses in Veroor, watershed showed that gamba grass thrived well without irrigation and was the best alternative for hilly areas. The best grass – legume mixture were grass + cowpea for the first season and grass + horse gram for the second season under water scarcity.
- Dual inoculation of rhizobium + AMF produced significantly higher green fodder and dry fodder yields for hedge lucerne [*Desmanthus virgatus* (L.) willd.] under rainfed condition.

Aromatic and Medicinal plants

- Kacholam, plumbago and asparagus were better suited for intercropping in coconut gardens as indicated by higher yield and benefit cost ratio.

- Adhatoda, chittaratha, kacholam, karimkurinji and sathavari can be successfully grown as intercrops in oil palm plantations of all age groups.
- Different shade levels did not significantly influence essential oil and oleoresin content in kacholam.
- In kacholam, both mother and finger rhizomes can be utilized for planting. Use of seed bits of size 5-7g was found to give maximum yield of rhizome and to economize the seed rate.
- Planting kacholam at a closer spacing of 20 x10 cm resulted in maximum rhizome yield. Application of FYM 20 t/ha + Azospirillum 2.5 kg/ha + 25 kg N and 50 kg each of K_2O and P_2O_5 and neem cake 1.5 t/ha + P solubilizer was beneficial in obtaining consistently higher yield.
- Application of organic manure (FYM) at the rate of 30 t/ha gave the highest rhizome and oil yield in kacholam, which was significantly superior to the application of inorganic fertilizers.
- For palmarosa, the combined application of chemical fertilizers along with biofertilizers ie. N and P_2O_5 each at 20 kg/ha along with *Azospirillum* is beneficial.
- A fertilizer dose of 30:30:30 kg/ha of N, P and K is beneficial for higher yield in Njavara, the medicinal rice variety.
- In coconut gardens, *Piper longum* performed better at 50 x 50 cm spacing with an application of 20 t FYM/ha and 30:30:60 kg NPK/ha.
- The yield of long pepper (*Piper longum* Linn.) as inter crop in coconut gardens was significantly influenced by irrigation levels and organic manure. Irrigation at 20 mm CPE and application of organic manure at the rate of 20 tonnes/ha gave the highest yield.
- Planting *Curcuma aromatica* at a spacing of 60x40 cm and application of FYM at 20 t/ha as basal followed by NPK at 100:50:50 kg/ha was found to be beneficial for realising maximum yield of rhizome, essential oil and oleoresin.
- Agrotechnology for optimum yield realization in *Saraca asoka, Holostemma ada-kodien, Strychnos nux-vomica* and *Curculigo orchioides* was standardised.
- Planting density, spacing and time of harvest in *Plumbago indica* were standardized. Optimum time of harvest was found to be 18 months after planting.

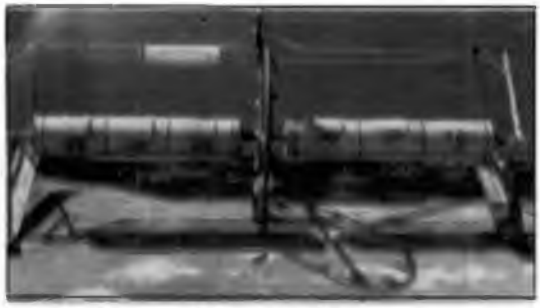
Integrated Farming Systems

- As a mixed farming system, fish can be successfully integrated with medium duration rice varieties in kole lands.

- Rice-fish integration provide the benefits viz., utilization of abundant water resources for fish cultivation during off- season, savings in the cost of pesticides, land preparation and cost of weeding, reduction in requirement of fertilizer application and maintenance of a high pH regime. The integrated farming model could generate an additional income of Rs 19,700/ha/year by an additional crop of fish during flood fallow period, increasing the rice productivity, and reducing the cost of cultivation.
- Inter cropping banana var. Njalipoovan with tuber crops in general increased the banana yield to the tune of 12 to 64%. Lesser yam was found to be the best companion crop of banana followed by elephant foot yam.
- For banana - tuber crop intercropping system, the fertilizer recommendation for tuber crops as intercrop can be reduced to 50% (NPK 40: 30:50 kg ha^{-1} for elephant foot yam and 40:30:40 for greater yam and lesser yam) along with the recommended nutrient for banana.
- A database developed on homestead farming system of Kerala and Andaman& Nicobar showed that the average size of homestead was less than 0.4 ha in as much as 70 per cent of the homesteads surveyed. Location specific, productive and profitable homestead models have also developed for the four agro-climatic zones of Kerala, *viz.*, the south zone, central zone, problem zone and the north zone as well as for the Andaman and Nicobar group of islands. Though individual models differed widely both inter and intra-zone, they could generate additional income and additional employment. The project created not only economic benefits to the farmers, but also caused an upliftment in their social standing.
- The homesteads were found to be repositories of biodiversity. One hundred and thirty different species of plants were identified in a 0.4 ha homestead. The soil test data revealed that the soils were generally low in available nitrogen and medium in available P and K and were acidic in nature.
- Comparison of different types of rice based integrated farming systems prevalent in the coastal districts of Kerala in terms of their profitability and employment generation capacity compared to rice monocropping revealed the superiority of the integ d system over rice monoculture both in the net returns of the farmers and employment prospects of labourers in all the coastal districts selected for the study.

Agroforestry and Silviculture

- Interplanting N_2 ..xing trees in teak plantations (alternate rows of teak and leucaena) stimulated teak growth.



Drum seeder

Organic rice at harvest stage

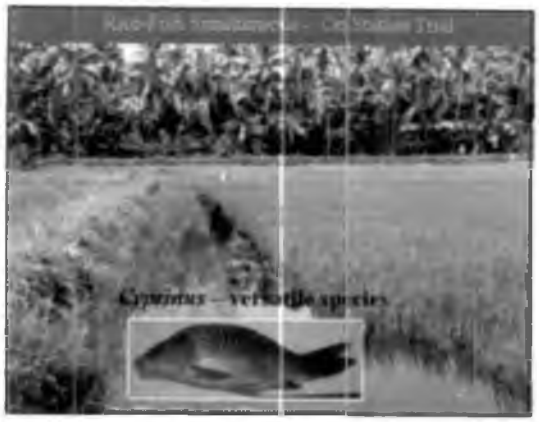
Rice transplanter

KAU Micro sprinkler

Rain shelter

High density planting of banana

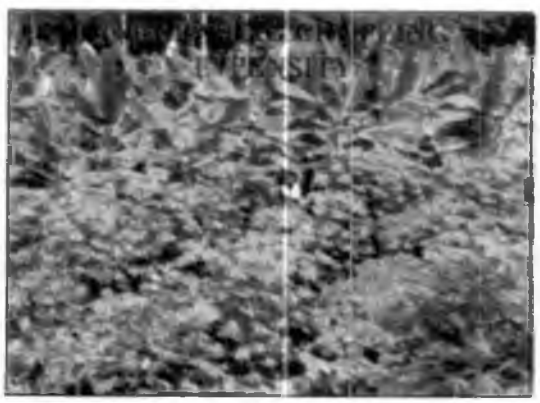
Pulsing orchids



Rice – fish simultaneous farming

Rice–fish sequential farming system of Kuttanad

Rice – prawn rotational farming in Pokkali



Banana – tuber crop intercropping system

- Ginger grown in the inter spaces of *Ailanthus* exhibited better growth as compared to sole crop. In general 2500 trees ha^{-1} registered better growth and yield of ginger.
- Among the fast growing trees *Acacia auriculiformis, Paraserianthes falcataria* and *Casuarina equisetifolia* recorded better growth.
- *Acacia auriculiformis* was found to be a good support tree for black pepper.
- The leaf litter of *Strychnos*, tamarind, cashew, *Gliricidia*, mango and *Ailanthus* (Matty) showed allelopathic influence on other crops growing around them. The leaf and bark extracts of these trees had insecticidal value as it was effective in controlling root grub of coconut.
- Sandal seedlings grew best under 50% shade and inoculation with *Arbuscular Mycorrhizal Fungi* (AMF) and *Glomus mosseae* improved the growth of seedlings. The plant water status was positively correlated with the water status of the host plant.
- In sandal, since the haustoria-connections are established only by 300 days after planting, the host plants need be planted only in the main field if the seedlings are transplanted at six to nine months stage.
- Under a research project on *Jatropha curcas*, the diesel plant, micro and macro propagation methods are being standardized. A total of 8,000 seedlings of *Jatropha* have been made in the nursery, which will be used for raising demonstration plantation in the University land.
- In the case of teak *(Tectona grandis)* the germination percentage as well as the vigour index of the 15-18 mm grade seeds was significantly higher compared to the lower grade seeds. The size grade and time of germination of the seeds significantly influenced the seedling characters such as height, number of functional leaves, collar diameter, root: shoot ratio etc.
- Standardized the ideal planting density, optimum thinning regimes and pruning regimes for *Acacia mangium*
- Developed an anatomical key for the identification of 50 important timbers of Kerala.
- Potting media with wastes like garbage and coir dust were highly promising with respect to initial establishment and final survival of *Tectona grandis, Albizia falcataria, Terminalia paniculata, Acacia mangium, Dalbergia latifolia* and *Artocarpus heterophyllus*.

- Soil faunal diversity was more in natural forests than in agroforestry system. Among the 25 different groups of organisms collected, the most dominant macrofaunal group showing diversity was coleoptera, followed by earthworms and hemipterans
- The role of soil faunal elements was highly significant in increasing the N concentration and decreasing K and Mg in the initial decomposition of litter.

1.2.3.Crop protection

Rice

- Evaluation of three new fungicidal formulations *viz.* Filia 52.5 SE, RIL –FA200 SC and Trycyclazole 70 WG for blast control of rice showed that all were effective in controlling the neck blast and increasing the grain yield.
- Flusiazole and Amistrar were found superior over the standard check fungicides in controlling the sheath blight incidence. In another trial, RIL-FA 200 SC was found highly effective in checking the sheath blight severity. Achook and Biotos were found to be a promising botanical fungicides against sheath blight than other botanicals and standard check fungicides.
- The plant oils lemon grass oil and cinnamon oil, the biocontrol agents *Trichoderma viride* and *Pseudomonas fluorescens* were found to be effective in reducing the sheath blight severity, which was on par with the check fungicide propiconazole.
- The fluorescent pseudomonad isolate Pf 16 could effectively control or suppress, sheath rot disease in rice caused by *Sarocladium oryzae* (Sawada) Gams and Hawksworth and it enhanced plant growth also.
- Among the new formulations tested against rice brown spot, difenoconazole+ propiconazole combination showed superior effect in controlling brown spot severity and increasing grain yield. Among the commercially available formulations Antracol was found promising.
- In addition to *Panicum repens* and *Digitaria sanguinalis, Echinochloa crusgali* was found to harbour the pathogen *Ephilis oryzae*, the casual organism of udbatta disease of rice.
- The pheromone traps of yellow stem borer are effective in monitoring the pest population and the male confusion technique helped in mass trapping the male moth, thereby reducing the infestation.
- For the management of stem borer and leaf folder in rice, the release of the biocontrol agents *Trichogramma japonicum* and *T.chilonis* @ 2cc at weekly

intervals for six weeks in IPM plots with comparison to farmers plots with sprays of conventional insecticides showed that the IPM plots registered low incidence of dead hearts and white ear of 9.6 % and 6.3 % while the farmers plots had 10.8 % dead hearts and 12% white ears with a mean grain yield of 5975 kg/ha in IPM plots and 4750 kg /ha in farmers plot respectively. The C: B ratios were 1:3.3 and 1:2.3 in IPM and farmers plots respectively.

- Among the three rice ecosystems surveyed, predators were dominated in Pokkali area and pests were dominated in Kuttanad and double-cropped area of Trivandrum. Insect predators were found more efficient than spiders in managing the pests in rice ecosystem. Among the insect predators *Cyrtorhynus lividipennis* and *Micraspis discolor* showed better ability to search for plant hoppers.
- Botanicals + half dose synthetic insecticides were as effective as full dose of synthetic insecticides in suppressing leaf roller and in protecting natural enemies. Hence the full dose of synthetic insecticides can be substituted with combination of botanicals (either NSO 3% or azadirachtin 0.004 per cent) and half dose of synthetic insecticides (either quinalphos 0.0025 per cent or imidacloprid 0.0025 per cent) for an eco friendly management of rice leaf roller.
- Two sprays of Bt formulations at 2, 1.5 or 1 kg/ha were effective in reducing the population of leaf folder and other caterpillar pests of rice such as case worm, skipper, hairy caterpillar etc.
- Evaluation of *Trichogramma japonicum* against leaf folder conducted during Kharif and Rabi seasons of 2004-05 showed that *T. japonicum* is equally effective as *T. chilonis* in managing leaf folder and there is no yield variation also.
- Carbofuran @ 1kg a.i./ha at 7 DAT was effective in controlling rice root nematode.
- Butachlor and Pretilachlor were found effective in controlling weeds in dry sown rice.
- Concurrent growing of cowpea and horse gram in semidry rice reduced the weed problems and increased yields.
- Almix-20 WP at 4 g a.i/ha at 20 DAS controlled broad-leaved weeds, sedges and Marselia in rice.
- In direct sown rice under puddled condition, pre-emergence herbicides Pretilachlor and Butachlor with safeners @ 0.4 and 1.0 k ai/ha, respectively, followed by one handweeding at 20 days after sowing were superior to other herbicides.

- Integrating a pre-emergence application of Sofit (Pretilachlor + Safener) @ 0.45 kg ai/ha at 3-5 DAS followed by hand weeding is more economical and efficient than hand weeding twice in direct seeded rice under puddled condition. Pre-emergence application of Safener added Pretilachlor and Butachlor were effective for weed control of wet seeded rice.
- Post emergence application of Oxadiargyl 80 per cent WP @ 0.1 kg ai/ha, Argold 0.5 kg ai/ha, Ethoxysulphuram @ 0.015 kg ai/ha and Butachlor 1.5 kg ai/ha recorded significantly higher grain yield over un weeded control and were on par with hand weeding twice.
- Anilophos + 2,4-D EE at 0.4 + 0.53 kg ai/ha was found to be superior for weed control in transplanted rice and comparable to handweeding twice.
- Integrating a pre-emergence application of 2,4-D Na @ 1 kg ai/ha at 5 DAT followed by a hand weeding at 20 DAT is more economical and efficient than any other weed control method for transplanted rice.
- Application of Bensulfuron Methyl as pre-emergence spray at 3-5 days after transplanting (DAT) or as post emergence spray at 20 DAT @ 0.06 kg ai/ha was most effective in controlling weeds in transplanted rice.
- Adopting 20 x 10 cm spacing and applying pre-emergence herbicide mixture anilofos + 2,4-D EE @ 0.4 + 0.53 kg ai ha^{-1} at 6 DAT followed by 2,4-D sodium salt @ 1 kg ai ha^{-1} at 20 DAT had a profound influence on weed control, yield and economics of basmati rice production.

Coconut

- Identified 395 elite palms, collected 5807 seed nuts, and standardized the protocol for the purification of phytoplasma against root (wilt) disease.
- Coconut eriophid mite infestation caused reduction of 18-42% copra content, 47-53 per cent fibre content and the seedlings emerged from these nuts were unfit for planting. Five predatory mites *viz., Amblyseius nucifera, A. largoensis, A. alstoniae, Hypoaspis karameri* and *Pachygnathous* spp.were identified. *Trigona irridipenis* and *Apis cerana indica* were reported as potential agents for vectoring *Pseudomonas fluorescens* to coconut. A new chemical Fenazaquin 0.05% (Magister 10 EC) was found effective under laboratory conditions.
- Triazophos (Hostathion 40 EC) @ 0.13% for spraying and 0.04% for root feeding were found to be effective against coconut eriophyid mite. A safe interval of 45 days is fixed as the waiting period.
- A schedule of three sprays of Cabaryl 0.1 per cent during May, August and October can be recommended for the effective management of coreid bug on coconut.

- Studies on sucking pest complex infestation on coconut bunches revealed that 15.42 per cent of nuts that fell from individual bunch (from emergence to harvest) showed symptoms of infestation of sucking pests. A lion share of this loss (13.34%) was due to coreid bug (CCB) infestation alone. Loss due to mite (CEM) was only 1.3%.
- The entomopathogenic fungi (EPF) *Verticillium suchlasporium* and *Metarhizium anisopliae* infected CEM and CCB respectively causing 30.8 and 96.7 per cent mortality.
- Some of the EPF identified for the control of coconut root grub gave 60-100 per cent mortality of root grubs depending on the growth stage of the insect and media in which EPF was grown.
- Biological suppression of coconut rhinoceros beetle *Oryctes rhinoceros* using *Oryctes baculovirus* and *Metarhizium anisopliae* in homestead gardens was found very effective.
- The present recommendation of 25 ml calixin/25 l water as soil drenching or 25 ml calixin/25 ml water as root feeding can control stem bleeding of coconut.
- Ferrolure with in bucket trap was very efficient for mass trapping the red palm weevil of coconut with an effective period of 9-10 weeks.
- Cashew apple extract (20%) or the pheromone, triferon was found effective for the management of red palm weevil. A dipteran predator, *Pipizia* sp., a predatory bird *Dendrocitta vagabunda parvula* and a fungus *Beauvaria* sp. were recorded as natural enemies. Male weevils could be sterilized by gama radiation at 1.5 Krads.

Vegetables

- Combined application of *Trichoderma* and *Pseudomonas* were more effective against *Rhizactonia solani* in tomato.
- The dual inoculation of AMF and *Azospirillum* was found to suppress the pathogen, *Pythium aphanidermatum*, causing damping off in chilli and tomato.
- All parts of *Plumbago rosea* showed inhibitory effect against pumpkin mosaic virus.
- Leaves of clerodendron have more effective antifeedant and growth inhibitory activity against epilachna beetle of brinjal than stem and root portions. Leaf extract with 4.0 per cent teepol effectively controlled epilachna beetle and the effect was on par with carbaryl treatment. Fresh leaf extract of clerodendron was

more effective than shade and sun dried leaf extract. Field application of clerodendron leaf extract had no adverse effect on the natural enemies especially, *Chrysocharis* sp., the potent biocontrol agent of epilachna beetle.

- Evaluation of DO.R *Bt.* against fruit borer of brinjal showed that four sprays of DO.R *Bt* @ 2 kg/ha was the most effective with lowest fruit damage. The fruit yield was significantly high in this treatment throughout the period of observation.
- Against brinjal shoot and fruit borer, percent fruit infestation was the lowest in *Bt.* @ 2 kg/ha and it was statistically on par with EPN as well as chemical control. In terms of fruit yield also EPN, *Bt* and chemical control were on par and significantly high as compared to untreated control.
- The major pests of brinjal viz., aphids, epilachna beetle and fruit and shoot borer could be effectively managed by spraying neem oil + garlic + *Hyptis suaveolens* extracts.
- Two per cent water extract of fresh leaf of *Thevetia nerifolia* can effectively be used for the control of major pests of bittergourd and amaranthus.
- Plantain – Furadan trap was found efficient to control fruit flies in snakegourd.

  "Banana trap" – a device smearing the cut ends of Palayankodan banana of 3-4 cm long with carbofuran granules and kept in coconut shell hanged in pandal found more effective in the integrated management of fruit flies in snake gourd.
- Five species of fruit flies *viz. Bactrocera cucurbitae, B. dorsalis, B. correcta, B. zonata* and *B. verbascifolia* were reported for the first time from trap catches. Methyl eugenol could be effectively used for trapping *B. dorsalis* and cuelure could be used against *B. cucurbitae* trapping.
- The management strategy of pests of vegetables using entomopathogenic fungi yielded one potent strain *Paecilomyces lilacinus* in addition to the two promising strains of *Beauveria bassiana* and *Aspergillus candidus.* The fungus *B.bassiana* was found pathogenic to *B.cucurbitae,* bhindi aphids *Aphis malvae* and scale insects *Saissetia* sp. The fungus *P. lilacinus* was found pathogenic to *S. derogata, B. cucurbitae, D. inidca, A. peponis* and scale insect *Saissetia* sp.
- Seed dressing with carbosulfan (25 ST) @ 3% (w/w) was found effective in managing the nematodes in bhindi. A yield increase of 8 to 35 per cent due to nematode control was obtained by nursery treatment with *Pseudomonas fluorescens* in brinjal.
- *Bacillus circulans* and *B macerans* are effective in controlling the root knot nematode in bhindi and the effect lasts for more than the cropping season.

- Seed treatment of bhindi with *Bacillus macerans* or *Paecilomyces lilacinus* @ 3% w/w (2.5kg/ha), nursery treatment of brinjal with *B. macerans* or *P.lilacinus* @ 25 g/m^2 along with drenching seven days after sowing @ 100 g/5 l/m2, drenching in coleus @ 35 kg/ha and seed material treatment of amorphophallus @ 3 g/kg with either of the organisms were very effective for nematode management.
- Application of vermiculate formulation of AMF @ 250 spores per plant or *Trichoderma* sp. 5 per cent at planting is recommended for integrated nematode management in chilli.
- In vegetable based cropping system, crop rotations/ cropping sequence has much influence in reducing the population of *M. incognita* in soil.
- Integrated management of root-knot nematode in tomato by solarization and addition of botanical materials like eupatorium leaves and neem leaves are found to increase yield and reduce nematode population in soil.
- Seed dressing treatment in okra for the management of *M. incognita* revealed that seed treatment with carbosulfan @ 3 % w/w increased the yield.
- For managing nematodes in bhindi, seed treatment with *Bacillus macerans* @ 3 per cent w/w (2.5 kg/ha) and in heavily infested area seed treatment with *Bacillus macerans* @ 3 per cent w/w and drenching with *B. macerans* @ 3 per cent solution 30 days after sowing can be recommended.
- For managing nematodes in amorphophallus and in brinjal nursery treatment with *Bacillus macerans / P. lilacinus* can be recommended.

Fruit crops

- For controlling panama wilt disease of banana, 3 ml of 20 per cent carbendazim solution as injection in the collar region followed by drenching 0.2 per cent solution 5, 7 and 9 months after planting were effective.
- Soil drenching with carbendazim 0.2% or injecting carbendazim 2% (3 ml) solution at 5^{th}, 7^{th} and 9^{th} month after planting was found to be most effective against panama wilt disease of banana var. Rasthali (AAB).
- Banana varieties Pisang lilin, Tongat, Sanna Chenkadali, Karivazha, Dudhsagar and Peyan were highly resistant to leaf spot disease.
- Alternate sprays of carbendazim at 0.1%, dithane M45 at 0.3% and tridemorph at 0.05% were effective in controlling sigatoka leaf spot of banana. Trimedorph 0.05% + carbendazim 0.1% was equally effective.
- For control of sigatoka leaf spot disease in banana, Companion (Mancozeb + Carbendazim) 75% WP, tebuconazole (Folicur 250 EW) 1 ml/litre and Propiconazole (Tilt) 1 ml/litre were found to be effective.

- Propiconazole (Tilt 25% EC) 1 ml/l (0.1%) + Spraying of *Bacillus subtilis* @ 5 g per litre three times proved to be effective against sigatoka leaf spot of banana.
- Application of 40 g carbofuran per plant, drenching blitox 5000 ppm and dipping suckers for 30 minutes in blitox 5000 ppm before planting resulted in low mortality due to rhizome rot in banana.
- The molecular detection of Banana Streak Virus (BSV) and Cucumber Mosaic Virus (CMV) were standardized. Their morphological characters were studied under electron microscopy and it was found that BSV particles were bacilliform virus belonging to BADNA group and CMV particles were spherical cucumovirus. Molecular detection of BSV was carried out in PCR using primers specific to RNAse H and Replicase gene and perfect amplicon was obtained at 750 bp region. Molecular detection of CMV was done in PCR using primers specific to coat protein. The phyllogenetic analysis was carried out and the particular Kerala isolate of BSV was found clustered around Australian and Nigerian isolates of BSV.
- Peak damage of pseudostem borer occurred in banana during the monsoon season. Acephate 0.1125% sucker dip followed by 0.1125% sprays on the pseudostem at 5th and 7th months after planting proved to be effective in the control in terms of yield as well as economics of cultivation.
- Soil application of carbofuran @ 750 mg ai/plant at 0, 2 and 5 months after planting followed by leaf axil application @ 375 mg ai/plant 7th month after planting was effective and economic control measure for pseudostem weevil of banana.
- The effectiveness of neem based insecticidal preparations in controlling the pseudostem borer in banana was confirmed. Neemazal 1% EC @ 5 ml/l is comparable to the recommended chemical, carbaryl 0.2%.
- The demonstration trial for the management of nematodes in banana revealed that paring + hot water treatment + carbofuran + neem cake increased the yield to a tune of 0.57 to 4.075 kg per plant
- Continuous pest and disease surveillance in farmers' fields detected presence of Pineapple Mealy bug Wilt Associated Virus (PMWaV) in Vazhakulam area.
- Ocimum trap containing ocimum leaf extract with carbofuran at the rate of four traps per tree and a bait spray with malathion 0.1% and 2% sugar at monthly intervals from initial fruit set upto harvest was found to be very effective in trapping large population of fruit flies in mango.

- Control of fruit fly using Methane euginol Pheromone through Male Annihilation technique was proved to be very successful in mango orchard.
- Weeding upto sixth month was critical in Nendran. The highest bunch weight was recorded in the treatment, where frequent weeding was taken up. In Nendran and Palayankodan, the best weed control practice was to raise a double crop of cowpea followed by its incorporation in the soil. Bunching was considerably delayed in unweeded plots. When no weeding was undertaken throughout the crop cycle, the flowering got delayed upto 46 days and this in turn resulted in a proportionate increase in crop duration.
- For post emergence weed control in pineapple, direct application of paraquat alone or with 2,4-D and 2,4-D and glyphosate, in the inter-row areas was found to be effective.

Spices and Plantation crops

- Dipping of rooted cuttings of black pepper in *Trichoderma harzianum* culture solution was found effective against the nursery diseases. Application of potassium phosphonate (Akomin) @ 3 ml/l as foliar spray and soil drench followed by soil application of *Trichoderma* proved effective against foot rot disease.
- Metalaxyl Gold MZ + *Trichoderma* was found effective in controlling the foot rot disease of black pepper.
- In the nursery, *Phytophthora* disease incidence was very low, when pepper cuttings were planted in solarized soil amended with *Trichoderma* and arbuscular mycorrhizal fungi (AMF) and the drenching with (0.3%) Potassium phosphonate. Application of *Trichoderma* @ 1g + AMF 100 cc in 1 kg of potting mixture also effectively controlled *Phytophthora capsici* in pepper nursery.
- Maximum percentage reduction of *Phytophthora* foot rot disease incidence (24.33%) was observed in *Trichoderma harzianum* + AMF and Akomin drenched plot than control.
- The application of potassium phosphonate / Ridomil MZ along with *Trichoderma harzianum* + neem cake was also effective in controlling the foot rot disease in pepper.
- Studies on control of *Phytophthora* foot rot disease in black pepper in farmers' field indicated that the disease incidence is very low in plots treated with potassium phosphonate @ 3ml/litre, *Trichoderma harzianum* @ 50 g/vine and neem cake @ 1kg/vine.
- In the nursery, *Phytophthora* disease incidence was very less, when pepper cuttings were planted in solarized soil amended with *Trichoderma* and Vesicular Arbuscular Mycorrhiza (VAM) with the drenching of Akomin (0.3 %).

- The Bacillus strain BY-2 and the fluorescent pseudomonad, *Pseudomonas putida* 89B61 were effective for plant growth promotion as well as the suppression of *Phytophthora* disease in black pepper nursery.
- The use of these biocontrol agents *Trichoderma harzianum* and *Glomus fasciculatum* either alone or in combination resulted in significant control of foot rot of black pepper caused by *Phytophthora capsici.*
- Inoculation with native mycorrhiza, *Glomus monosporum* and *Trichoderma longibrachiatum* or *T. viride* alone and in combination significantly reduced the incidence of foot rot and improved the growth of black pepper in the nursery and field.
- For the management of Phytophthora foot rot disease, recommendations were made -Phytosanitation, Spraying 1% Bordeaux mixture and drenching with 0.2 % copper oxy chloride followed by 2nd and 3rd spraying of 1% Bordeaux mixture during 2nd week of July and September respectively. 0.3 % potassium phosphonate as foliar spraying and drenching in second round is found to be equally effective with the existing practice of foliar spray of 1% Bordeaux mixture and drenching with 0.2 % copper oxy chloride. Application of lime @ 1 kg / vine followed by neem cake @ 2 kg/ vine reduced the Phytophthora foot rot disease and increased the yield of pepper vines and general vigour of the vine.
- Spraying of Bordeaux mixture (1%) at the time of flowering did not affect the berry setting in black pepper.
- Spraying with Carbendazim @ 0.05% or combination of Carbendazim + Mancozeb @0.05% was effective in the management of pollu disease in pepper. Karimunda variety was found tolerant to the disease.
- Application of a combination fungicide ie. carbendazim and mancozeb during spike initiation and berry formation stage in black pepper was found to be effective in the management of anthracnose in high ranges of Idukki district.
- In the high ranges of Idukki district five new insect pests of black pepper *viz.*, leaf miner, aphid, bagworm, stem borer and leaf gall midge were reported. Three species of scale insects *viz.*, mussel scale, soft scale and coconut scale caused more than 30% yield loss in black pepper.
- Two sprayings of either Dimethoate (0.05%) or Monocrotophos (0.05%) at fortnightly intervals after the harvest of berries were effective in the management of black pepper mussel scale, *Lepidosaphes piperis.*
- Three sprays of either 2% neem oil + soap + garlic or neem oil + soap + garlic + karanji oil 1% at spike emergence, berry formation and berry maturation is recommended for ecofriendly pest management in black pepper.

- Bordeaux mixture (1%) as spray or drench or both was very effective method to control capsule rot of cardamom.
- Inoculation with *Glomus monosporum* in pepper, *G. mosseae* and *Acaulospora morroweae* in cardamom, *G. mosseae* and *G. fasciculatum* in ginger enhanced the growth of these crops and induced better tolerance against wilt caused by *Phytophthora capsici* in pepper, azhukal by *P. nicotianae* in cardamom and rhizome rot due to *Phythium aphanidermatum* in ginger.
- Stem rot, root tip rot and *Katte* virus infection are spreading very fast in the cardamom plantations of Idukki district. It is found that the infestation by the root mealy bug or root grub of cardamom predispose the plants to root rot infection. Spray and drenching of Carbendazim @ 0.05% is recommended for the management of fungal diseases.
- Seven rounds of insecticide application per year are being recommended for the management of cardamom thrips (*Sciothrips cardamomi*) and stem borer (*Conogethes punctiferalis*). Bee safe insecticides such as Phosolone (0.07%) and Quinalphos (0.05%) are advised during peak flowering period (June-September) and skipping of insecticide application coinciding monsoon is also recommended.
- Yellow sticky traps on shade trees as well as spraying of neem oil @ 0.5% on the leaves suppressed the cardamom whitefly (*Kanakarajiella cardamomi*) population. An entomopathogenic fungus *Verticillium* sp. infecting on cardamom whitefly was reported from Pampadumpara panchayat, Idukki district, Kerala for the first time.
- Spraying of Nimbecidine 0.2% and Fish Oil Insecticidal Soap (FOIS) 2.5% resulted in reduced cardamom yield and increased itch symptom on capsules.
- Root mealy bug of cardamom is spreading very fast in the plantations of Idukki district. Evaluation of various insecticides revealed that plots drenched with Chlorpyrifos @ 0.03% was very effective in the management of this pest.
- Continued application of entomopathogenic nematodes and neonicotinoid is found successful in the management of cardamom root grub.
- Basal application of carbofuran @ 1kg a.i./ha or neemcake 1 t/ha and application of carbofuran at 45 DAP significantly reduced the nematode population and increased the yield from 17 – 38 per cent in ginger and turmeric.
- Lamda-cyhalothrin (20 and 25 ppm) can be used as an effective and cheap insecticide for TMB management in cashew. It is safe to predators such as ants and spiders and not phytotoxic at 4N dose.
- An integrated Cashew Stem and Root Borer (CSRB) management strategy has been developed by the KAU involving both prophylactic and curative measures.

- Paraquat (0.4 kg/ha) application thrice at monthly intervals ensured full season weed control in cardamom. Uncontrolled weed growth delayed the flowering and fruit set in cardamom.
- Pre-emergence herbicides such as oxyfluorfen @0.3 kg/ha and pendimethalin @ kg/ha were very effective for weed control in the cocoa nursery.

Pulses and Oilseeds

- Leaf extracts of *Lawsonia inermis*, *Melia azadiracta*, *Vinca rosea* and *Ocimum sanctum* were effective in controlling fungi, *Fusarium* sp., *Helminthosporium* sp., *Colletotrichum* sp and *Rhizoctonia* sp. infesting cowpea plants.
- Field evaluation of the fungus, *Fusarium pallidoroseum* at 3.5 x 10 spores/ml was very effective in controlling the cowpea aphid, *Aphis craccivora*. Spore formulation of the fungus can be stored at 4°C for more than 10 months.
- Soil application of farmyard manure (2t/ha) + *Pseudomonas fluorescence* seed treatment (10 g/kg of seed) was found effective in controlling the dry rot of cowpea.
- Spray application of Bavistin 50 WP @ (0.1%) followed by the application of Contaf 0.2% D @ 25 Kg/ha. was effective in reducing the powdery mildew incidence in black gram.
- Male coccinellids were found to be the most efficient predators of cowpea aphids. Integrated method involving neem kernel suspension 5% + mechanical + cultural control was found to be promising against major pests, safety to natural enemies, highest yield and low level of terminal residue.
- Chlorpyrifos (0.05%), profenofos (0.05%), acetamiprid (0.002%) and acephate (0.05%) could effectively manage the major pests of cowpea. Against aphids and other sucking pests, Imidacloprid (0.025%) was effective with safety to predators.
- Release of the predator, *Chrysopherla carnea* @ 50 $plot^{-1}$ of 80 m^2 at fortnightly intervals was found as the effective biocontrol method to check the aphid population in cowpea.
- For the effective management of pests of cowpea, botanical insecticides like tobacco decoction and neem kernel suspension were found to be effective in Onattukara region.
- Effective management of important pests of cowpea could be achieved through the operations *viz*., spray a botanical insecticide, tobacco decoction at 3-4 leaf stage of the crop against stem fly attack followed by a neem kernel suspension (0.1%) spray at trailing to flowering stage against pea aphids and again give a spray with neem kernel suspension at pod forming stage against pod borers.

- Infestation of pulse beetle in cowpea could be managed by field application of quinalphos 0.03% before harvest and post harvest treatment with *Acorus calamus* 1%.
- Neem oil 2% against *Aphis craccivora* and pod borers in cowpea and nimbicidine 0.2% against *A. misera* and pod bugs at 7th, and 20th DAS and there after need based application were found very effective.
- The incidence of pea aphids, *Aphis craccivora* and damage by pod borers were minimum in the treatment receiving 2% urea + 2% neem oil at 7th and 20th DAS followed by need based application. The best treatment against pod bugs was 2% urea + 0.2% Nimbicidine. The natural enemy population and the yield of cowpea grains was the maximum in Nimbicidine treated plots. In the case of sesamum also, the treatment nimbicidine 0.2% at 15th DAS followed by need-based application was observed to be very effective against leaf and pod webber, pod borers and phyllody incidence.
- In cowpea, 15 to 47 per cent yield increase was obtained due to carbosulfan 0.1% seed soaking for 4 h by controlling the nematodes.
- Management of phytoparasitic nematodes through botanicals / chemicals revealed that in cowpea, carbosulfan seed dressing was the best treatment followed by seed soaking with nimbicidine and carbosulfan showing an yield increase of 44.44, 36.11 and 19.44 per cent respectively.
- Nimbecidine 0.2% was effective against leaf and pod webber, pod borer and phyllody of sesamum.
- Two hand weedings at 15 DAS and 30 DAS were effective in controlling weeds in sesame. Among the weedicide treatments, Alachlor @ 1.5 kg/ha with hand weeding at 30 DAS was most effective.
- Application of Alachlor and Pendimethalin @ 1 kg ai/ha was highly suited for controlling weeds in sesame at Onattukara when applied as pre-emergence herbicide combined with one hand weeding at 30 DAS. This treatment was as good as two hand weedings at 20 and 30 DAS.

Floriculture

- Extract of *Allium sativum,* and *Tagetes erecta* (2:1), neem cake extract (2%), neem oil (1%) and coconut oil (1%) could be used as a substitute for antibiotics in the management of bacterial blight of anthurium.

Sugarcane

- Application of Goal at 3 l ai/ha as pre and post emergence had effectively controlled the weeds and produced the highest cane and sugar yield.

- Application of the chemical Metribuzin at 1 kg ai /ha or Ametryn 2 kg ai /ha as pre- emergence coupled with one hoeing at 60 DAP effectively controlled the weed spectrum and produced maximum cane and sugar yield. It was as good as hoeing at 30, 60, and 90 DAP.

Medicinal plants

- For controlling nematodes *(Meloidogyne incognita* and *Radopholus similes)* associated with thippali and chethikoduveli, *Pseudomonas fluorescens* or carbosulfan can be recommended.
- For controlling nematodes *(M. incognita* and *R. similes)* associated with kacholam, rhizome treatment with *P. fluorescens* or by green leaf mulching with neem, chromolaena and glyricidia can be recommended.
- Pathogenicity of plant pathogenic nematodes, *Meloidogyne incognita* and *Radopholus similis* to chethikoduveli *(Plumbago indica)* showed that the level of the former was >1000 and of latter was 100 per plant. Both these nematodes produced more than 25% reduction in yield of the crop. The biocontrol agents like *Glomus fasciculatum, Pseudomonas fluoresecens* and *P. lilacinus* performed as efficient as the nematicide carbosulfan in controlling the infestation and improving crop yield.
- *Pseudomonas fluorescens* @ 3% w/w was the best biocontrol agent for rhizome treatment to reduce the nematode population and increasing the yield of kacholam. However for soil application, neem cake @ 200g/ sq.m and AMF @ 10g/sq.m were the best treatments. Mulching with the leaves of neem, chromolaena and glyricidia also proved to be equally effective.

Aquatic weeds

- Field release of the mite, *Orthogalumun terebrantis* for the biocontrol of the weed, *Eichhornia crassipes* revealed cent per cent infestation in released locations.
- *Fusarium equisetti* and *F. pallidoroseum* were effective in destroying water hyacinth. Guinea grass straw, coir pith and rice bran can be used for storage and mass multiplication of these fungi.
- *Fusarium pallidoroseum* was developed into an effective mycoherbicide against water hyacinth.
- A combination of *Alternaria eichhorniae* @10^7 spores/ml and *F. pallidoroseum* @ 10^{11} spores/ml caused 89.84 per cent intensity of infection on water hyacinth *Eichhornia crassipes.*

- Cent per cent control of water hyacinth at Akkulam lake, Thiruvananthapuram was achieved with two sprayings of 5% wettable powder formulation of *Fusarium pallidoroseum* and 5% CSNL without any toxic effect on other aquatic flora and fauna.

Pesticide residue

- Application of confidor 350 SC @ 75 ml/ha and 150 ml/ha at 60 days after transplanting rice, no residue was detected in the samples(in paddy grain, raw rice, parboiled rice, straw and soil) except in the husk which recorded a mean residue of 0.011 and 0.014 mg/kg respectively.
- Application of Confidor 70WG @ 35 g/ha at 60 days after transplanting resulted in residues to an extent of 0.016 mg/kg in straw while no residue in the other products. However, when applied @ 70 g/ha, the residues in grain, husk and soil were 0.016, 0.010, and 0.016, respectively.
- Application of lindane, quinalphos or chlorpyriphos at 0.5 or 1.0 kg ai/ha at 30 and 45 DAP did not leave any residues in the harvested produce of paddy, *viz.*, grains, straw, bran and husk.
- Translocation studies of carbosulfan in coconut palms treated by root feeding with Marshal 20 EC indicated that residues did not persist in tender coconut water. Traces of carbosulfan could be detected in tender coconut pulp on seven days after treatment.
- A waiting period of three days could be fixed for mancozeb in chillies. Washing the fruits removed residues up to 52 per cent.
- Lindane can be recommended as a safe insecticide in bhindi, chilli and brinjal as the residues are below the Maximum Residue Limit (MRL), one day after treatment.
- About 28.7 per cent decrease of lindane, and 82 per cent decrease of quinalphos are seen upon washing the chilli fruits. The waiting periods of lindane, quinalphos and mancozeb in chilli were 2.9, 2.57 and 3.9 days, respectively.
- Pesticide residue studies in vegetables indicated that 72.2 per cent of the vegetables were found to be contaminated with pesticides. Quinalphos was the main insecticide contaminant whose residue exceeded MRL value.
- Studies on the effect of decontamination techniques for the removal of residues in vegetables indicated that the removal of residues due to washing ranged from 15.16 to 56.2 per cent and washing followed by cooking ranged from 22.15 to 75.8 per cent.

- Endosulfan, quinalphos and monocrotophos were the major contaminants in cardamom, of which only 11.3 per cent samples exceeded MRL values. None of the pepper samples were contaminated with pesticide. The samples of chilli powder showed the presence of dicofol, but their levels were below the MRL value.
- Of the five samples collected from endosulfan aerial sprayed cashew plantations of Kasaragod during Febrary 2001 endosulfan residues were detected in two samples (0.11 to 0.224 ppm) while alpha endosulphan in three samples with a range of 0.025 to 0.29 ppm. Among the four samples of leaf analyzed (cashew-3 and betel vine-1) residue of alpha endosulfan was below detectable level in all samples while beta endosulfan was detected in cashew leaves with a range of 0.0507 to 0.858 ppm. Samples collected during August 2001 from suranga, tube well, open well or rivulet, soil, bovine milk, blood, butter, ghee and egg were free from endosulfan residues.
- Samples of grapes and mango showed contamination with mancozeb residues below MRL values.
- Twenty three per cent of the surface and ground water Thiruvananthapuram, Pathanamthitta, Kasaragod) samples were contaminated with traces of lindane, dicofol and endosulfan.
- Milk samples collected from Thiruvananthapuram district indicated contamination with isomers of HCH in 32.25 per cent samples. 18.75 per cent exceeded MRL values.
- Fishes from local markets in Thiruvananthapuram district indicated the presence of methyl parathion, endosulfan, lindane and fenvalerate below MRL values.
- Monitoring of total diet samples analyzed indicated the presence of HCH isomers in 80% of the samples with a range of 0.34 to 1.65 ppm. 11.5 per cent samples showed 0.02-0.25 ppm of chlorpyriphos residues wherein cowpea was one of the food components.
- Pesticide residue studies in meat samples revealed that 30.2 per cent samples contained residues of alpha HCH and 10.1 per cent contained dicofol. In liver samples 18.2 percent contained alpha HCH and 6.8 percent contained dicofol. Blood samples were free from residues.
- An analytical method using HPLC was standardised for the estimation of carbofuran and its metabolite residues in banana.

1.2.4. Biocontrol and Beneficial organisms

Biocontrol

- The technique for the large-scale production of the entomopathogenic fungus *Fusarium pallidoroseum* infecting the cowpea aphid was standardized. Rice bran was found as an ideal substrate for large-scale production of this fungus.
- *Chrysoperla carnea*, a general predator of soft-bodied insects was mass-produced and distributed to 485 farmers.
- The techniques for mass multiplication of predatory mites *viz.*, *Amblysieus longispinosus* and *Macrochelus merdarius* on prey mites such as *Tetranychus ludeni* and *Tyrophagous* sp. were developed.
- Sixteen species of coccinellid predators were found associated with the pests of vegetables viz., cowpea, coccinia, bittergourd, brinjal and bhindi.
- Six species of platygasterids (Platygasteridae: Hymenoptera) were identified as the parasitoids of the rice gall midge, *Orseolia oryzae* (Wood-Mason) of which five were new reports. Parasitism by platygasterids was high during the mundakan season as compared to virippu.
- The use of vermi compost and neem cake in the ratio of 5:1 was found to be an ideal carrier material for the mass production of myco inoculants such as *Trichoderma harzianum* and *Glomus fasciculatum.*
- Four seasons data showed that the population of predators such as spiders and coccinellid beetles were high in organic farming plot than in chemical control. There was no significant difference in the pest incidence.
- Extensive survey and intensive fungal isolation studies were conducted for the specific biocontrol agent of the coconut eriophyid mite *viz*; *Hirsutella thompsonii.* The pathogen was found to occur in all the three agro-ecological situations studied and could be isolated throughout the season, though its occurrence was more during rainy season. Under natural field condition, 30% of the nuts were found infected with *Hirsutella.*
- *Pseudomonas fluorescens* was found to be compatible with commonly used insecticides like quinalphos, triazophos, imidacloprid, carbaryl, dichlorovos, dimethoate, malathion, carbofuran, phorate and fungicides like mancozeb, thiride, hexaconazal, carbendazim, propeconazol and potassium phosphonate. It is not compatible with common fungicides and antibiotics.
- As part of the bioecology, conservation and predatory potential study of spiders of rice and vegetable agro-ecosystems of Kerala, two notable achievements

were made. A new species of spider *Acusilas indicus* sp. nov. the spider *Achaearanea angulithorax* were reported for the first time from India. A website on spiders was launched for the first time in India and rated as one of the best visually pleasing, colourful and informative sites on spiders (www. southindianspiders.com).

- Biocontrol of insect pests by spiders in rice showed that *P. sumatrana* was the most potent predator of rice bug (consuming an average of 2.6 individuals), brown plant hopper (consuming an average of 5.9 individuals) and green leaf hopper (consuming an average of 4.6 individuals).
- *Metarhizium anisopliae* (Met.) Sorokin and *Mucor heimalis* f. *heimalis* were found as the potential biocontrol agents for controlling the incidence of banana pseudostem weevil (*Odoiporus longicollis* Oliv. (Coleoptera): curculionidae).
- Neem cake was identified as an excellent food base for the mass multiplication of *Trichoderma* sp., used as a bio control agent.
- A simple technique for inoculum production and farmer level multiplication of *Trichoderma* in cowdung-neemcake food base has been developed.
- Developed a novel fluorescent pseudomonas (P1) from Kerala soil for effective control of important fungal and bacterial diseases including foot rot of black pepper, rhizome rot of ginger, azhukal of cardamom and wilt of vegetables with improved the crop growth.
- An efficient fluorescent pseudomonas was developed from Kerala soils and the selected isolate P_1 effectively suppresses major crop disease incited by fungal sp. *viz., Pythium, Phytophthora, Rhizoctonia* and *Fusarium* and bacterial sp. *viz., Xanthomonas* and *Ralstonia.*
- Developed native *Trichoderma viride* and *T. longibrachiatum* for the effective management of fungal diseases such as foot rot of black pepper, azhukal disease of cardamom, rhizome rot of ginger, wilt disease of vegetables and fungal diseases of vanilla and betelvine.
- Dual inoculation with native mycorrhizal fungi *viz., Glomus monosporum* and *Trichoderma viride* and *T. longibrachiatum* was found effective for the management of root disease of crop plants *viz.*, foot rot of black pepper, azhukal diseases of cardamom, rhizome rot of ginger and wilt disease of vegetables.
- Highly effective *Bacillus* and actinomycetes were isolated from Kerala soil for the management of soil borne diseases.
- The technique of pre-inoculation with AMF, was formulated for the management of soil borne disease in vegetables and ornamental plants nursery.

Micro-organisms

- Three acid tolerant strains of *Bradyrhizobium* sp. suitable for cowpea (KA-G-C-1), blackgram (VE-G-B-2) and greengram (PA-G-G-1) were developed. These cultures were suitable for soils with pH upto 11.5 and are recommended for seed treatment of cowpea, blackgram and greengram along with the POP recommendations of the University.
- Use of microbial inoculant technology (AMF, *Azospirillum* and *Pseudomonas*) for the establishment and growth of tissue culture plantlets have been developed.
- Successfully commercialized and transferred mother cultures of *Trichoderma*, *Pseudomonas fluorescens*, AMF and *Azospirillum* and the production technology has been transferred to government institutions.
- An orchid mycorrhiza has been successfully isolated and found to improve the growth and development of vanilla in the field.
- Paddy straw supplemented with neem cake gave maximum yieldof *Pleurotus* sp. followed by rice bran, coconut oil cake and wheat bran.
- Ten strains of *Calocybe indica*, four strains of *Pleurotus* and one strain of *Ganoderma* sp. were collected, purified and domesticated.
- 156 strains of *Bacillus thuringiensis* have been isolated from the Western Ghats of Kerala
- A short duration Oyster mushroom which gives yield even after 15 days of cultivation was developed.
- The liquid formulation technique of pseudomonas was standardized.

Earthworm

- The Earthworm *Eudrilus eugeniae* was identified to be the superb agent for vermicomposting under southern Kerala conditions.
- Study of composting efficiency of different earthworm species revealed that the exotic species *Eudrillus eugeniae* was the most efficient in terms of duration of composting and biomass production.
- Maximum composting efficiency of *Eudrilus eugeniace* was observed during the months of October – November.

Productive insects

- The mulberry varieties, MR 2 and S 59 were found superior to the variety K 2 for cultivation in Kerala.

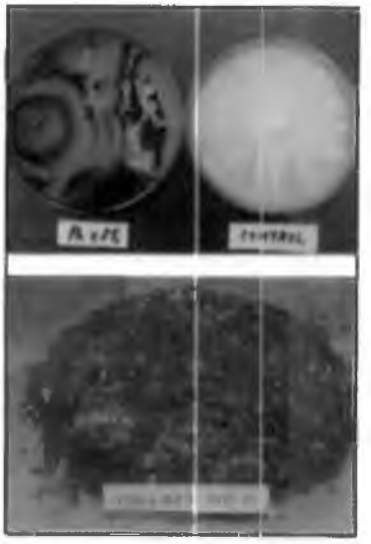
- A closer spacing of 60 x 60 cm along with a higher nutrient level of 300:120:120 kg NPK ha^{-1} and *Azospirillum* treatment @ 20 kg ha^{-1} resulted in maximum leaf yield and better profit from mulberry cultivation in coconut garden and under open irrigated conditions.
- *Terminalia paniculata* of Combretaceae commonly known as "Maruthi or Maruthu" has been identified as a new nectar source for honeybee in Kerala. The nectar is secreted by a pair of glands situated on either side of the midrib near its base on the lower surface of the leaves. This tree sheds its leaves in December and January and new flushes usually appear by March. The nectar glands become active when the new leaves are about a week old and continue the secretion for about 7-10 days. The nectar flow lasts for over a month depending on the climate and locality. Both *Apis mellifera* and *A. cerana indica* were found to forage on this nectar and therefore this tree can serve as an alternate source of minor honey flow immediately after the major honey flow from rubber.
- The exotic species of honey bee, *Apis mellifera* is found suitable for bee keeping under Kerala conditions, based on brood rearing, honey collection and absence of any serious pest and disease incidence.
- The stingless bee *Trigona iridipennis* could be domesticated and reared in artificial hives viz., wooden hive, earthen pot and bamboo bit. The bamboo hive having a volume of 1500cc was found to be more suitable showing maximum brood development, pollen storage, population build up and honey storage. The average life span of *T. iridipennis* was recorded as 44.5 days
- Stingless bee was found to be one of the most efficient insect pollinators available in the ecosystem for crops and wild plants.
- Stingless bee honey is more acidic than that of *A. cerana* honey. This honey has greater medicinal value as it collected nectar from most of the medicinal plants from which the other *Apis* sp. could not collect due to their bigger body size.
- The ant, *Solenopsis geminate,* a megachilid bee, a dipteran fly and a mite were recorded as the pests of *T. iridipennis* under Kerala conditions.

1.2.5.Basic research

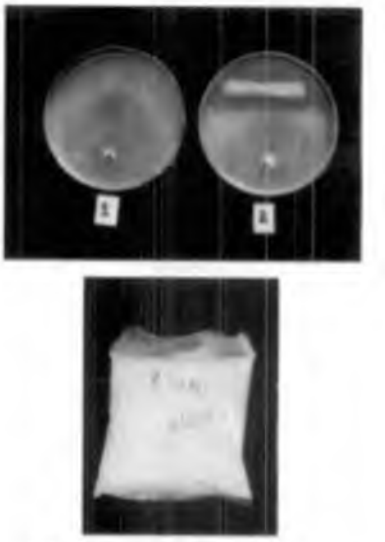
- Long-term application of urea resulted in drop in pH as well as depletion of cations. In the case of superphosphate, continuous application showed build up of calcium and phosphorus.
- Vermi composting of medicinal plant waste product from Oushadhi using *Eisenia foetida* indicated its importance as a promising bioagent for enrichment of

Different isolates of Hirsutella thompsonii

Biocontrol – Trichogramma egg card installed in rice field

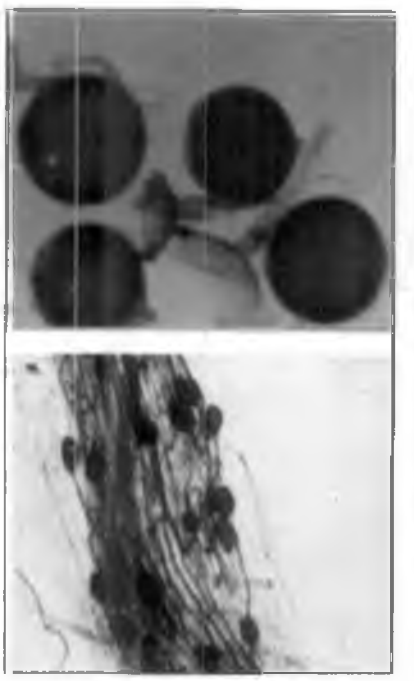


Biocontrol – Trichoderma



Biocontrol – Pseudomonas

Azospirillum



Mycorrhiza

Rhizobium

organic wastes. The compost obtained was a good source of organic manure. Oushadhi compost at 5 t/ha and full dose of NPK as per POP recorded maximum yield and nutrient uptake in amaranthus.

- Available S status in 96%-99% of the soils of Thiruvananthapuram and Kollam districts was low and in 1%-3% medium, soils with high S content were negligible.
- Compaction with four passes of 400 kg roller along with 2.5 t/ha of FYM and 5t/ha coir pith significantly improved the physical properties, nutrient uptake and yield of crops in rice based cropping system in Onattukkara.
- Phosphogypsum as an amendment for acidic upland laterite soils significantly increased yield and uptake of nutrients by cowpea. Greater mobility of Ca to the sub surface layers decreased the exchangeable aluminium content. The residual effect on the subsequent crop was pronounced which was reflected in the yield and available nutrient content of soil.
- Application of sulphur at 60kg /ha in the form of gypsum was found to be beneficial for the black soils Palakkad.
- Alleleo chemicals present in purple nutsedge (*Cyperus rotundus* L) were identified as p-hydroxy – benzoic acid, p. coumarie acid, m-coumaric acid, vanillic acid and gentisic acid.
- Weeds that could be used as indicators of soil conditions were identified as *Aeschynomene indica* (low nitrogen) *Seirpus juncoides* (low p) *Monochoria Vaginalis* (high organic matter) *Eleocharis duleis* (acidity) *Leptochloa chinensis* (alkalinity) *Diplachne fusa* (high salinity).
- A survey conducted in 2005 on presence of parthenium revealed that the weed had spread to large areas during the last 10 years.
- Integrated weed management experiment in rice-rice system indicated that weed management in the previous crop has great influence on the weed problems in the next crop. Application of 2, 4-D has resulted in higher population of grass weeds in the next crop while butachlor application resulted in increased incidence of broad leaf weeds.
- For rice cyst nematode, *Heterodera oryzicola*, the hot spot areas identified were Pullari in Kannur, Karimbil and Kodancherry in Wyanad, Alathur, Pattambi and Palancode in Palakkad, Puttadi and Anakkara in Idukki district. In banana, the hot spot areas of rice cyst nematode identified were cheemeni in Kasargod district, Kakkavayal and Kodencherry in Kannur, Pattambi and Alathur in Palakkad. The population of *R. similes* was uniform in different districts.

- The rate of depletion of SOM in sandy soil, laterite soil and red soil was determined. The extent of depletion in sandy soil was 48% as against 23% and 18% noticed in red and laterite soils. In all the soils depletion increased with increasing levels of mineral N. The information generated will be useful in suggesting nutrient management that will sustain soil organic matter level in coconut farming systems in different soil types.

Agrometeorology

- The intensity of UV-B radiation (harmful to biological activities) is high between 10.30 a.m. and 2.30 p.m. across the central part of Kerala.
- The monsoon rainfall is likely to be below normal when the onset of monsoon is before 25th of May. No such trend is noticed when the monsoon is late, that is beyond 8th June.
- There existed a negative relationship between the water deficit from December to May and annual cardamom production.

Socio-Economic and Gender studies

- Majority of the commercial banana growers adopted more than 79 per cent of recommended cultivation practices.
- The Thozhil sena (Labour force) formed in Kunnathukal panchayath, in Thiruvananthapuram resulted in increased employment and income generation. Education, achievement motivation and attitude towards peoples plan had positive and significant relationship with the role of Thozhil sena.
- Regarding dynamics of co-ordination for agricultural development in the context of democratic decentralisation in Kerala, maximum extent of co-ordination performance was at the district level followed by block panchayath and grama panchayat. Lack of proper interaction among the agencies involved in agricultural development was rated as the most important problem.
- Majority of agricultural officers were having a moderate awareness and knowledge on land evaluation for sustainable agricultural development.
- Participatory socio-economic land evaluation revealed that crops *viz.* pineapple, mango, sapota and cocoa were not suitable for watershed area due to various socio-economic reasons.
- In Thiruvananthapuram, livestock, rubber and tapioca, in Kollam rubber, livestock, pepper, and coconut and in Pathanamthitta rubber, coconut and livestock were the major components contributed towards annual home garden income.

- Under the Institution Village Linkage Programme of NATP, a novel concept of participatory research is put into practice. The system has tested more than 52 technologies and refinements were done on 17 technologies. Many of the high yielding varieties in rice and vegetables were made popular through this project.
- The benefit-cost ratios for banana varieties Nendran, Palayankodan and Red banana were 1.80, 1.30 and 1.75 respectively.
- The farmers were not completely aware about the various sources of inputs and their supply even though the distribution mechanism was so wide.
- The marketing strategies followed by various fertilizer companies were not farmer or soil oriented because the farmers neither followed any rationality in the purchase of fertilizers nor did soil testing prior to fertilizer application.
- Since 1990, the share of institutional finance in the financing of agriculture is significantly falling. While the stipulated rate is 18% of the total advances, currently it is below 12% in Kerala.
- There existed sizable production credit gap in Kerala because of the unscientific norms followed for fixing the scale of finance.
- Women farm labour of rice sector faced high rate of wage discrimination, poor nutritional status and negative energy balance.
- Women entrepreneurs of agribusiness sector need capacity building for entrepreneurship traits, technological expertise and motivational support. Co-operative marketing arrangements and supply of marketing information are essential for motivating and sustaining women entrepreneurs of agribusiness sector.
- Male members are mainly involved in decision-making and marketing activities in the farming systems of central Kerala. Female family members were mainly responsible for livestock management in small and marginal households, while male labourers were engaged for livestock management in large farms.
- Major gender impact indicators of technologies are employment, health, income, drudgery, leisure time, profit, and efficiency.
- A work load classification is brought out for the female workers of Kerala *viz,*. operations requiring energy expenditure less than 6kJ/min are found to be light, 6 kJ/min-12 kJ/min moderate, 12 kJ/min -18 kJ/min heavy and above 18 kJ/min unduly heavy for the target group.
- Energy expended by the workers for performing some common agricultural tasks involves in the paddy production process were estimated. Weeding (15.7 kJ/min), transplanting (14.89 kJ/min) and harvesting (13.64 kJ/min) were found to be tedious among the operations considered.

- Women were trained on the operation and minor maintenance of agricultural machinery like tractor, power tiller, transplanter, bush cutter, sprayer, pump, vertical conveyor reaper and thresher. Nine female workers, trained under the project, could obtain license for driving tractors and the women trained under the project are forming co-operative groups. Two groups are already registered under the names *"Sthree Shakthi" and "Vanitha Shakthi"*.

Seed Technology

- In mango, Chandrakkaran was found to be the most adaptive variety and exhibited more tolerance to seed desiccation indicating that it has a broad genetic base.
- Mechanical manipulation of the mango seed by splitting of the endocarp was found to be advantageous in reducing the days taken for germination, enhancing the rate of germination and promoting more number of sprouts in polyembryonic varieties.
- Osmopriming with sodium chloride having concentration of –1.5 Mpa for 48 hours can be used as a post storage treatment to maintain the vigour and viability of chilli (*Capsicum annuum* L.) seeds up to 10 months.
- Harvesting chilli fruit at red ripe stage along with seeds from bottom portion gave maximum viable seeds. Combining vegetable harvests along with seed production can also be practiced since this favoured the production of good quality seeds with comparable fruit and seed yield. Maximum yield and highest net return were obtained with 50 ppm NAA.
- Seed production can be combined with two vegetable harvests in cucumber (*Cucumis sativus* L.), for getting maximum returns.
- In snakegourd (*Trichosanthes anguina* L.), the keys for varietal identification were developed based on the primary diagnostic characters like seed size index, 100 seed weight, seed coat colour, leaf lobes, leaf pubescence, tendril length, fruit skin colour, fruit girth, fruit length and fruit weight.
- After cryopreservation (both direct plunging and slow freezing techniques) the seeds and excised embryos of thambakam (*Hopea parviflora)* failed to regenerate. Synthetic seeds obtained from excised embryos and stored at 4°C retained higher germination percentage compared to those at 20 and 27°C after four weeks. The viability of synthetic seeds stored at 27°C declined rapidly and none of them retained their viability after 3 weeks of storage.
- Collection, characterization, evaluation and seed multiplication for storage in National Seed Banks are being carried out in rice, chillies and cucurbitaceous vegetables. 189 rice accessions were collected and deposited after characterization in MTS and LTS. 180 accessions were collected in chillies and cucurbits and 143 were characterised and deposited.

Training for women on user friendly farm machineries

Rice transplanter

Paddy reaper

Paddy thresher

Biotechnology

- Somaclonal variants derived from tomato variety Sakthi were checked for resistance against tomato leaf curl virus (TLCV). Two variants were free from the disease and five plants showed only mild curling and puckering. Two variants were free from fruit cracking and another two yielded higher than the control plants.
- TOLCV was isolated and characterized in tomato through molecular techniques.
- HMGR, the gene capable of imparting pest and disease resistance could be isolated from differenct species of *Solanum.*
- *In vitro* propagation protocols were developed for the tree spices, clove and cinnamon. The tissue culture plants were planted out for field evaluation. Procedures for genomic DNA isolation and RAPD analysis in nutmeg were standardized.
- RAPD profiles of 13 species of *Piper* were compared for genetic similarity. With the 20 primers used, these species formed four clusters.
- Protocols for the isolation of protoplasts from *Piper nigrum* and *P. colubrinum* were standardized.
- Gene fragments encoding B-1, 3 glucauase and HMGR were isolated and characterized in black pepper and *Solanum torum* respectively.
- Transgenic plants for stress tolerance were generated in bell pepper.
- In ginger, *in vitro* pollination was successful with pollens suspended in ME3 medium, showing 90% development of ovules. Controlled selfing and crossing among autotetraploids and diploid cultivars using *in vitro* placental pollination were successful.
- *In vitro* fertilization technique in ginger was refined with respect to media for seed development and seed germination.
- Protocol for the invitro embryo culture technique was standardized and attempted as a successful tool for the interspecific embryo rescue in *Abelmoschus* spp.
- Standardized the protocols for in vitro propagation of ginger, pepper and cardamom.
- Protocols for *in vitro* culture, callus induction indirect organogenesis and *in vitro* mutagenesis were perfected in ginger.
- Formulated an isoenzyme-based classification for species of Piper and Curcuma.

- *In vitro* pollination in turmeric was done by suspending pollen grains in modified ME3 medium. Ovule development was observed in intra ovarian, placental and modified placental pollination techniques. Two hybrids from the *in vivo* crosses (VK70 x VK76) were germinated *in vitro* and six *in vitro* plantlets were successfully planted out in the field.
- In vanilla, intra and inter specific hybrids were produced through *in vitro* pollination and embryo culture.
- Multiple shoots induction and rooting of the microcuttings were successfully carried out from the nodal segments of Malabar tamarind. Callus regeneration and somatic embryogenesis could be induced from the endosperm. Isozyme markers were developed (esterase) to identify the male and female sex forms at seedling stage.
- In Garcinia, *in vitro* regeneration techniques were standardized with different explants *viz;* embryo, endosperm, meristematic tissues and axillary buds. Plantlets were regenerated from the endosperm callus tissue. Multiple shoots were developed from endosperm through direct organogenesis. Protoplast was isolated from the leaf mesophyll tissues.
- Standardized the protocols for in vitro propagation of cashew.
- The protocol for RAPD analysis in banana was standardized.
- Protocol for tissue culture technique was standardised in banana varieties Kadali and Njalipoovan.
- The protocol for immature hybrid seed culture *(in vitro)* in anthurium was developed.
- Protocol could be evolved for the *in vitro* propagation of the anthurium variety Dragons Tongue.
- Protocol could be evolved for the *in vitro* clonal propagation of the two orchid varieties, Sonia 17 and Annie Black.
- The protocol for clonal multiplication of gladiolus has been standardized
- Molecular characterization has been standardized in vegetable crops *viz*., culinary melon *(Cucumis melo)*, ashgourd *(Benincasa hispida)*, amaranth *(Amaranthus* spp.*)*, vegetable cowpea *(Vigna unguiculata)* and drumstick *(Moringa oleifera)*. This could be used as a tool to develop a database on the landraces of traditional vegetable crops of Kerala.
- Molecular characterization and molecular analysis of 17 promising types of Heliconias were carried out using eight primers.

- Genetic similarity matrix was constructed using the Jaccard's coefficient method with the score values of RAPD marker bands. Corresponding to the similarity coefficient value of 0.42, the 17 species and varieties of *Heliconia* were grouped into nine clusters.
- Protocol could be evolved for the *in vitro* clonal propagation of *Holostemma annulare*.
- Protocol for the rapid *in vitro* multiplication of *Trichopus zeylanicus* could be developed.
- Protocol for direct and indirect organogenesis and embryogenesis was standardised in *Trichopus zeylanicus*.
- *In vitro* propagation of *Aegle marmelos* (Koovalam) *via* enhanced release of axillary buds was standardized. Compared to nodal segments, cotyledons responded better with respect to percentage of survival (100) and shoot proliferation (49 shoots per culture). MS medium containing BA 0.5mgl^{-1} produced the highest rate of multiplication.
- Teak populations in India were characterized through AFLP assay.
- In neem, MS medium with combinations of BA + IAA or Kn + NAA was found ideal for shoot proliferation. Methanol: water (30:70) was the best solvent system for elution of azadiractin. The highest amount of azadiractin (6.71ìg g^{-1}) was produced in MS medium containing 1.0 mg l^{-1} IAA on the 30th day.
- The technique of micro propagation of Bijasal *(Pterocarpus marsupium)* is being taken up through tissue culture techniques. Shoot induction from axillary bud cultures has been achieved.

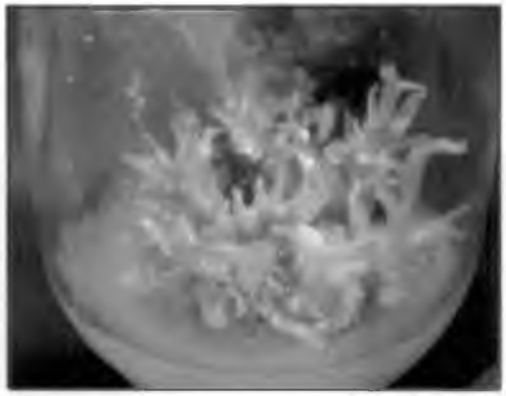
1.2.6.Post Harvest Technology/Value addition

- Packaging of mushrooms in Polypropylene without ventilation and PP with air blow was evolved as a simple and cheap technique to extend the shelf life of fresh mushroom species – *Pleurotus florida* and *Pleurotus sajor-caju* for 36 hrs under ambient conditions and 10 days under refrigerated conditions with least deteriorative changes.
- An instant sapota-milk shake powder was developed by spray drying the mix with a shelf life of 4 months under ambient conditions when packed with metalized polyester pouches.
- Two fungal organisms viz., *Aspergillus* sp and *Trichoderma harzianum* were found to produce enzyme pectinase in solid-state fermentation of fruit wastes.

- A technology to produce ripe robusta banana powder was standardized by spray drying ripe pulp under suitable conditions.
- Breadfruit when wrapped individually with unventilated polymeric pouches gave a shelf life of 5 days under room temperature.
- Chopped, dried and powdered adhatoda when packaged in rigid plastic containers retained vasicine, the principal alkaloid up to 5 months in ambient conditions. The technique developed could store bulk quantity in a limited space without chemical or microbial spoilage.
- Studies on small-scale fermentation and drying using heap, box, basket and tray methods showed that the heap method (50kg) produced commercially acceptable cocoa beans. When the quantity of the ferment is smaller than 50kg, basket method was the best.
- The acidity of cured cocoa beans could be reduced by soaking the beans in sodium bicarbonate (0.5 – 2%) for different duration (1-3h) and by increasing the pH from 4.97 to 5.5.
- Roasting duration varied markedly with the size of cocoa beans. Small beans (100g) took only 3 minutes under 100% microwave power as against 4 minutes by big beans for roasting.
- The method of extracting cocoa butter on farm scale (up to 31%) was standardized. The cocoa powder separated by cocoa butter extractor fabricated for farm level processing contained 26-35% cocoa butter. The use of beans of smaller bean count (76.3) recorded the highest butter yield of 31.5 percent and less shell (10.03%).
- Incorporation of the cowpea variety Kanakamony (which was found to have an arginine: lysine ratio of 1:1.02 in a high fat high cholesterol diet decreased the lipid level of liver and blood of experimental animals, indicating its hypocholestrolemic efficiency.
- Organoleptically acceptable jackfruit products having a shelf life of more than four months can be prepared using osmotic drying technique, utilizing both soft flaked (koozha) and firm flaked (varikka) varieties. The best products were obtained by a pre-treatment comprising of immersing the bulbs in a sugar solution of 60° brix, containing 0.4 per cent sodium metabisulphate and 20 per cent glycerol for 60 minutes at 70°C.
- Novel complementary food products such as noodles, macroni, wafers and weaning mixes could be produced using cassava and sweet potato. They were superior in nutritive value and protein quality; comparable with respect to

Micropropagation in different crops

Artemesia



Banana

Black pepper

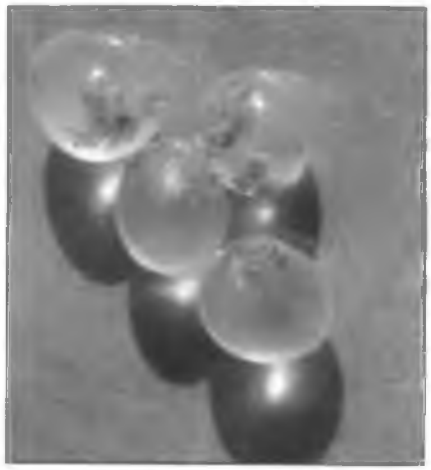
Cashew

Ginger

Trichopus

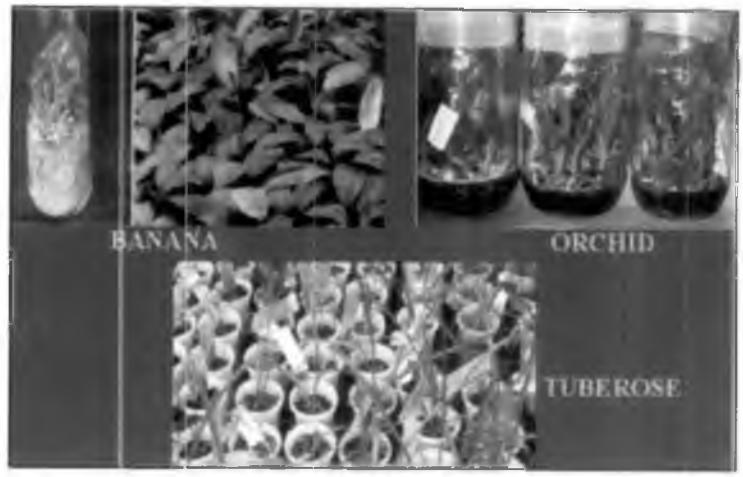
Stevia

Holostemma

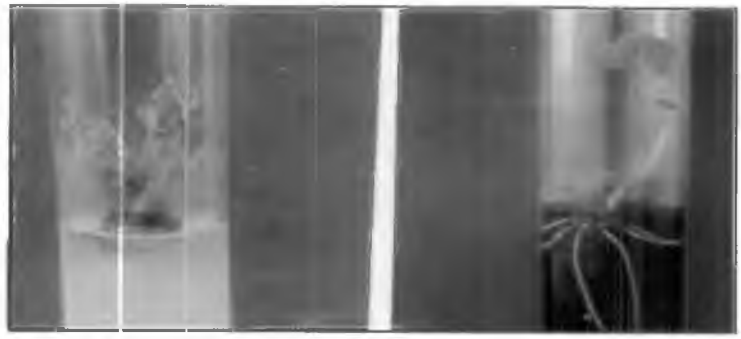


Holostemma encapsulated shoot buds

Vanilla

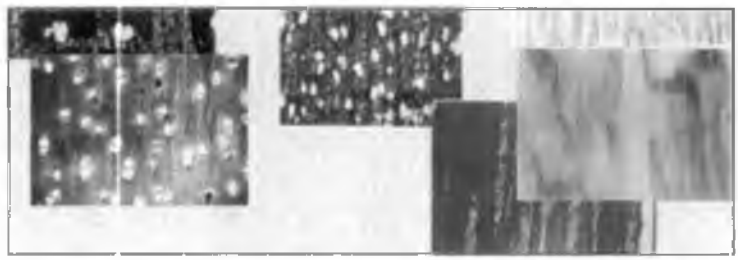


Micropropagation in banana, orchid and tuberose



Micropropagation – Rose wood

Micropropagation – Teak



Anatomical key for identification for timber

acceptability, consumer preference and economical when compared to standard products available in the market.

- Mango pulp can be stored for three months with 0.1 per cent potassium metabisulphate and 1.0 per cent citric acid in glass containers.
- A weaning mix of high biological value; low in viscosity and bulk density; easy to prepare and suitable to feed an infant of six to nine months of age can be produced using rice, soya, amaranthus and skim milk powder by cottage level technology at a cost of Rs.45 per kg.
- Different baked, confectionery, preserved and extruded products with good nutritional, chemical, organoleptic and shelf life qualities were developed from sweet potato. This technology was transferred to 100 women from different self-help groups and small-scale entrepreneurs.
- Highly acceptable and value added diversified food products *viz.* beverages, bioprocessed products, simulated dairy milk products, protein enriched products, bakery and confectionary products were developed. Suitable packaging materials were also identified, for these products.
- Excellent preparations *viz.* pickle, squash, jam and preserves with shelf life of six months using under exploited fruits like bilimbi, roseapple and lovilovi were developed.
- Food supplements standardized using spray dried spirulina (*Spirulina fusiformis*) was found to be effective in reversing the pre-cancerous symptoms of the oral cavity of selected fisher women.
- Red palm oil blended with sunflower oil based on P/S ratio (60:40) was found to be most ideal for baking and frying purpose.
- Vytila-2 and cul: 2006 were found as the best varieties with respect to physical and organoleptic characters respectively among 10 pokkali rice varieties.
- Varieties of hyacinth bean (*Dolicos lab lab purpureus* (L) sweet) DL40 and DL50 were superior in nutritional quality, acceptability and yield.
- For cardiac patients a ready reckoner was formulated in consultation with the competant physician, which could help the patients to select and plan their daily diets. Diet counseling based on the diet chart, booklet and ready reckoner was found to be very effective in controlling the lipid profile of these patients.
- Consumption of antioxidant rich foods was inadequate in the diets of smokers. The serum lipid profile of the subjects was found to have a direct relationship with the smoking Index.

- Food security was found to be better in the households of women agricultural labourers in the organized sector, mainly due to their better purchasing power. In the households of unorganized sector, food insecurity without hunger and with moderate hunger was prevalent.
- Moderate levels of malnutrition leading to mild anaemia, Vitamin A and energy deficiency was observed among pre school children of coastal areas and adolescents of urban and rural areas of Thiruvananthapuram and Thrissur.
- Technology has been developed for preparing spray dried instant sapota – milk shake powder, ripe robusta juice powder, mango juice blended with clarified robusta juice and a number of value added products from mango ginger.
- Instant cocoa beverage powder was developed which is suitable for pudding, ice cream and chocolate production. Techniques for value addition of fig fruits were standardised
- The nutrient analysis and product development of three under utilized fish varieties namely Netholi, Flat fish and Veluri indicated that they are good sources of nutrients and products developed from them are highly acceptable. Dried fish could be stored for three months and pickles could be stored for six months without affecting quality. Among the three fish varieties, Veluri was found to be the most suitable fish for preparing products.
- The nutritional profile of fisher women residing in Trichur was assessed and about 38 percent of the respondents were found to be malnourished on the basis of Body Mass Index. The intakes of most of the nutrients were found to be below the Recommended Dietary Intake. About 65 percent of the fisher women were found to have acceptable iron status on the basis of haemoglobin content of blood.
- The analysis of tribal foods consumed by the tribes of Palakkad, Idukki and Wayanad Districts indicated that most of the leafy vegetables consumed by them are rich in micro nutrients with lower anti nutritional factors.
- Fruit nectars and fruit bars from two varieties of jackfruit were standardized individually and blended with other fruits during the period under report. Successfully technologies for preserving jackfruit bulbs in sugar syrup and clarified juice from jackfruit were developed.

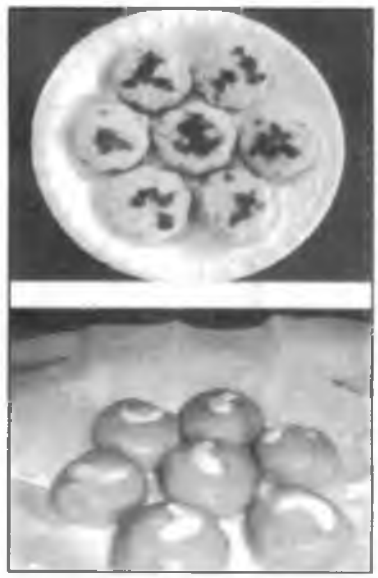
1.3.Technologies/Protocols transferred

- Production technology of mother cultures of *Trichoderma*, *Pseudomonas fluorescens*, AMF and *Azospirillum* has been transferred to government institutions.

Jackfruit preserve

Jackfruit varatty

Jackfruit toffeee

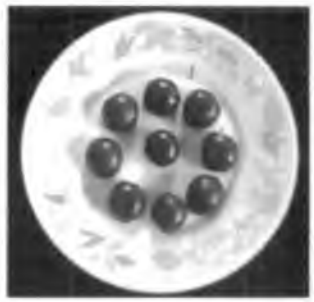


Bakery and confectionery products from jackfruit seed flour

Jackfruit juice

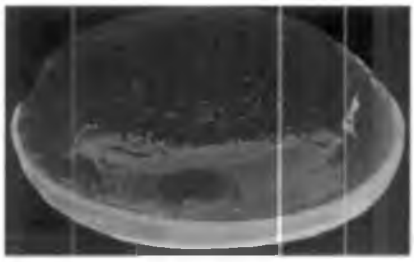
Cocoa products

CIS Granules



CIS Toffee

CIS Honey



CIS Jelly

CIS RTS

CIS Cake

CIS Wine

Tender coconut ice cream

Improved palm gur

Tender coconut shakes

- Protocols for the production of tissue culture plants of banana (Nendran, Red banana, Njalipoovan and Robusta), pineapple, orchids and anthurium were transferred to Mithramkathan, Thiruvananthapuram
- Protocol for the production of tissue culture plants of black pepper was transferred to Spices Board & Biotechnology and Model Floriculture Centre , Kazhakootam.
- Technology of farm level value additon of cocoa was transferred to Self help Group.

1.4. Patents applied

Sl. No.	Name of Product /Process	Year of application	Name of Scientists
1	A process for the preparation of ripe banana powder	2003	Dr. P. Vijayanand, (CFTRI) Mr. Kulkarni (CFTRI) Mrs. Evelin Mary (KAU) Dr. P. Jacob John (KAU)

2. VETERINARY AND ANIMAL SCIENCES

Technologies developed

Breed improvement

- Developed triple breed combination piglets, the demand for which is increasing amongst the farmers, as their profit and acceptability for the lean pork among customers are increasing. They are having 50% more growth rate with 60-70% less fat content in the meat.
- Animals with light coat colour had a significantly higher conception rate than those with dark coat colour irrespective of seasons. Animals inseminated in the A.N were generally found to have a better conception rate. Conception rate was significantly higher in the animals, which were given pre-insemination rest for 90 and 120 minutes.

Health

- Plasma treatment is an effective and less expensive non-antibiotic alternate therapy for endometritis in cows.
- Gonadotrophin releasing hormone is a potent drug for regulating overian and uterine functions and the reproductive efficiency.

- Investigation was carried out to estimate the seroprevalence of brucellosis among infertile cross-bred cows in and around Thrissur District. The study revealed an overall incidence of two per cent in infertile cross-bred cows and fourteen percent in slaughtered cows.
- Staphylococci from bovine mastitis cases were characterized using various methods like biotyping, antibiogram typing, resistogram typing and plasmid profile. Antibiogram typing and its combinations were found to be the best method.
- Collagen sheets are cheap and easily available material over synthetic ones for cystoplasty in treating urinary bladder rupture in rabbits and goats.
- Canine and dish collagen sheets used for cytoplasty in rabbits and dogs were found to be readily accepted by the body causing very little adverse tissue reaction.
- Propofol under atropine-xylazine pre-medication provided smooth induction of anaesthesia.
- Plaster of paris cast favoured the return of limb function and disappearance of symptoms of fracture earlier than modified Thomas Splint in fracture of tibia.
- Immobilization of the fractured limb with PVC splint facilitated the repeated attention of concurrent complications associated with fracture and application of the same material, thus resulting cost effectiveness of treatment.
- In the treatment of aural haematoma partial thickness suturing technique was found to be more effective.
- Xylazine – atropine premedication reduced the dose of thiopentone for general anesthesia in dogs and enhanced the duration of anesthesia.
- Management of tibial fractures in dogs using modified Thomas splint was found to be more effective than plaster of paris cast.
- Epidurography is found to be advantageous over venography in diagnosing the site and type of lesions in cases of posterior paralysis in dogs.
- Duck plague virus and duck Pasteurella were isolated from cases of duck plague and this is considered as the main reason of vaccination breakdown against duck plague
- Dot ELISA was found to be suitable for detection of Duck plague viral antibodies in serum under field conditions.

Production technologies

- There is a need for changing the PFA act minimum standard of 3.5 per cent milk fat because 65 per cent of cows in second month of lactation and 16 per cent of cows in 5th month of lactation produced milk with less than 3.5 per cent fat.
- A crude protein level of 17% with 25 % of protein as undegradable was sufficient for crossbred lactating cows producing 7 to 8 liters of milk per day.
- Mineral availability from grass based and straw based lactation rations was studied and found that only calcium need be supplied in diet. Phosphorus, Mg. Cu and Zn requirement can be met from the feed ingredients.
- Energy supplementation at different levels did not improve growth rate or feed efficiency in crossbred heifers.
- Bakers yeast and Potassium diformate when incorporated in the ration improved growth and feed efficiency of growing pigs.
- Dried cuttle fish waste silage can be used to replace dried fish in the diet of growing pigs.
- Prawn waste can be used to supply 50% of the protein requirement of the grower and finisher rations for Large White Yorkshire pigs.
- Animal fat added at 15% over and above their standard ration during late gestation and lactation improved the performance of sows and the litter.
- For maximum growth of broiler rabbits a digestible energy level of 2500 kcal/kg and CP of 20% in diet was found sufficient.
- Cellulase enzyme supplementation in high fibre layer ration was beneficial especially when fibrous agricultural byproducts are used as alternate feed ingredients in chicken diet.
- Phytase and citric acid when fed along with low available phosphorus (P) diet improved growth and feed efficiency of broiler chicken.

Value addition

- The shelf life for beef frankfurter was four days and for chicken pepperoni was less than six days when stored at 4-7° C. The frozen samples of both products had a shelf life of 90 days.
- Various critical points of bacterial contamination, samples of air, water, rinse samples from equipment, hand washing of personnel in the processing line and packaging material were examined for their hygienic quality. The mean total viable count and yeast and mold count of air samples were found to increase after

processing. Among the water samples, the high microbial count was recorded for hand washings, reflecting unsanitary working practices. Among the equipment, sausage filler was found to contribute maximum to the total microbial load of the product. Among the raw ingredients, samples of beef used for preparation of beef frankfurter and samples of pork used for chicken pepperoni were found to possess high bacterial load. The study reflects the importance of quality assurance during every step of preparation of ready-to-cook meat products to avoid the early spoilage and to safeguard consumer health.

- In chronic cases of otitis, radiographic evaluation was found useful in identifying the severity of the condition and thus was helpful in prognostic evaluation of the condition and to adopt suitable surgical management. Radiography is an ideal mode of diagnosis of Urolithiasis in dogs and it helped in locating the site of obstruction and thus favoured surgical correction.
- Detection of *P. multocida* by PCR was carried out using species specific (PM-PCR) type-B specific (HS-B) PCR and nested primers. All the five isolates obtained were confirmed as type-B using species-specific primers and the isolates showed a single REP-PCR profile indicating a high level of homogeneity among them. Among the five isolates examined two harboured plasmids.
- The prevalence of Canine Parvo Virus (CPV) infection was tested by HA, PCR and seminested PCR. Seminested PCR was found to be more sensitive and specific method over HA and PCR for the early diagnosis of CPV infection. Restriction enzyme analysis using three enzymes revealed no difference in the fragment length pattern between CPV vaccine strain and field strain.
- *Pasteurella multocida* isolates from ducks and from fowl were characterized using standard bacteriological procedures and PM-PCR. The OmPH-PCR product was helpful for differentiation of various serotypes of *P. multocida.* OmPH gene of inactivated fowl cholera vaccine revealed similarity with the amplified region of local duck isolate and hence the vaccine can be expected to confer immunity to ducks in Kerala against Pasteurellosis.
- Low voltage electrical stimulation and vacuum ageing of meat could significantly improve the tenderness and organoleptic quality of meat. Marination and blade tenderisation of meat was found to increase the eating qualities of meat. Developed a quality management programme in the production and processing of meat and meat products by implementing HACCP.
- Shelf stable meat products like chicken, egg and pork pickles were prepared, quality analysed and popularized. Chicken sausage was also prepared using broiler chicken and spent chicken. Quality and shelf life were analysed and found that it can be stored up to 240 days without any organoleptic changes.

Triple breed – Duro White

Triple breed – D. D. Cross

Duck plague vaccine

Manufacture of minced meat

Dry rendering of meat

Blade tenderizer

Preparation of sausage

Hot deboning of meat

3. FISHERIES

Technologies developed

Breeding technologies

- Captive breeding technology was developed for the ten prioritized species of indigenous ornamental fishes such as *Puntius flamentosus, P. melanampyx, P. melanostigma, Danio malabaricus, Garra mullya, Nemacheilus triangularis, Pristolepis marginata, Rasbora daniconius, Esomus danricus and Puntius sarana.*
- Fine-tuning of captive breeding protocols of four new fish species was accomplished under NATP.
- A protocol for breeding of the pearl gourami was developed.
- RARS, Kumarakom could accomplish captive breeding of five prescribed fish species viz. Karimeen *(Etropleus suratensis),* Manjakkoori *(Horabagus brachysoma),* Naadan Muzhi *(Clarias dussumieri)* Pullan *(Labeo dussumieri),* Kooral *(Gonoproktopterus curmuca).* Technology for breeding of Karimeen, the high valued endemic fish of Kerala has been a major accomplishment as now it is possible to produce seeds of this species on a massive scale by breeding them in race way systems.
- The biodiversity of prawns of Kerala consists of 14 species of *Macrobrachium*; one species of *Palaemon*, two species of *Leptocarpus*, four species of Caridina and four species of *Macrobrachium.*
- The highly priced freshwater ornamental fish, sucker catfish, could be successfully bred in earthen suitable habitat conditions.
- A male reproductive pheromone, from testis/vas deferens of *Macrobrachium idella* (Hilgendorf) was seen to be essential for normal ovarian maturation of females and in the absence of this male pheromone ovarian maturation gets arrested at the state IV at which stage massive yolk deposition usually starts.

Production technologies

- Commercial culture of giant freshwater prawn, *Macrobrachium rosenbergil* has been found technically feasible in pokkali fields. Production rate upto 808 kg/ha/ 153 day was achieved. June-December has been found the ideal period for culture. The species can fairly withstand pH fluctuations and the growth is satisfactory upto 9 ppt water salinity.
- From the integrated farming of pig and carps an average fish production of 3414 g/ha was obtained in 18 months without supplementary feeding, while in

the control ponds, where cowdung was used as manure, the production was only 1752 kg/ha in 18 months. In addition to fish yield an average of 348 kg of pig meat per pond size of 450 m^2 was also obtained.

- Prawn head meal based diet produced the highest growth rate for the culture of the fishes *Labeo rohita* and *Cyprinus carpio*. Best percentage of growth and survival of fish was obtained by using test diet with 20% soya bean inclusion level containing 27% crude protein.
- Monoculture of the giant freshwater prawn *Macrobrachium rosenbergii* with single stocking and drain harvest yielded a production of 903 kg/ha/6 months with a retrieval rate of 60%.
- Cage and pen fish culture in open waters like Vembanad lake is found to be commercially viable than pond fish culture. Small sized pens allow higher fish yield and lower production cost and easier management, although cost per unit area will be higher.
- A fish sanctuary (10 ha) in the Vembanad lake for the indigenous fish species was established to promote natural habitat, breeding and also for in situ conservation and to evolve technologies for fish ranching through artificial stocking of fast growing fish and giant fresh water prawns. In the ranching studies, tagged prawns were monitored through collections from capture fishery. The released prawns attained a maximum size of 350gm in the first year. Maximum distance travelled was 30 km.
- Study of pesticides on the juveniles of rohu *Labeo rohita* (Ham.) showed that chlorophenoxy herbicide was moderately toxic, organophosphate (malathion and methyl parathion) was toxic and endosulfan was very toxic. The insecticide–weedicide combinations were strictly additive toxic. The insecticide pairs (methyl parathion and malathion, malathion and endosulfan) showed more than additive toxicity, especially the malathion and endosulfan combination.
- In Cochin region, infestation with bopyrid isopod, which causes damage to fishery, was observed only in two species of *Macrobrachium* namely *M. idella* and *M. scabriculum*.
- The region around Panangad in Vembanad lake and tidal section of rivers, a partially mixed estuary during post monsoon season becomes well mixed type during pre-monsoon. Maximum primary production was seen during post monsoon.
- Silt laden turbidity of water directly and indirectly hinder the gonadal maturity of *Penaeus indicus* in coastal wetland grow outs.

- In monoculture, limited manuring and application of frugal quantity of eco-friendly feed containing 20-25% crude protein can substantially promote growth and production of *Liza parsia* @ 1.4 t/ha/yr.
- In monoculture of *Chanos chanos*, application of eco-friendly feed at optimum dose and frugal quantity of manuring could enhance mean growth @ 348 g achieving an appreciable production of 1.8 ton/ha/yr.
- Developed an eco-friendly management technique to effectively maintain disease free brood stock specimens of *Penaeus indicus* in wetland grow-outs.
- An adaptable low cost carnivorous fish farming method for *Lates calcarifer* in coastal wetlands was devised.
- Biculture between *Lates calcarifer* and *Oreochromis mossambicus* (Tilapia) @ 5000/ha in 1:5 ratio in grow-outs, enabled to attain optimum growth in both species ensuring the production of2 ton fish/ha/crop.
- Qualitative and quantitative increase in sustainable fish production @ 2.5 to 2.8 t /ha was attained at 1:5 stocking ratio during biculture between *Lates calcarifer* and *Oreochromis mossambicus.*
- The seasonal availability and recruitment of quality seed of Milk fish and Mullets is seen deflected during post Tsunami period with enhanced rate of turbidity and temperature prevailing in the coastal waters.

Value addition

- Solar tent and solar cabinet driers for drying fish without contamination and a technology for curing fish using irradiated salt for controlling spoilage were developed.
- Products such as prawn stick, prawn cutlet and value added paste products like fish cake, fish ball, burger, sausage, ham and fish paste were developed from low cost fresh water fishes.
- From the processing wastes of squid and cuttlefish bioactive substances like anti-bacterial, anti-viral and anti-cancer substances have been determined.

Technologies/Protocols transferred

Hatchery technology for *Macrobrachium* (fresh water prawns) seed production was transferred to the government and private sectors, especially in Andhra Pradesh, Karnataka and Tamil Nadu.The first 30 million (in a season) commercial hatchery was set up in Bhumanaram in Andhra Pradesh based on this technology.

Patents obtained

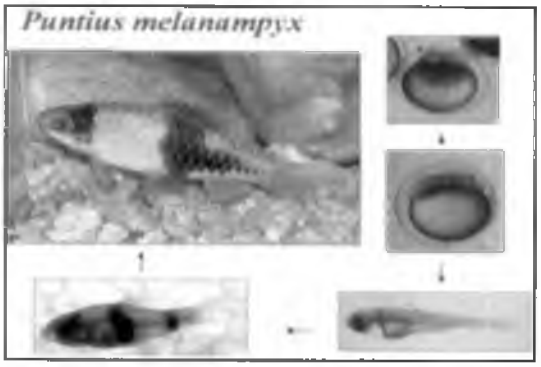
Sl. No.	Name of technology	Year of granting patent	Name of Scientists
1.	Depuration system for bivalves	1995	Dr. D.D. Nambudiri Dr. P.M.Sherif Dr. Sajan George Dr. I.S.Bright Singh

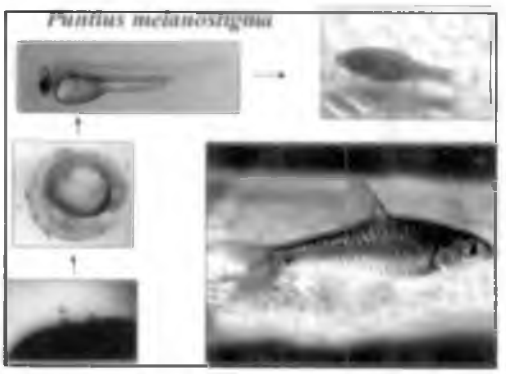
4. AGRICULTURAL ENGINEERING AND TECHNOLOGY

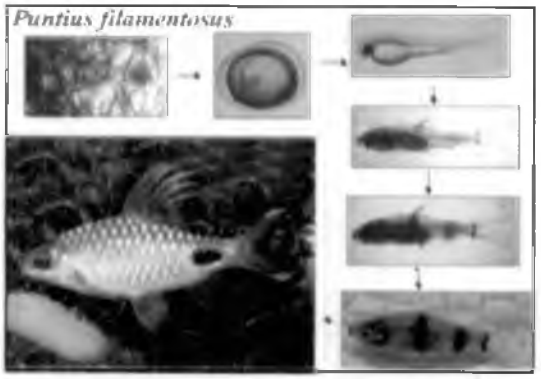
Machineries developed

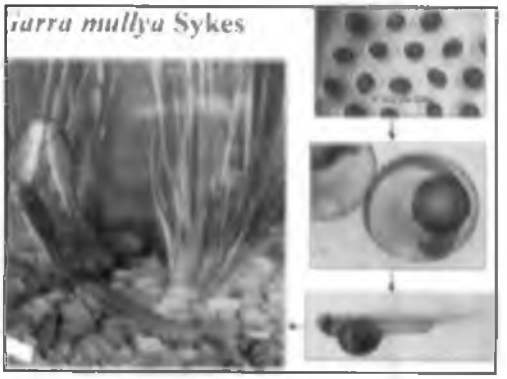
- Developed a power operated paddy dibbler.
- Developed a black pepper skinner.
- A simple pedal operated coconut husking tool was developed.
- A jackfruit harvester was designed and developed.
- An effective banana chipper was designed and developed.
- A self-centering basin lister attachment to power tiller, tractor or bullocks was developed for making a basin of 2 m radius in 2 –3 minutes.
- Tractor operated ditcher cum bed former was developed to make a ditch of 86.7 cm width, 17.75 cm depth and two half beds each of width 34 cm on either side. The equipment can cover 2.5 ha per day at about Rs.2000/-.
- A light weight, direct driven weeder (Micro tiller) with field capacity of 0.024 ha/hr was developed to clear weeds even where clods/stones exist. The working diameter of the cutting blades is 0.42 m.
- A large diameter pit digger was formulated to take a pit of size 80 cm deep and 100 cm diameter at the top in nearly 3 minutes.
- The rotary coconut-husking machine was redesigned and refined. The concept of continuous rotary husking was introduced in this machine for the first time. The machine gave 400-600 nuts/hr.
- The power operated coconut climber was redesigned and refined which reduces the cost of harvesting to half and also avoids falling from the tall trees.
- An integrated composite anthropometer is designed for quick and reliable collection of anthropometric data.

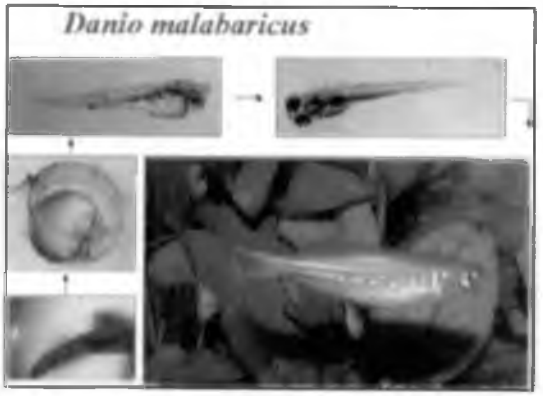
Captive breeding

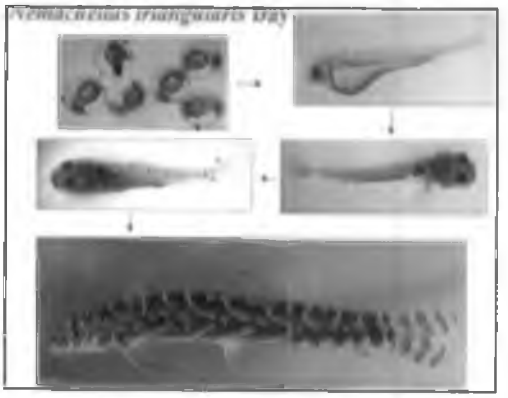


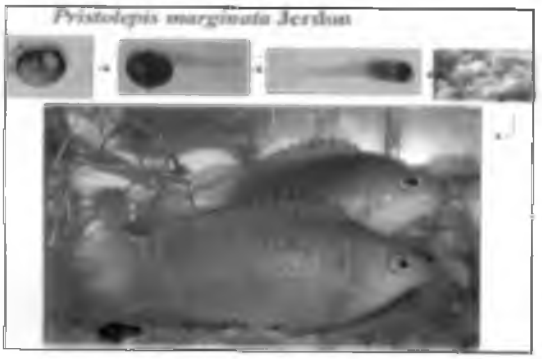


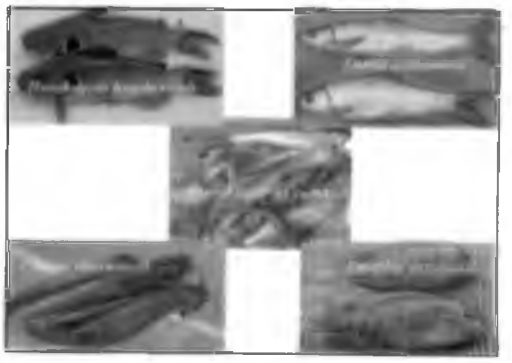












Fish – Pig integration

Fish – Duck integration in padasekharams

Grass carp for the control of Azolla imbricata

Fish sanctuary in Vembanad lake

Cage and Pen structures for fish culture

Depuration system

- Mitsubishi power tiller with air–cooled engine for mounting it with reaper assembly was delivered to Kerala Livestock Development Board and the machine was redesigned after incorporating the suggestions by KLDB. This fodder harvester was fabricated in the college workshop and it was delivered to Dhoni farm with a view to substitute the costly imported machines.
- A counter weight type climber was fabricated with a weight of 50 kg permanently installed on the top of the palm and a sliding mechanism with foot-rest connected each other with a steel wire rope was fabricated. It took 15 seconds to go up and come down in 4.5 m palm and 3 minutes of preparation.
- A nut splitting machine was developed which consists a pedestal, pivoted long handle, cutting knife and a platform. The knife was raised by lifting the handle, the kernal was placed on the platform and then the knife was lowered and forced to cut the kernal.
- The design, development and field evaluation of low cost transplanting mechanism for paddy by employing the crank and oscillating link mechanism with a seedling pusher attached with inertia force exerted by a sliding mass was completed. The total cost of transplanter can be reduced by 30%.
- Design and fabrication of a motorised paddy winnower cum cleaner with an efficiency of cleaning 1000 kg of grain or 600 kg of seed per day.
- Developed and popularized KAU micro sprinkler (Bubbler).

Technologies developed

- Use of Yanji transplanter resulted in saving of 80 % labour, 56 % cost, 40% time, 30 % seed paddy and 20 % increased yield. After transplanting with Yanji transplanter the cono-weeders are found effective for weeding and invariably used by farmers.
- Mini tiller with tilling rotor having 62.5 cm width and up to 20 cm working depth with 104 rotory blades is found suitable for cutting and levelling dry fields and also for wet fields.
- The miracle rotor is found effective to loosen the topsoil in the coconut/arecanut fields.
- Under Frontline Demonstration, 8-row paddy transplanter, paddy reaper, lift type paddy thresher and horticulture tools were taken up. Custom hiring of modern agricultural machinery were promoted. Rural youths both men and women were given training in operating and maintenance of power tiller, paddy transplanter, paddy reaper and paddy threshers. Under Kundumbasree programme, these groups were provided with power tiller, transplanter, reaper and threshers.

- Anakkara Panchayat in Palakkad Dt. and Tavanur Panchayat in Malappuram Dt. had supplied Agricultural machinery to women groups and they were encouraged to operate on custom hiring basis successfully.
- Fertigation experiment on banana: Water use efficiency, benefit-cost ratio and yield were higher for the treatment with 80% of the recommended fertilizer dosage through drip system.
- Fertigation studies in Nendran showed that water use efficiency and yield were higher with 80 per cent of the recommended fertilizer dosage.
- Crop geometry experiments in banana (Nendran) revealed that water use efficiency and benefit cost ratio were maximum for the treatment with three suckers per pit at 4 m x 3 m spacing.
- Standardised water requirement and irrigation methods for rice, banana, cowpea, blackgram, groundnut, sesamum, coconut, tuber crops, bitter gourd, ash gourd, pineapple etc.
- Performance evaluation of different types of green houses indicated that green houses with sophisticated environmental control are not essential in our climate, instead, a low cost technology called 'protected cultivation' is useful. The frame work of the structure can be made of bamboo or arecanut palm poles and the roof claddings is to be done with transparent UV stabilized polythene film. The sides can be kept open to ensure ample ventilation or can be provided with insect proof netting or shade net. Cultivation of high value crops like salad cucumber and capsicum, off-season production of tomato and cultivation of cut flowers like aster and gerbera gave high returns with increased productivity.
- The Precision Farming Development Centre at KCAET, Tavanur has developed a low cost technology called rain shelter cultivation for protected cultivation of vegetables. The framework of this structure can be made of bamboo or arecanut palm poles, which are easily available. The roof claddings are to be done with transparent UV stabilized polythene film. The sides can be kept open to ensure ample ventilation or can be provided with insect proof netting or shade net.
- Trials conducted inside the rain shelter with high value crops like salad cucumber and capsicum showed that high returns can be obtained with increased productivity. Off-season production of tomato, bhindi and cut flowers like aster and gerbera were also successful.
- Off-season cultivation of tomato inside rainshelter was a success and productivity of tomato was higher by about 3.5 times than outside in the same season.

- Plastic mulching significantly increased the growth and yield of vegetables like bhindi, brinjal, amaranthus etc.
- Sub-surface tile drainage is very effective in washing out toxic salts from sub soil and increasing rice grain yield in the kayal and kari soils of Kuttanad.Sub surface drainage using clay tile drains at spacing of 30 m significantly improved the leaching and removal of toxic iron, sulphates, chlorides and drastically improved the N use efficiency and it significantly improved the productivity of the area and the over all increase in rice yield was 1.1 t/ha over ill drained areas.
- In Karumady area, introducing subsurface drainage attained perceptible improvement in soil conditions and productivity. An additional paddy yield of 1.36 t/ha could be obtained by introducing subsurface drainage. This could also control acidity and salinity and remove spatial variation in its occurrence.
- Studies conducted under AICRP on agricultural drainage has shown that perceptible improvement in soil conditions and productivity can be made by sub-surface drainage. Controlling acidity and salinity and removal of spatial variation in its occurrence is made possible by sub-surface drainage. Additional paddy yield to the tune of 1 t/ha can also be realized.
- Economic analysis for a 100 ha farm revealed that sub surface drainage is economically feasible with a B-C ratio of 2.45. The system can economically support if it can realize an additional yield of 0.41 t/ha from the present level.
- Full potential of N efficiency can be realized only in conjunction with drainage.
- The performance of clay tile drains are better than PVC drains even though mean port opening area is more in PVC drains. This is due to the thin slot width of the PVC drains that are clogged due to iron sludge deposition.
- The crop growth parameters, the grain yield and 100-grain weight were significantly higher when subsurface drainage was provided.
- Field studies on sub-surface drainage indicated that partial pumping will be sufficient for attaining significant increase in grain yield during additional crop season when a well-distributed rainfall is available.
- Drain spacing up to 30 m could significantly improve the productivity of the area and the overall increase in rice yield due to subsurface drainage is 1.36 t/ ha.
- Subsurface drainage could remove the heterogeneity in the soil chemical properties, which is the root cause for patchy crop growth and uneven ripening of rice crop in the Karumady area.
- Subsurface drainage was very efficient in leaching iron, sulphate, chloride, sodium, potassium, calcium and magnesium and for controlling salinity.

- K18 culture was found to be the most suitable of the rice varieties tested in *Kari* soils under subsurface drainage yielding 3.16 t/ ha with a fertilizer dose of 120:60:60 of N: P: K per ha and a seed rate of100 Kg/ha.
- Coir geotextiles can be very effectively used for conserving soil and water in varying slopes and for slope land cultivation.

Technologies/Protocols transferred

- Technology of coconut husking tool was transferred to RAIDCO for mass production and popularisation.
- Technology of tender coconut punch –cum-splitter was transferred to Kerala Agro Industries Co-operation Pvt.Ltd.

Patents applied

Sl. No.	Name of product	Year of application	Name of Scientist
1.	Coconut husking tool	1995	Jippu Jacob Joby Bastian
2	A soil counter sinking attachment	1996	Jippu Jacob P.R.Jayan Joby Bastian
3	Regenerative pump	1999	Prof. K.P. Pandey
4	A hinge with integral stepper	2000	Prof. C.P. Muhammad
5	An improved Seedling Transplanting mechanism	2000	Prof.C.P. Muhammad Dr. M. Sivaswami Er. Jippu Jacob
6	Improvements in/or relating to a Syphoning device	2000	Prof. C.P. Muhammad
7	Improvements in/or relating to cooking and or storing vessels	2001	Prof. C.P. Muhammad
8	Attachment for making basins around trees	2002	Prof. C.P. Muhammad Er. Jippu Jacob Dr. V.R. Ramachandran
9	The novel roto_dynamic regene-rative pump for wind powered water pumping applications	2002	Dr. Sathyajith Mathew Prof. K.P. Pandey

Seed drill

Banana chipper

Jack plucker

Self centering basin lister

Bed former

Direct driven weeder

Large diameter pit digger

Rotary coconut husking machine

Power operated coconut climber

Tender coconut punch-cum-splitter

Frontline demonstration of paddy transplanter

Frontline demonstration of paddy reaper

Use of Conoweeder

Field investigations for the polyethylene sub-surface dyke in Bharathapuzha

Use of coir geo-textiles for varying slopes and river bank protection

Coconut husking tool – Kera Mithra