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# RESEARCH HIGHLIGHTS 1993-95



**Directorate of Research  
Kerala Agricultural University  
Vellanikkara 680 654  
Thrissur, Kerala**

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# Foreword

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The Kerala Agricultural University is entering its Silver Jubilee Year in 1997. The report, besides briefly indicating the major contributions made by the scientists in the Faculties of Agriculture, Agricultural Engineering, Veterinary & Animal Sciences and Fisheries highlights the significant research achievements during the period 1993-95. With the substantial assistance received from the Government of Kerala, ICAR (including the World Bank aided National Agricultural Research Project) and other Central Government agencies, most of the research stations have been strengthened substantially. The University has adopted multi-disciplinary, location - specific, problem-oriented research which has started yielding useful results. Thrust is being given to passing on the information and seeds/planting materials/young ones of animals, birds, fishes to the respective Government Departments and farmers. We shall continue to follow this path consciously, giving emphasis on entering the frontier areas of research such as Biotechnology, Molecular Biology, Appropriate farm mechanization, Computer applications, Remote Sensing and Crop/System Modelling, and to train young scientists in the Centres of Excellence in India and abroad. Evolving appropriate technology with bias towards reducing the drudgery of the agricultural technologists would receive attention of the researchers. The Central Library and Information System with connections to National and International Information Network, being established would help our scientists and students to instantly interact with their counterparts around the world.

It is sincerely hoped that the report would be useful to the researchers, policy makers and to the enlightened farmers alike.

A.M. MICHAEL  
VICE-CHANCELLOR



# Preface

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*In the past, the KAU has been publishing its annual research reports adopting project-wise format. Now, in addition to this format (which will be circulated to the libraries, Research Institutes and Stations), we are bringing out an abridged version in a more readable format with appropriate photographs. The University, has identified thrust areas for research and has, therefore, presented the information grouped under different co-ordination groups. The major contributions so far made have also been summarised in each Co-ordination group so that the reader would get an overview of the activities. The intention is to give a lucid picture of the achievements so far made and to indicate the present trends.*

*The highlights reported were generated by projects funded by the ICAR, DBT, STEC, FERRO, ICSSR, Commodity Boards, DAC, Government of Kerala, several agro-based industries, CSB, Coffee Board, Rubber Board, Spices Board, National Horticulture Board, KHDP, ISRO, Wasteland Development Board etc.*

*This report on the highlights summarises the outcome of research carried out during 1993-94 and 1994-95.*

N. Mohanakumaran  
**DIRECTOR OF RESEARCH**



*Faculty  
of  
Agriculture*

### Crop improvement

Research on rice and rice-based cropping system progressed in various centres, namely, the Regional Agricultural Research Station, Pattambi; Rice Research Station, Moncompu; Rice Research Station, Vyttila; Agricultural Research Station, Mannuthy; Rice Research Station, Kayamkulam; Agricultural Research Station, Chalakudy and Cropping Systems Reserach Centre, Karamana. These stations have made substantial contribution in the past by the release of varieties as well as through the development of technologies. From "Aryan" till "Aiswarya", 52 varieties were released from Pattambi. Eleven varieties were evolved at Moncompu and a few varieties from Kayamkulam, Mannuthy and Vellayani.

Among the earlier selections from Pattambi, many received international acceptance as donors of resistance to various pests and diseases. Ptb 18 and Ptb 21 are resistant to stem borer, gall midge and tungro virus. Ptb 7 is resistant to foot rot and gall midge. Ptb 19 and Ptb 33 have been universally acclaimed as varieties resistant to brown plant hopper. Ptb 12 is tolerant to bacterial leaf blight. Ptb 15 and Ptb 16 are resistant to water logging. Ptb 10 (Thekken Cheera) deserves special mention as it has won name and fame in other rice growing countries, being helpful in the development of most of the short duration high yielding dwarf varieties released from Kerala.

Ptb 35 (Annapoorna) released in 1966 from Pattambi was the first high yielding rice variety of the Country. Rohini, Aswathy, Triveni, Jyothi, Bharathy, Sabari, Swarnaprabha, Jayathy and Neeraja are widely in use within as well as outside the Country.



With the emphasis on integrated pest and disease management, the effort during the period under report has been on evolving rice varieties with multiple resistance to major pests and diseases. Considering the multiple resistance to blast and sheath blight, four new varieties, Kairali (Pt 49), Kanchana (Pt 50), Aathira (Pt 51) and Aiswarya (Pt 52) were released in 1993 for general cultivation.

The eleven varieties evolved at Moncompu are Mo 1, Mo 2, Mo 3, Mo 4 (Bhadra), Mo 5 (Asha), Mo 6 (Pavizham), Mo 7 (Karthika), Mo 8 (Aruna), Mo 9 (Makam), Mo 10 (Remya) and Mo 11 (Kanakom). These varieties are specifically suited for the Kuttanad tract as they resist brown plant hopper, an endemic pest of rice in the region.

The rice varieties released from Kayamkulam include UR 19, KYM 1 (Lakshmy), KYM 2 (Bhagya) and KYM 3 (Onam).

The Vyttila Station, in the pokkali tract, has evolved Vyttila 1, Vyttila 2, Vyttila 3 and Vyttila 4, with ability to withstand salinity.

The rice varieties released from Mannuthy include Cochin-1, a popular rabi variety and H 4, a promising tall variety withstanding waterlogging. An extremely short duration variety suitable for the kole areas was released in 1993 under the name Hraswa.

The significant contributions in rice research during the period under report include the release of the following varieties:

**Ahalya (Cul. 10-1-1)**

It is a selection from the cross Pt 10 x TN 1, having short duration and red kernels, maturing in 90-100 days and producing around 5.0 t/ha grain yield (Plate 1). It fetches premium price in the market as the grain has excellent cooking quality. The variety tolerates leaf folder and moisture stress in the early growth phase.



### **Mangala Mahsuri**

This is a selection from Mahsuri (Plate 2). It tolerates abiotic stress like iron toxicity and shallow flooding as well as major pests and diseases of the Central region, from where it is proposed. The grain colour is red and it has excellent cooking quality and volume weight.

### **Vyttila 5**

It is a Mahsuri mutant with medium duration and has tolerance to acidity, salinity and flooding (Plate 3). This fine grained, white kernelled variety has excellent cooking quality and very high protein content. Average yield is about 3.0 t/ha.

### **Renjini (Mo 12)**

This resulted from a cross between Mo 5 and Improved Sona (Plate 4). It is a medium duration, blast resistant variety with an average grain yield of 4.5 t/ha. It is ideally suited for blast endemic areas. The variety tolerates sheath blight, sheath rot, brown plant hopper and gall midge under field conditions.

Rice varieties in the pipeline are:

Mo 1-20-19-4, a mutant derivative from Mo 1 (Chettivirippu), is a heavy yielder and tolerant to sheath blight and sheath rot.

M6 1-6-1-1-1 (Pothane x Mo 5)

M6 9-29-2-1-2 (Surekha x Mo 6) resists gall midge biotypes 1, 2 and 4.

Edavaka has promise for the high ranges (Plate 5).



Culture 877117 and Culture 87136, which resulted from crosses between Co 25 and Adt 14, are photosensitive. The former is red kernelled, while the latter is white kernelled.

Another promising culture is A 4-3-1, evolved from the cross Ptb 20 x M 210. It has red kernels, non-lodging character, good initial vigour and a duration of 110-115 days.

IET 12797, an entry in the advanced yield trial at the Agricultural Research Station, Mannuthy, recorded high grain yield of 7288 kg/ha.

At the Rice Research Station Moncompu, three promising cultures from the breeding programme for high yielding varieties with multiple resistance suited to Kuttanad, viz. M 38-4-1 (Mo4/Cul. 25331), M-38-4-2 and M48-11-3 (Thonnuran/IR8) and three promising cultures from the breeding programme for high yielding varieties of rice specifically suited to the additional crop season of Kuttanad (with seed dormancy), viz. Cul. M42-6-2 (Mo6/Pokkali 372), M42-6-3 and M45-20-1 (Cul.12814/Mo6) were advanced to multilocational trials.

In the breeding programme for evaluation of gall midge resistant varieties suitable for Kuttanad, one culture M59-29-2-1-2 (Surekha/Mo5, IET 13983) was found to be resistant to gall midge biotypes 1 to 4. It ranked 17th in grain yield out of the 68 entries in the Initial Variety Trial - IME under the All India Coordinated Rice Improvement Project. It was promoted to the Advanced Variety Trial - IME of Kharif '95.

In the gall midge screening trial at Pattambi, 31 cultures showed resistance to the gall midge biotype prevalent in the locality.

In the breeding programme for evolving high yielding varieties for Pokkali area Cul. 852 and Cul. 857 outyielded Vyttila 3 for four consecutive seasons.



A photosensitive variety of Kayamkulam, Culture 8781 (PTB 20/ Mahsuri) was promoted for farm trials with Culture P 22, a mutant line from PTB 20.

### **Crop management**

In dry sown rice under semi-dry system, growing cowpea as a green manure crop concurrently increases rice yield through the addition of about 12 t/ha green matter, improvement of soil fertility and suppression of weed growth.

Delaying planting beyond July 20th and using seedlings of more than 25 days old reduced the yield. When delay in planting is anticipated, varieties like IET 9757, Red Mahsuri or IET 5914 may be used to minimize yield reduction.

In wet sown puddled rice, application of the herbicide anilophos @ 0.3 kg ai/ha recorded the lowest weed biomass and the highest grain yield. The efficiency could be enhanced by the combined continued application with 2-4 DEE @ 0.4 kg ai/ha. Under semi-dry conditions, the herbicides butachlor (1.5 kg ai/ha), pendimethalon (1.5 kg ai/ha) and pretilachlor (1.0 kg ai/ha) were effective in suppressing weed pressure and increasing grain yield. Weeds in dry sown low land rice was also most economically managed by the application of butachlor (1.5 kg ai/ha). Post emergent application of metalochlor (1.0 kg ai/ha) and oxyflourifen (0.1 kg ai/ha) reduced weeds considerably.

The herbicides Pretilachlor and Butachlor with safeners were found promising in wet seeded rice and did not show any phytotoxicity at Moncompu.

Permanent manurial trials indicated that inorganic fertilisers in combination with organics (cattle manure) have a positive influence on increasing grain yield. Among the different urea forms tested, neem coated



urea applied either full as basal or as two splits recorded maximum grain yield and nitrogen use efficiency.

Neem extract (nimin) was found to be an effective coating material for urea to increase nitrogen use efficiency in wet-seeded rice, under puddled condition.

Application of modified and coated urea material as a single basal dose was as effective as split application of prilled urea at Moncompu. This can be adopted under situations where split application is not feasible due to various reasons.

Zinc sulphate application at higher rates than 25 kg/ha was detrimental to rice crop.

In an evaluation of fertilizer response and production potential of promising saline tolerant rice cultures of Vyttila, it was observed that for realising economic yield in the inherently fertile pokkali soils, application of chemical fertilizers was not required.

Water management studies at Chalakudy revealed that the different irrigation treatments influenced grain and straw yields. The best practice for Kharif was 5.0 cm water, while the same for Rabi was 2.0 cm.

Continuous flow submergence gave maximum yields of grain and straw (4094 and 4298 kg, respectively) and was superior to continuous stagnant submergence and 7.0 cm irrigation three days after the disappearance of ponded water. In summer, when water is scarce, irrigation can be delayed up to three days after the disappearance of ponded water without yield reduction. In the sandy loam soils of Chalakudy having shallow water table, irrigation at five days after the disappearance of ponded water was found to be on par with continuous submergence, for the second crop.





Plate 1. Rice variety Ahalya



Plate 2. Rice variety Mangala Mahsuri



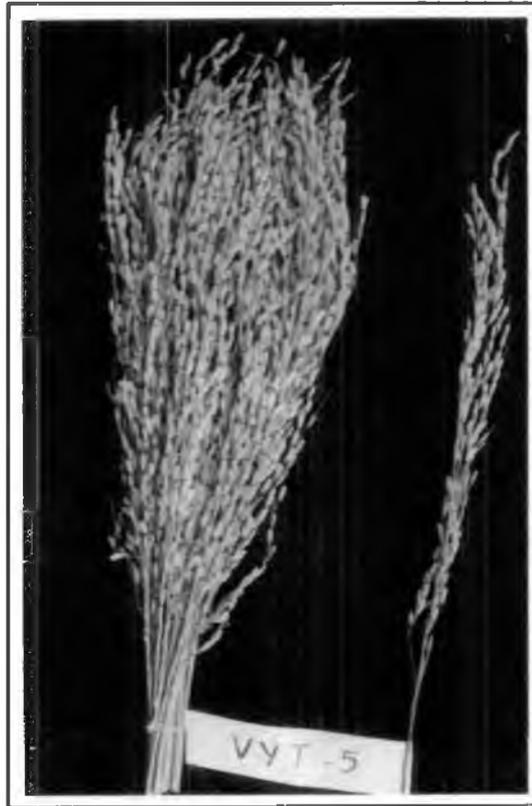


Plate 3. Rice variety Vytilla 5



Plate 4. Rice variety Renjini





Plate 5. Rice variety Edavaka



Plate 6. Coconut variety Lakshaganga





Plate 7. Coconut variety Keraganga



Plate 8. Coconut variety Anandaganga



Field experiments at Karumady on soil surface drainage to alleviate soil problems of kari land provided a good response with respect to rice production. The incremental yield was computed to be 1.0 to 1.2 t/ha with a spacing of 30 cm between the drain lines. Seepage losses in paddy fields could be reduced by brick lining. Effective sub-surface drainage removes toxic salts, improves aeration and thereby increases grain yield.

In the insecticide evaluation trial, Miral 0.6 kg ai/ha was effective in controlling stem borer incidence at 50 DAT (at Moncompu) and leaf roller and stem borer incidence (at Pattambi). Application of carbofuran / phorate @ 1.0 kg ai/ha significantly reduced the *Heterodera oryzae* larval population in soil and root as well as the cyst count in soil and root at Vellayani.

Contaf 5 EC @ 2 ml/litre was effective in controlling sheath blight of rice, which was promoted for farm trial.

In the genetic evaluation of rice germplasm against biotic stress at Moncompu, 6000 accessions were screened for sheath blight and sheath rot resistance. Seventy six accessions were found to have low score values for the diseases.

In the variety screening for sheath blight at Pattambi 14 entries in NSN I, 58 entries in NSN II and one entry in DSN were found to have low score values for the disease.

Beam 75 WP (tricyclazole) and Baycor 25 WP (bitertanol), two new fungicides, were effective in controlling blast disease of rice and increasing yields of grain and straw.



Exploitation of heterosis to enhance production and productivity has been the major objective in coconut research. The Regional Agricultural Research Station, Pilicode, is the main centre of the University where research on coconut is undertaken. The first hybrid coconut was released as T x D, which is very popular throughout the State. The Station has a unique collection of coconut germplasm consisting of several exotic and indigenous types. During the early nineties, three new hybrids, Lakshaganga (LO x GB) (Plate 6), Keraganga (WCT x GB) (Plate 7) and Anandaganga (AO x GB) (Plate 8) were released. Among the outstanding contributions of the Station during the period under report, is the release of the hybrid Kerasowbhagya (WCT x MYD) (Plate 9). As MYD is responsible for disease resistance in general, in all coconut growing countries, this hybrid has the potentiality for good yield in disease prone areas.

The exotic coconut variety Kudat was found promising among the new introductions made in 1976.

With respect to the root (wilt) disease, only management studies have been carried out by the University. The disease is debilitating and non-lethal in nature. The death of the palm occurs subsequently due to infection by a weak fungal pathogen, *Helminthosporium halodes* as well as due to infestation by red palm weevil. In case a root (wilt) affected plant is not attacked by leaf rot or red palm weevil, the palm can continue to produce fairly good yields for at least ten years. Spraying the foliage with 1.0 per cent Bordeaux Mixture before the onset of monsoon and root injection of monocrotophos have been found to be very effective for the purpose. Further studies on the etiology of root (wilt) is in progress.



Irrigating the palms at IW/CPE ratio of 0.5 along with a fertilizer dose of 0.5 : 0.32 : 1.5 kg NPK per palm per year increased nut yield and oil content. The effect of drought on nut yield was seen in the eighth month which continued for twelve months, with the maximum effect in the 13th month after the drought.

Growing *Coleus vetiveroides* as an intercrop in coconut gardens was found to be remunerative.

It was found possible to reduce the cost of cultivation by partial substitution of Muriate of potash with NaCl. Experiments with WCT as well as hybrids indicate that partial substitution of potassium by sodium is quite likely. Further studies are in progress.

Long term fertiliser experiments of the Coconut Research Station, Balamapuram, representing laterite soils in southern Kerala, have shown that potassium can independently influence the nut yield. Nitrogen was found to influence the yield only in combination with P or K.

Elaborate studies conducted at the Coconut Research Station, Balamapuram showed that NPK requirement for an adult palm in red loam soil of southern Kerala was 0.68:0.23:0.90 kg/year. Study on the effect of interaction between spacing and manuring on the growth and productivity of coconut indicated that NPK @ 0.68:0.45:0.90 kg/palm/year and the spacing 7.5 x 7.5 m were the best with respect to per palm yield. However, NPK @ 0.68:0.45:0.90 kg/palm/year and the spacing 5.0 x 5.0 m recorded the maximum yield/ha.

The optimum spacing of coconut was found to be 7.5 m x 7.5 m. Trials conducted at Pilicode indicated that coconut hybrids require 300 l water once in four days along with a fertilizer dose of 0.5 : 0.5 : 1.5 kg NPK/palm/year in two split doses.

The response of magnesium, a secondary element has been tested in



two different soil types, laterite and alluvial. In laterite soil, the yield of coconut increased due to magnesium application. However, the trend was not observed in alluvial soil. Diagnosis and Recommendation Integrated System (DRIS) was applicable to coconut. DRIS could be used for nutrient management in conjunction with critical level approach.

Moisture conservation is of vital importance in coconut cultivation, especially in the northern districts with prolonged spell of drought. Surface mulching of coconut basins with waste coconut leaves (12/basin) or burying coconut husk in linear trenches helped moisture conservation and increased nut yield.

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

Multilocational trials conducted in different parts of Kerala indicated that Carbaryl 0.2 per cent, HCH 0.2 per cent and Endosulfan 0.1 per cent were effective in the management of coreid bug. Guava was found to be an important collateral host for the pest.

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

Root production in banana varied between the plants grown in the coconut garden and in the open. Rainfed banana in the coconut garden developed a spreading root system, while irrigated banana developed a compact root system. Irrigated banana and rainfed banana in the open developed spreading and compact types of roots, respectively.



Root production in colocasia variety Cheruchempu, grown as an intercrop in coconut garden, differed with light intensity. Root production and distribution increased with growth phases upto 120 DAP and declined thereafter.

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

When banana and cassava were grown as intercrops, 75 per cent of the fertiliser dose recommended for each crop was found sufficient for obtaining high yield in both the crops.

The economic feasibility of growing pepper as a component crop of coconut was confirmed in an experiment conducted at the Regional Agricultural Research Station, Kumarakom. Panniyur-1 was found to be the best variety for the system. Planting yams as intercrop among coconuts in the reclaimed alluvial soil was found feasible.

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



The cultivation of solanaceous crops is a difficult task in the acidic soils of Kerala due to the high population dynamics of the bacterial wilt pathogen *Pseudomonas solanacearum*. The growth and survival of all the solanaceous crops, viz. tomato, chilli and brinjal are affected; tomato being the greatest victim. Shakthi, a tomato variety resistant to bacterial wilt has already been released from the College of Horticulture, Vellanikkara. Another promising tomato line, LE 79-5 (a segregant of LE-79), resistant to bacterial wilt could be identified (Plate 10). This line was recommended for release in national level.

Five hybrids, resulted out of a line x tester analysis, viz. Arka Abha x LE 370, Arka Alok x PKM-1, Arka Alok x LE 312, Arka Alok x RFH-1 and Sakthi x RFH-1, were found promising.

The incidence of early blight, cercospora leaf spot and target leaf spot were severe during rainy season, while virus diseases viz. mosaic and leaf curl were severe in summer months. Two new lines, LE 214 and LE 447 were found resistant to bacterial wilt, besides the existing variety Sakthi.

Crossing wilt resistant and crack resistant tomato lines resulted in promising hybrids resistant to both the problems.

A paprika line, CA 517 was identified as promising for yield and minimum incidence to bacterial wilt (12.5 per cent).

Ujwala (CA 219), a clustered chilli variety, having resistance to bacterial wilt was recommended for release (Plate 11). This variety has the highest colour value (139 ASTA units) and capsaicin content (0.49%).



Swetha (SM 6-6), a bacterial wilt resistant line (Plate 12) was recommended for release. The variety is having white fruits and yield potential of 30 t/ha. The variety Soorya was found resistant to *Meloidogyne incognita*.

Crosses of brinjal SM-6-6 x SM-132, SM-6-2 x Pusa Purple Cluster and SM-6-7 x Pant Ritu Raj out-yielded parents and showed resistance to bacterial wilt. The resistance is inherited in monogenic recessive manner.

Cucurbits are the main summer vegetables of the State, cultivated in river banks, rice fallows and homesteads. The leading cucurbits grown are bittergourd, snakegourd, pumpkin, ashgourd and watermelon.

MC-84 (proposed as Preethi) from the College of Horticulture, Vellanikkara is a high yielding selection of bittergourd which can be grown throughout the year (Plate 13).

Priyanka (Sel 1010), a high yielding variety (28 t/ha) suitable for cultivation in the acidic, alluvial soils of South Kerala was recommended for release (Plate 14).

The snakegourd variety, Kaumudi (Plate 15) evolved at the Sugarcane Research Station, Thiruvalla is highly acceptable to farmers and is already under commercial cultivation in Alappuzha and Kottayam districts.

Advanced generations of the interspecific crosses of *Trichosanthes anguina* x *T. cucumerina* gave the maximum number of fruits per plant (26 numbers).

Three genotypes viz. CM 349, CM 346 and CM 350 with orange flesh were found high yielding. They had more flesh thickness (5.5 cm). The line CM 349 is being tested under farm trial in the State and CM 346 and CM 350 have been given for national level testing under the AICVIP.

BH-21, a superior accession of ashgourd with an yield potential of 20 kg/plant from an average of five fruits is under farm trial.



There is tremendous scope for the cultivation of water melon in rice fallows and in river beds in view of its short duration nature, high productivity and great demand during the summer. Huge quantity of water melon fruit reaches Kerala markets from the neighbouring States. Varietal screening carried out indicated the superiority of Sugar Baby with respect to yield, earliness and TSS content. This variety was found suitable for the river bed system of cultivation in Malappuram district.

A watermelon hybrid, MHW-6, tested under AICVIP, Vellanikkara was found to have an yield potential of 25 t/ha.

Pusa Sharbati and PMR-6 are two varieties of dessert type musk melon suitable for cultivation in December in the southern zone of Kerala.

Mudicode Local with an yield of 9 kg/plant was identified as a high yielding type of oriental pickling melon.

The cucumber variety, Cul. EC-179394 with an average yield of 20 t/ha was found promising for cultivation in Kerala.

Yellow vein mosaic disease of bhindi affects the fruit yield. Resistance is easily broken as exhibited by Pusa Sawani. Therefore, studies on genetic divergence as well as crossing between wild parents were undertaken at the College of Agriculture, Vellayani. Seventy genotypes were grouped into six clusters. The maximum divergence was observed between clusters II and VI and the minimum between clusters I and IV. Most of the wild species of *Abelmoscus* and cultivated accessions, viz., 94-148, 94-271 were found resistant to yellow vein mosaic. Hybrid seeds of the cross between *A. manihot* and *A. esculentus* were developed. As the disease is transmitted by insect vectors, the incidence is generally low during May-September when the insect population is low.

Wild species like *Abelmoschus tetraphyllus*, *A. manihot* ssp. *tetraphyllus*, *A. ficulneus*, *A. moschatus* and *Hibiscus hegeli* and varieties like Arka





Plate 9. Coconut variety Kerasowbhagya

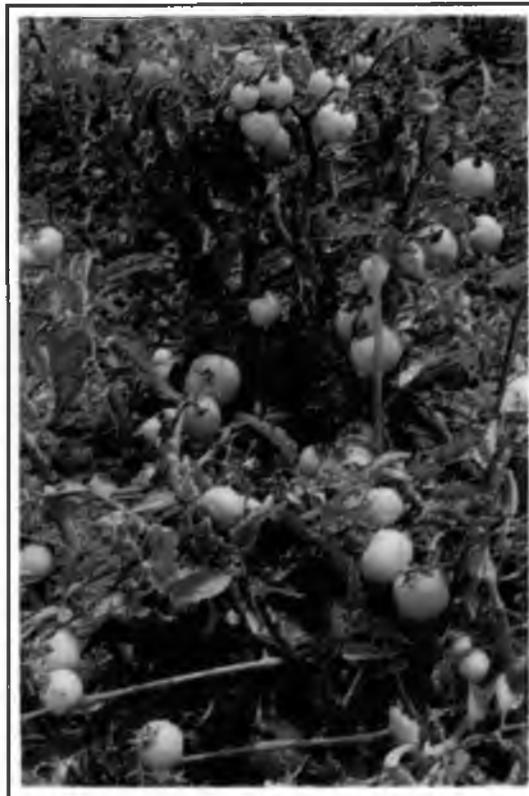


Plate 10. Tomato line LE 79-5





Plate 11. Chilli variety Ujwala



Plate 12. Brinjal variety Swetha



Anamika, Arka Abhay and P<sub>7</sub> were found resistant to yellow vein mosaic virus.

AM-4, Thamaravenda (*Abelmoschus manihot*) genotype resisting yellow vein mosaic virus was found promising (13.5 fruits / plant).

Two promising genotypes of bhindi, AE-202 and AE-198 with an average yield of 12-15 t/ha, evolved at the College of Agriculture, Vellayani were recommended for farm trials.

Amaranthus is a leading leafy vegetable. Two late flowering lines of amaranthus viz. A-6 and A-152 were identified. The lines take 105-110 days to flower when planted in August.

Water convolvulus (*Ipomoea aquatica*) was found to be a potential leafy vegetable for Kerala. It has good palatability, high nutritive value and less oxalate content. Green yield to the tune of 8 t/ha can be realised.

A tetraploid in coccinia with more number of fruits was developed.

Vegetable cowpea has great demand in Kerala due its high dietary value. However, only very few commercial varieties are available in the State. The variety Arka Garima is a bush type vegetable cowpea with high yield potential.

Two hybrids, Sel. 2-1 x VS-398 and VU-18 x Arka Garima were found promising (122.4 g and 89.9 g/plant, respectively).

Winged bean and dolichos bean are suitable for commercial cultivation in Kerala. PT-52 (Revathy), a promising variety of winged bean has been recommended for release. PT-35-1 with an average yield of 6 t/ha is another promising type. Accession number DL-13, with average yield of 16 kg/pit, is a high yielding dolichos bean type.



Germplasm collections of perennial vegetables including 200 accessions of drumstick, 65 accessions of ivygourd, 62 accessions of curry leaf, 105 accessions of gamboge and 23 accessions of star gooseberry are being evaluated.

Collections of vegetables, namely, bittergourd, snakegourd, cucumber and ridgegourd were made at the Regional Agricultural Research Station, Pilicode. They were screened for high yield and tolerance to pests and diseases. One superior line each was proposed for farm trials.

Nidhi / Koombu Vella, a tapioca variety developed through clonal selection at the Rice Research Station, Kayamkulam is specially suitable for Onattukara tract.

A sweet potato variety Kanjhangad (ACV 1) was developed through clonal selection. It is recommended for Kharif season due to higher yield (40 t/ha) and quality of tubers, low weevil incidence and tolerance to pests and diseases.

Farmers depend largely on organic source of manure for cultivating vegetables. Attempts for standardising fertiliser doses and agrotechniques are not sufficient enough. The University has initiated earnest efforts in this regard, to be of help to the vegetable growers of the State.

Bhindi is found to be the most remunerative crop during summer in rice fallows.

In bittergourd, application of the plant growth substance CCC (100-300 mg/l) was found effective in increasing the yield.

Drought tolerance could be induced in cucumber using triazole compounds like triadimefon. Use of the chemical could reduce the quantity and frequency of irrigation.



With the evolution of the high yielding varieties the problem of pests and diseases has become very severe. As vegetables are often used in raw condition, application of chemicals has to be done in judicious manner.

Pumpkin when raised in September-October was relatively free from mosaic disease and produced better yield as compared to the crop raised in January to June.

Carbofuran 3.0 kg ai/ha significantly increased the yield of bhindi.

Intensity of die back and fruit rot of chilli (caused by *Colletotrichum capsici*) could be reduced by treating the seeds with carbendazim (0.05 per cent), spraying the plants at three weeks intervals 15 days after transplanting with copper oxychloride (0.35 per cent) and carbendazim (0.05 per cent). Intensity of the disease was severe in October than in July-August indicating a disease escape in early planted crop.

Chemodynamics of carbofuran is about 26 days and hence to be considered as its waiting period. As higher concentration accumulates in the outer skin in cucumber, peeling before use is recommended for safety.

Waiting period of carbofuran (0.5- 1.0 kg ai/ha) in amaranthus is 20 to 30 days.

The damage due to defoliators can be reduced by dimilin, a kitin synthesis inhibitor, in combination with carbaryl or malathion.

Application of quinalphos for the control of fruit and shoot borer in brinjal may be restricted to the vegetative phase as the waiting period is only 11 days.



The chilli variety Jwalamukhi showed increased water use efficiency, yield and nutrient uptake when wick irrigation at 100 per cent field capacity and mulching with coir pith were given.

Insecticide contamination due to spraying was detected in vegetable cowpea and bhindi ; but not in brinjal and snakegourd. Among the different insecticides higher accumulation was observed for monocrotophos and phosphamidon. About four to five times MRL were present in edible portions. When carbofuran was applied in flowering stage, residues became below MRL of 0.1 after 27-29 days, respectively, for low and higher doses. Lindane residues are dissipated below detectable levels at harvest. Washing and cooking reduces the residues considerably.

A spacing of 75 x 75 cm was found to be the optimum for tannia. In intercropping situations, nitrogen at the rate of 40 kg/ha and potassium at the rate of 100 kg/ha were found to be sufficient for the crop.



An unique collection, the biggest in Asia, of about 200 cultivars of banana belonging to dessert, culinary and dual purpose groups are being maintained at the Banana Research Station, Kannara. Out of the above, eighteen cultivars (four dwarf dessert, eight tall dessert, two dual purpose and four culinary) were recommended for release.

Substantial contribution has been made by the Kannara Station in formulating agro-techniques for banana. April-May and August-September planting were the best for rainfed and irrigated banana, respectively. Njalipoovan and Robusta were found to be shade tolerant varieties, suitable for coconut gardens. Single hedge method of planting up to 5000 plants/ha gave higher yield in banana var. Robusta. Fertilizer dose evolved for Nendran and Palayankodan are 190:115:300 g and 100:200:400 g NPK/plant/year, respectively. The requirement of lime and  $MgSO_4$  was 550 g/plant. Trimming of one or two terminal hands of Palayankodan bunch just after the emergence was found to improve finger size. Soil application of carbofuran or phorate @ 20 g/plant (one application at the time of planting and another three months after planting) considerably reduces rhizome damage due to weevil. Application of carbofuran @ 20 g/plant at the time of planting and at 65 and 175 days after planting in the leaf axil effectively controls rhizome weevil, aphid and nematode in Nendran banana. Sigatoka leaf spot can be effectively controlled by spraying difoltan 0.3 per cent or Bordeaux Mixture 1.0 per cent.

Application of 200g N at seven split doses after planting was optimum for banana var. Nendran with respect to plant growth and bunch characters. An yield increase of 45 per cent over the local practice was obtained.



Application of 300 g K in four splits of 200 g was optimum for plant growth, development and yield.

The highest yield per hectare was realised from a planting density of 4762 plants per hectare with a spacing of 1.2 m x 1.5 m x 2.0 m. Irrigation at 20 CPE was the optimum for growth and yield of the banana variety Nendran. Irrigation at 5-6 days intervals with 5.0 cm depth of water during December to May is essential for banana. Weeding during the first six months was found critical for growth and yield. Flowering was delayed up to 38 days in unweeded plots.

Spacing of 2.13 x 2.13 m was the best for Poovan, Red banana, Palayankodan and Monthan while Nendran requires 2.00 x 2.00 m. In Robusta, single hedge method of planting with a population of 5000 suckers/ha raised at a spacing of 2 m between rows and 1 m between plants was ideal. In Palayankodan, retaining two suckers and manuring with 100:200:400 g of NPK/plant for first ratoon and half the above (50:100:200 g/plant) in the second ratoon was optimum for economic yield.

Studies in banana-based cropping system with various annuals revealed that the combination of Nendran and tapioca was the best in the B:C ratio of 1.9:1.

Banana hybridisation work of Kannara resulted in the production of seven hybrids. Pisang lilin, a diploid acuminata cultivar was the best pollen parent with respect to compatibility status. Among the hybrid, H1 (Agniswar x Pisang lilin) and H2 (Vannan x Pisang lilin) were superior than the parents for bunch weight, number of hands, number of fingers and taste.

One spray with glyphosate 2.0 kg ai/ha followed by two sprays with grammoxone 1.8 l ai/ha was effective and economic for controlling the weeds of banana. Raising two crops of cowpea in the interspace is an alternative to manage weeds in banana.

*Radopholus similis* was found to be the main nematode pest of banana in Thrissur, Palakkad and Malappuram districts.



At the College of Agriculture, Vellayani, significant reduction in the population of *Radopholus similis* in soil and root was effected by hot water treatment of suckers + parring + application of neem cake (1 kg/plant) or carbofuran (0.5 g ai/plant) at the time of planting.

Screening of banana germplasm against leaf spot disease revealed that the varieties Pisang lilin, Sannachenkadali, Hybrids H<sub>1</sub> and H<sub>2</sub>, Chinali, Kanchikela and Manoranjitham were less susceptible to the disease, recording less than 10 per cent disease incidence.

The banana aphid, *Pentalonia nigronervosa* was found to complete the life cycle in 8-9 days with four instars. The highest aphid population was during December. The minimum population was observed in April-May.

Among the fungicides tried against leaf spot disease of banana var. Nendran, sprays of Bavistin (0.1 per cent), Calixin (0.05 per cent) or alternate sprays of Bavistin, Calixin and Dithane M-45 (0.02 per cent) were more effective.

Somatic embryoids could be produced from the nucellus of monoembryonic (Neelum, Mulgoa and Banglora) and polyembryonic (Vellari Manga) mango varieties using MS basal medium containing supplements.

In pineapple, the spacing of 90 x 60 x 25 cm ( 53,333 plants/ha) is optimum for high yield. Deep trenches are preferable for high density planting in plant crop.

A spineless hybrid of Kew and Ripley Queen was produced. Superior variants from the variety Kew were identified.

Germplasm collection of pineapple consisting of 24 varieties is being maintained at Vellanikkara. Descriptors for all the varieties were prepared.

Performance studies for five years on the hybrids of pineapple, (Kew x



Ripley Queen), evolved at the Pineapple Research Centre, Vellanikkara revealed the superiority of the hybrids H<sub>8</sub>, H<sub>7</sub>, H<sub>6</sub>, H<sub>3</sub> and H<sub>1</sub> in that order, over other hybrids.

Clonal variation studies in pineapple variety Kew revealed the superiority of six clones with respect to number of leaves, D leaf area, yield, TSS and sugar/acid ratio.

May planting was found to be the best for high fruit weight. However, pulp/peel ratio and TSS were the maximum in September and July plantings, respectively.

A collection of 155 varieties of mango is maintained under KHDP at Vellanikkara.

Growth, flowering, fruit set and fruit development studies in Kodampuli (*Garcinia cambogea* Desr.) at the College of Horticulture, Vellanikkara revealed the seasonal nature of shoot growth. The main flushing period was from January to March. The period of flowering was 4-5 months in male trees and 2-3 months in hermaphrodite trees. Maximum fruit set (80 per cent) was observed when the flowers were pollinated 12 hours before anthesis.

Floral biology and compatibility studies in *Dendrobium* hybrids revealed that anthesis occurred between 9.00 and 11.00 am. Out of the 63 crosses, 22 were successful. The best response for embryo culture was obtained in 90-110 day old pods.

Germplasm collection of 12 orchid varieties is maintained at the College of Agriculture, Vellayani. Hybridization work was in progress. Fruits were obtained in 15 cross combinations.

Among the 18 gladiolus hybrids evaluated the College of Agriculture, Vellayani, Tropic Seas, Vink's Glory, Oscar, Friendship and Wedding Bouquet were found suitable for cut flower production.





Plate 13. Bittergourd variety Preethi



Plate 14. Bittergourd variety Priyanka





Plate 15. Snakegourd variety Kaumudi



Plate 16. Multiple shoots of Dendrobium induced *in vitro*



Twenty one accessions of *Gerbera jamesonii* were collected and maintained at the College of Horticulture, Vellanikkara.

Protocols were developed for the *in vitro* propagation and *ex vitro* establishment of pineapple. Immersing the roots of plantlets in water for 18 hours prior to planting out increased the survival.

The vase life of gladiolus could be improved by treating with 15 or 20 per cent sucrose along with 8-HQ (200 mg/l).

Planting gerbera in June was better than in October with respect to vegetative and floral characters.

Number of leaves, clumps and florets, size of florets and length of inflorescence in *Cymbidium traceanum* could be increased by spraying an one per cent solution of 17:17:17 complex fertilizer.

Protocols for the *in vitro* propagation and *ex vitro* establishment of *Dendrobium nobile* could be evolved. Plantlets could be established in the open using potting medium containing coconut husk (Plate 16).

Suitable potting media and containers for the *ex vitro* establishment of *Anthurium andreanum* plantlets were identified. 'Soilrite' was the best rooting medium. Plastic pot, mud pot and polythene cover were the suitable containers.

Protocol was developed for the *in vitro* propagation of gladiolus. *In vitro* corm production was also made possible (Plate 17).



Kerala, endowed with bountiful varieties of spices makes a significant contribution to the national and international trade in spices. The State maintains monopoly in the production of major spices like black pepper, cardamom and ginger. The spices from Kerala are highly esteemed in the world market due to their superior intrinsic qualities.

Black pepper is a major spice crop of the State. Research on this crop is carried out in Pepper Research Station, Panniyur, Regional Agricultural Research Station, Ambalavayal, Cardamom Research Station, Pampadumpara and College of Horticulture, Vellanikkara. At the Pepper Research Station at Panniyur a collection of 73 cultivated types and 120 wild accessions are maintained. Four high yielding varieties *viz.* Panniyur-1, 2, 3 and 4 were already released. A rapid vegetative propagation method through two node cuttings was standardised.

Culture-239 (proposed as Panniyur-5) developed at Panniyur from the open pollinated progeny of Perumkody is a heavy yielder (Plate 18). It is suitable for open as well as shaded conditions of coconut and arecanut gardens. The culture is protrandrous in nature which favours berry setting and high yield.

Isoenzyme variation studies in *Piper* spp. showed three groups of closely related species. The first group included *P. nigrum*, *P. pseudonigrum*, *P. bababudani* and *P. galeatum*. The second group consisted of *P. chaba*, *P. hapnium* and *P. colubrinum*. *P. argyrophyllum* and *P. attenuatum* formed the third group. *P. longum* and *P. betle* were found to be distinct from the rest of the species.



The germplasm evaluation of black pepper proved the superiority of the cultivars Karimunda I (PRS-20), Karimunda III (PRS-22), Sullia (PRS-49) and TMB IV (PRS-54) in terms of yield and spike characters.

Protocol was developed for the *in vitro* propagation of pepper (Plate 19). It was found ideal for all the high yielding varieties. The plantlets produced showed cent per cent field establishment and normal growth habits (Plate 20). Normal flowering and fruitset were observed by the second year of field planting.

Pongalyam (*Ailanthus malabaricum*) was identified as the best standard for pepper. Coral tree (*Erythrina indica*), glyricidia and azhantha were also found suitable.

Combined application of neem cake (2.0 kg/vine) and phorate 3 g ai/vine) along with Bavistin (0.1 per cent foliar spray) was found effective in controlling the slow wilt disease of black pepper.

Investigations on the effect of soil amendments for the control of *Phytophthora* foot rot of black pepper indicated that Bordeaux Mixture 1.0 per cent with neem cake 1.0 kg/vine and lime 0.5 kg/vine reduced the disease incidence and increased yield.

Nursery diseases of pepper could be effectively controlled by spraying and drenching validacin (0.2 per cent) or difoltan (0.1 per cent).

The additional nutrient requirement for an increase of 1.0 Kg pepper berries was found to be 6.35 g N, 6.33 g K, 1.11 g Ca, 0.47 g Mg, 0.44 g P, 0.29 g S, 42.82 mg Fe, 34.45 mg Mn and 4.2 mg Zn. This requirement was irrespective of the yield potential. This indicates that vines with higher production potential require higher doses of nutrients. The present fertiliser recommendations need to be revised on the basis of yield potential of varieties.



Evaluation of cardamom germplasm revealed the superiority of the clone 57 with an yield of 507g dry capsule/plant. The clone could tolerate capsule borer infestation.

Research on ginger and turmeric was initiated about two decades back at the Regional Research Station at Ambalavayal and at the College of Horticulture, Vellanikkara. Varieties suitable for various end uses could be identified. An effective storage method for the seed material, namely, pit method, could be perfected. In addition to various agrotechniques, effective plant protection measures for soft rot, shoot borer and scale insect were developed.

V2E5-2 was identified as a superior ginger cultivar at Ambalavayal, yielding 70 t/ha. This can be used as green ginger. Studies at Vellanikkara revealed the superiority of three cultivars *viz.* PGS-35, PGS-10 and Thingpuri.

The ginger type ZO-74 from Himachal Pradesh outyielded all other types/varieties. It had a green yield of 1.36 kg/plant.

Seeds of ginger could be produced via *in vitro* techniques and germinated (Plate 21). Placental pollination, modified placental pollination or ovular fertilization were useful. Histological examination of the ovules, 40 days after pollination, showed well developed embryo and endosperm rich in starch and oil grains. Eighty-day old seeds when incubated in suitable medium germinated.

Ginger plantlets could be produced *via.* callus mediated somatic organogenesis and planted out. The calli induced on media with 2,4-D and BA were observed to regenerate on the same basal medium with higher levels of BA. Silver nitrate was found favourable for callus regeneration.

Turmeric types VK-47 and VK-82 were proved to be high yielding (7.34 t and 6.74 t dry turmeric/ha, respectively) with very high curcumin



content (7.18 per cent and 7.39 per cent, respectively). They were proposed for release as 'Kanthi' (VK-47) and 'Shoba' (VK-82) (Plates 22 & 23).

In turmeric, 20 cm x 20 cm was proposed as the most convenient and economic spacing as compared to the present recommendation of 15 cm x 15 cm.

Cultural practices as well as effective plant protection measures against rhizome rot, shoot borer and scale insect were evolved.

Application of neem cake 1.0 t/ha at the time of planting and carbofuran 1.0 kg/ha 45 days after planting was found to be effective in the control of nematodes associated with ginger.

An initial nematode (*Meloidogyne incognita*) population of 345 larvae/250 g soil can result in 11.5 per cent yield loss in ginger.

The turmeric cultivar Sugantham performed well (yield 44 t/ha) at the Regional Agricultural Research Station, Ambalavayal. At the College of Horticulture, Vellanikkara, the variety VK-144 was found promising.

Nematode complex was found to reduce the yield of ginger and turmeric up to 43.0 per cent. In ginger, the population could be minimised by the combined application of carbofuran (910 Kg ai/ha) and neem cake (925 t/ha), 45 days after planting.

Two fungi, namely, *Botryodiplodia* sp. and *Phytophthora* sp. were found associated with the wilt disease of clove.

*Sesbania acculeata* and cowpea, grown in the interspace were found to increase the yield of ginger.



Under low shaded conditions, 25 per cent of the mulch requirement (30 t/ha) of ginger could be reduced without affecting the yield.

Application of Bordeaux Mixture (1.0 per cent) as spray and soil drenching could be recommended as prophylactic measure against bacterial wilt of ginger. The treatment is also effective in preventing further spread of the disease.

*In situ* budding was found reliable for assuring femaleness and productivity in nutmeg. Viable buds having deep scar inner to the bark were essential for successful budding.

Forkert budding (by leaving space on all sides of the bud patch) on three year old seedling (during July) was the most successful method of nutmeg propagation.

Orthotrops in nutmeg could be induced by cutting back the existing orthotrops close to the tree trunk, leaving 30cm stump.

In studies on the *in vitro* propagation of clove multiple shoots could be induced from the shoot apices on WPM basal medium, containing supplements. Rooting of shoots could be induced in a few cases on the same basal medium, containing auxins.

Application of hormones like kinetin 100 ppm or kinetin 100 ppm + IAA 100 ppm was found to give higher rate of success in soft wood grafting of garcinia.

Waiting periods of plant protection chemicals like Dimethoate, Quinalphos and Mancozeb were standardised as 5, 12 and 20 days, respectively in black pepper and 23, 22 and 21 days in cardamom.

Intensity of slow wilt in pepper can be reduced by inoculating vesicular arbuscular mycorrhiza (*Glomus* species). The fungus could as well increase the yield in ginger and turmeric.



A germplasm collection of one hundred types of cashew is maintained in the Cashew Research Stations of the University at Madakathara and Anakayam. The germplasm consists of clones as well as seedlings. Two cashew hybrids, namely, Kanaka and Dhana were released. Kanaka (H 1598) is a hybrid of Anakayam-1 and H 3-13. It has an average yield of 18 kg/tree, nut weight of 7 g and shelling percentage of 40. Kernel weight is 2.1 g and export grade is W. 280. The variety is early maturing with a flowering duration of 61 days. Dhana (H 1608) is a hybrid of ALG9-1 and K 30-1. The mean yield is 17 kg/tree, nut weight is 10 g and shelling percentage is 27. Kernel weight of the variety is 2.2 g and export grade is W.210. The variety is early maturing with a flowering duration of 62 days. Trials at Anakayam revealed the superior performance of the types BCA-139-1, BCA-273-1, K-19-1, K-25-2, BRZ 112 and K 30-1 in nut production. The hybrid 4-9-4 recorded a nut yield of 39 kg/tree.

At the Cashew Research Station, Anakayam 47 clonal and 43 seedling types were evaluated for their vigour, flowering behaviour, fruit and nut characters and yield potential. From the yield data for 15 years, 11 types were found promising. The type K-10-2 (with high yield and big nut size) was recommended for release as 'Sulabha'. This has a nut size of 9.8 g., shelling percentage of 29.4, kernel weight of 2.5 g and export grade of W.210.

Propagation methods like soft wood grafting, flush grafting, air layering and budding have been standardised. Top working has been standardised for rejuvenation of old trees.

Recent achievements from the Cashew Research Station, Anakayam



include the recommendation of three varieties, Mrudula (PTR-1), Dharasree (H-3-17) and Sulabha (K-10-22).

*Mrudula*, a selection from the germplasm collected from Pattanoor in Kannur district, is a special type of cashew without acrid taste. Hence its nuts can be consumed raw.

*Dharasree*, generated from Tree No. 30 of the Research Station at Kottarakkara and BRZ-18 collected from Brazil, exhibited high yield, high shelling percentage, bold nut size and superior grade kernels. It is suitable for export.

*Sulabha* (K-10-2) is from a collection of clonal material of Tree No. 28 of the Research Station at Kottarakkara, which was planted in the Cashew Research Station at Anakayam as K-10-2. Based on its yield and other characters, this was identified as a superior type.

Madhuri was the first sugarcane variety released by the Kerala Agricultural University suitable for the southern Kerala, from the Sugarcane Research Station, Thiruvalla. Thirumadhuram (Culture 577/84), developed by hybridisation and selection, is a cross of Co 740 x Co 6808. This variety yields more than 100 t/ha with a commercial sugar yield of more than 10 t/ha and possesses field tolerance to red rot. This is recommended for Palakkad area. The most outstanding contribution during the period under report is the evolution of a hybrid variety Madhurima (Culture 527/85), which is a cross between Co 740 and Co 7318 evolved at the Sugarcane Research Station, Thiruvalla (Plate 24). Madhurima out-yielded Madhuri and withstands flooded conditions very well due to its erect nature. The variety has field tolerance against red rot and is highly acceptable to growers. Pooled analysis of zonal varietal trials of the mid-late group revealed that the cultures Co-88017 and Co-88121 are superior to the existing varieties. These two cultures are now under farm trial.

At the Sugarcane Research Centre, Menonpara an experiment was laid





Plate 17. Gladiolus corms produced *in vitro*



Plate 18. Pepper variety Panniyur 5





Plate 19 Multiple shoots of pepper induced *in vitro*



Plate 20. Tissue cultured pepper plant established *ex vitro*





Plate 21. Germinating ginger seeds produced *via in vitro* pollination

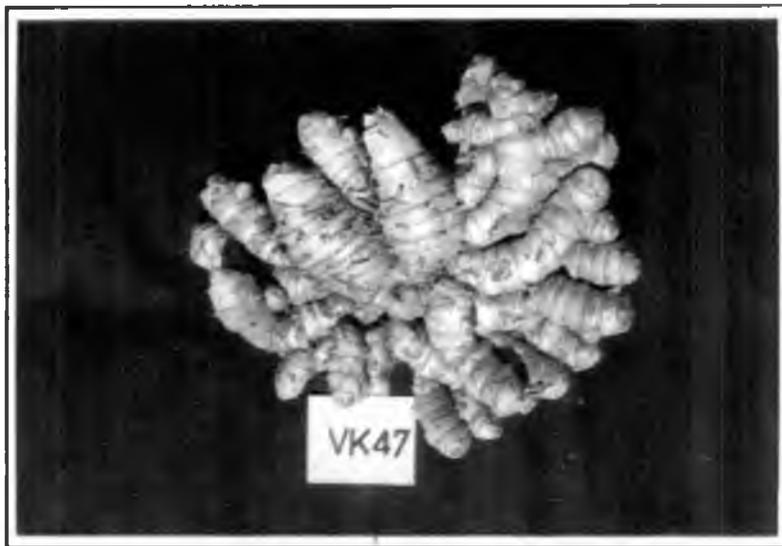


Plate 22. Turmeric variety Kanthi





Plate 23. Turmeric variety Shobha



Plate 24. Sugarcane hybrid variety Madhurima



out in 1994 for developing an efficient integrated nutrient supply system for sugarcane using *Azotobacter* and *Azospirillum* along with different levels of nitrogen. The results revealed that soil application of *Azospirillum* @ 5.0 kg/ha along with N 175 kg/ha was comparable with N 255 kg/ha alone.

The survey work carried out on the occurrence of vascular streak disease of cocoa at the College of Horticulture, Vellanikkara indicated the presence of the disease in all cocoa gardens. Seedling blight pathogen of cocoa was identified as *Phytophthora palmivora*. A new leaf blight caused by *Cylindrocladium illicicola* was noticed in the surveyed fields.

A procedure for top-working cocoa was standardised. About one thousand plants were successfully top-worked so far.

For the *in vitro* propagation of cocoa, somatic embryoids could be produced from anther. Multiple shoots could be induced from the shoot apices of field grown trees of cocoa using WPM containing supplements (Plate 25). Use of streptomycin sulphate (100 mg/l) in the culture medium helped to reduce the cessation of growth and drying of leaves in the cultures.



Two high yielding cowpea varieties, namely, Pournami and V-118 and three black gram varieties, namely, Syama, TMV-1 and KM-2 were released/recommended for cultivation in coconut gardens or summer rice fallows of Onattukara region. This was made possible by the meticulous screening of germ plasm in the Rice Research Station, Kayamkulam from 1986 onwards.

Two cowpea varieties, namely, V-317 and V-276 were identified as resistant to cowpea aphid borne mosaic virus (CAMV) at the College of Agriculture, Vellayani. Since these resistant varieties were poor in yield and quality characters a hybridization and selection programme was initiated to combine resistance with yield and quality.

Based on eleven biological nitrogen fixation traits the cowpea genotypes, VCP-4, COVU-358 and DPLC-210 were identified as top rankers. Nitrogen fixing ability was negatively correlated with grain yield. The top grain yielders among the 53 genotypes tested were V-322, V-27 and V-271. In the line x tester analysis involving the top rankers in yield and nitrogen fixing ability, VCP-4 was found to be the best general combiner for nitrogen fixing and V-322 the best general combiner for grain yield.

Twenty one varieties of rice bean were collected and evaluated for productivity parameters. Yield showed positive genotypic correlation with plant height, number of primary branches, number of pods per plant, seeds per pod, days to maturity, nodule weight and protein content. Organoleptic studies revealed that the variety '23 Lg' was the most acceptable, followed by '558 red', '6 LB', '3 LB' and '7 BR'.



Promising specific combiners for yield and drought resistance in green gram could be identified. The cross combinations Pusa 103 x Co 2, Pusa 103 x ML 131, PDM-139 x Pusa Baisakhi and PDM-146 x PDM 134 were found to be the best specific combiners. Promising lines which are well adapted to the partial shaded conditions and drought situations during Rabi season are expected to be obtained from these crosses.

Through the various breeding projects on pulses and oil seeds intensive search is going on among existing germ plasm as well as on segregating generations created through artificial crossing to identify superior genotypes of cowpea, greengram, blackgram, horsegram and sesame.

Through the projects on standardisation of agrotechniques for pulses and oil seeds attempts are being made to identify sustainable doses of major and minor nutrients through both chemical and organic sources for maximising the yield in cowpea, greengram, blackgram, horsegram, sesame and groundnut. Various chemical and integrated methods of weed control in sesame are also being standardised.

Preliminary trials indicated minimum pest incidence in cowpea (variety Kanakamony) treated with quinalphos 0.03 per cent.

An early duration cowpea variety, Kanakamony was released from Pattambi (Ptb 1) in 1977. It is a dual purpose strain (as grain as well as vegetable) evolved by pure line selection from a popular variety Kunnamkulam Local. Following this, a gram cowpea variety Krishnamony (Ptb 2) with black seed colour was released. Thereafter two promising cultures (Culture 7 and Culture 9) were evolved by crossing Krishnamony and Kanakamony so as to improve the black seed colour of the former parent. These two cultures exhibit synchronized flowering and maturity and the seed colour of Kanakamony. They out-yielded Krishnamony and are ready for release.

Under the All India Co-ordinated trial for pulses, the best varieties and



cultures nominated by various states and finalised at the National Pulse Workshop were tested for their yield performance. The promising ones are the following.

Cowpea : V240, GC 3 and Samba (V16)

Greengram : PDM 84-143, Pusa-103, Pusa 117, RMG 146 and MLR

Blackgram : LBG 17, PDU 5 GH 80-9, T-9 and Pant 4-30.



The guinea grass variety Marathakam (MC 16) was developed through mutation breeding from the parent FR 600, which is semi-perennial in nature. As it tolerates shade, it can be grown throughout the year. It is suitable for uplands of the southern region of Kerala. Yield is 9 t/ha/cutting. This variety is preferred by domestic animals.

Another guinea grass variety, P 1188, out-yielded the other varieties for green and dry fodder production. Management studies revealed that a spacing of 60 x 60 cm and a fertiliser dose of 100:80:60 kg NPK/ha were the best for the highest seed yield.

In coconut garden, growing subabul in the alleys and intercropping guinea grass in the interspaces resulted in the highest green and dry fodder yields.

In a cassava based fodder production system consisting of three methods of planting of cassava *viz.* normal row, paired row and skipped row and four levels of fertilizers for the intercrop, maximum fodder yield of fodder cowpea was recorded when it was intercropped in the skipped row system. Full recommended dose (25:60:30 kg/ha NPK) of fertilizer to fodder cowpea recorded better tuber yield of tapioca as well as higher forage yield.

### **Legume fodder**

In a comparative fodder-cum-seed production trial involving three legumes, namely, cowpea, rice bean and soybean in the uplands, the highest



fodder yield and seed yield were recorded by cowpea. In a separate trial, the cowpea variety C 152 was identified as the best fodder legume under rice fallows on account of its high dry matter production and nutrient content.

The bajra variety RFB-1 recorded the highest green and dry fodder yield among thirteen varieties in a nutrient-fodder production trial.

Two prominent perennial grasses *viz.* guinea grass and gamba grass, were tested for their production potential in coconut garden. Guinea grass cv. Riversdale was superior to gamba in forage production.

In a varietal evaluation trial with ten varieties of annual guinea grass the variety PGG-489 recorded the highest fodder yield.

The fodder production potential of nine varieties of amaranthus was evaluated. The variety APGA-4 recorded 40 t/ha green fodder/hectare.



Kerala is the homeland of several rare and valuable medicinal and aromatic plants. Considering our heritage in Ayurveda, congenial agroclimatic conditions and the high international demand for biomedicines, medicinal plant cultivation and processing need greater attention. Evolving superior cultivars, techniques for rapid propagation and suitable cultural practices is required. Aromatic and Medicinal Plants Research Station at Odakkali has initiated research on various medicinal plants, in addition to the studies on essential oils. An improved variety of lemongrass, OD-19, with high oil and citral content was released. Thalimalangatha, a collection of palmarosa is identified as a superior genotype.

In kacholam when farm yard manure 30 t/ha was applied the rhizome and oil yield increased as 5 t and 23 l/ha, respectively.

Dry spikes of long pepper (*Piper longum*) is the "thippali" of trade. It is required in large quantity for the manufacture of ayurvedic medicines. The demand in the State, at present, is met largely from outside sources. Cultivar LP-1 is a glabrous undershrub yielding 300 kg/ha dry spike with an alkaloid content of 3.0 per cent.

In thippali the variety 'Viswam' (Plate 26) was recommended to be released for cultivation as an intercrop in coconut gardens (Plate 27). It is superior in yield and quality.

Ecotypes of *Gymnema sylvestre*, *Aristolocia indica* and *Habenaria latilabris* were added to the germplasm collection of the Department of Plantation Crops & Spices, College of Horticulture, Vellanikkara.



*Trichopus zeylanicus* and *Smilax zeylanicus* were new additions to the germplasm collection at the Department of Horticulture, College of Agriculture, Vellayani.

Seedling was found to be the best planting material for good yield in adakodiyam. The crop has to be harvested 18 months after planting for better root yield, good quality and economic benefit.

In *Plumbago rosea* when the lower ends of stem cuttings were dipped in IBA 500 ppm for 30 seconds, higher survival was obtained. The treatment resulted in higher number of longer roots and quicker sprouting. This can be profitably cultivated as an intercrop in young coconut plantations adopting different planting methods such as ridge and furrow, flat bed, mound or pit followed by mounds. *Maranta arundinaceae* recorded the highest yield (18.3 t/ha). Thippali was found to be the most economic intercrop with a C:B ratio of 1:1.87.

Cytogenetic analysis in kacholam (*Kaempferia galanga*) showed that  $2n = 55$ . Seedlessness is mainly due to incompatibility factors in the style and stigma, and not due to cytological factors.

Protocols for the *in vitro* propagation of *Kaempferia galanga* was developed. The plants are being evaluated for their field performance. Culture medium supporting slow growth of *Kaempferia rotunda*, useful for germplasm conservation was developed.

Application of 30 t/ha of FYM was found to increase rhizome and oil yields in kacholam.

Distinguishing morphological features of different species of *Rauwolfia* were described. It was found that the alkaloid content of the roots (in crude as well as chloroform extracts) and the chlorophyll content of the aerial parts were negatively correlated.





Plate 25. Multiple shoots of cocoa induced *in vitro*



Plate 26. Thippally variety Viswam





Plate 27. Kacholam plants intercropped in coconut garden



Plate 28. *Fusarium pallidoroseum* infesting pea aphid (*Aphis craccivora*)



A fertilizer dose of 150:90:30 kg NPK per hectare was found beneficial for *Catharanthus roseus* for improving weights of roots and shoots, root girth and content of leaf and root alkaloids.

A catalogue on the available 400 accessions of lemongrass germplasm at the Aromatic and Medicinal Plants Research Station, Odakkali was prepared and documented.

Two lepidoptera pests of *Tylophora asthmatica*, namely, *Dichroma orodia* and *D. aglea* were identified. A new white fly (Aleurodidae) was observed in *Ocimum sanctum*.

Three promising accessions of lemon grass, namely, OD-440, NLG- 84, RRLBI were found suitable under rainfed conditions of Kerala. All the three accessions recorded significantly higher oil yield than OD-19, the presently available commercial variety.



The group deals with the basic aspects in insect and plant disease management. Fifty experiments in this group include biocontrol of insect pests, diseases and weeds, monitoring of pesticide residues and strain variation in pathogenic nematodes and fungi.

The pheromone trap of yellow stem borer of rice worked efficiently. The maximum catch was during November - December.

Different species of *Trichoderma* were found to be the most successful antagonists against *Pythium aphanidermatum*, the causal agent of rhizome rot of ginger.

Soil solarization for 30-45 days was found to have a profound influence on the control of soft rot of ginger incited by *P. aphanidermatum*.

The two bioagents (*Bacillus macerans* and *B. circulans*) @  $1.0 \times 10^8$  cells per plot increased the yield of bhindi by 27.3 per cent.

The leaf extract of *Thevetia nerifolia* was not toxic upto 1000 mg/kg body weight. However, seed extract above 500 mg/kg body weight was toxic in albino mice.

Leaf and flower extracts of *Clerodendron infortunatum* were effective against epilachna beetle.

Residues of methyl parathion, quinalphos and phosphamidon were found in vegetables, viz. bittergourd, snakegourd, cowpea and cucumber



collected from market. In the majority of the samples residues exceeded the MRL, fixed.

Bio-ecological appraisal of Vellayani lake revealed that the residue in water ranged from 4.2 to 32.4 ppb of HCH.

The crude extracts of *Vitex nejundo*, *Curcuma longa* and *Phyllanthus niruri* (at 20 per cent concentration) caused total inhibition of mosaic symptoms in chilli.

Garlic extract (at 20 per cent concentration) showed total inhibition of germination of the spores of *Helminthosporium oryzae*, causing brown spot in rice. The same was also found to inhibit mycelial growth of *Colletotrichum* sp., *Pythium* sp. and *Rhizoctonia* sp. in cowpea.

Seed oil of *Ricinus communis* at 3-5 per cent caused total inhibition of growth of *R. solani*.

*Trichoderma viride* can be effectively used for controlling the disease caused by *R. solani* in forage grass and the leaf blight of amaranthus. *T. viride* possesses antagonistic activity and it could minimise post-harvest spoilage of solanaceous vegetables.

Study on the identity of *Phytophthora* sp. affecting coconut and pepper revealed that coconut isolate could infect pepper plants, while pepper isolate failed to infect coconut.



The need for technological advancement in Agriculture is increasingly felt at present. During the last two decades advances in the understanding of plant cell and molecular biology have formed the basis for a new array of techniques called biotechnology. It covers the concepts and methodologies of plant tissue culture and genetic manipulation and offers scope for vertical increase in crop productivity. The Kerala Agricultural University is set to exploit this promising field for making meaningful contributions, relevant to Kerala.

Biotechnology work was initiated at the University in 1981 with the establishment of a tissue culture laboratory at the College of Horticulture, Vellanikkara. Subsequently, laboratories were established at the College of Agriculture, Vellayani, Regional Research Station, Ambalavayal, Rice Research Station, Kayamkulam, College of Forestry, Vellanikkara, Department of Pomology and Kerala Horticultural Development Programme, Vellanikkara. The initial emphasis was on standardising techniques for the micropropagation of crops. Research on crop improvement has been initiated recently.

The achievements made so far, are mainly concerned with the micropropagation of perennial crops, that are comparatively recalcitrant to *in vitro* techniques. Viable protocols could be evolved for the tissue culture propagation of jack, black pepper and rosewood. Hardening and field establishment of the plantlets could be done. Substantial progress could be made in the micropropagation of cashew and cocoa. Multiple shoots and plantlets could be produced. Further work, however, is required to evolve protocols. The progress achieved in nutmeg and clove, in spite of serious



efforts, was not very much. In a few instances plantlets could be produced. Research on somatic embryogenesis in mango was initiated and the results, so far, are promising. Viable protocols could be evolved for the tissue culture propagation and field establishment of pineapple, Red Banana, Nendran, anthurium, orchids, rose, ginger and kacholam. Research on micropropagation of several medicinal plants, ornamentals and foliage plants is in progress.

The work on crop improvement using tissue culture techniques, recently initiated, yielded significant results. Ginger seeds could be produced for the first time in the world. The seeds on testing, were found viable and could be germinated on a suitable medium (Plate 21). This has opened up possibility for crop improvement in ginger using hybridisation techniques.

Attempts are in progress to evolve disease tolerant pepper and ginger. Somaclonal variation and *in vitro* mutagenesis are being resorted to for evolving novel varieties.

Hardening and field establishment of tissue culture plantlets are often critical. Further, the plants have to be field tested in large numbers to ascertain their superiority. A pilot project on field testing of the tissue culture plants, supported by the Department of Agriculture is ongoing for the purpose. Plantlets of jack, pepper, Red Banana, Nendran, pineapple, anthurium, orchids and medicinal plants are subjected to multilocational trials.

Commercial ventures in biotechnology has already been established in Kerala. There is tremendous potential for employing educated youth in this sector. Training programmes aimed at generating technical manpower for the purpose are essential. The University has already initiated training programmes for unemployed educated youth in tissue culture at Vellayani and Vellanikkara.



## 14 Post Harvest Technology

Post harvest technology research primarily aims at reducing postharvest losses. Development of value added products from major and minor agricultural produce of the State is also aimed at. Technologies for postharvest loss reduction in different fruits and vegetables have been worked out. Standardisation of technology for utilization of cashew apple and banana has been done. The technology of cashew apple syrup / squash has been commercialised.

Storage life of cashew apple could be enhanced up to twenty one days, by soaking them in potassium metabisulphate (0.1 per cent) and brine (0.7 per cent). Techniques were evolved to remove astringency and reduce tannin content of fruit.

Packing banana hands at 0.2 to 0.4 per cent ventilation was found to increase the keeping quality upto 12 days at ambient conditions.

Four local varieties of mango *viz.* Chandrakaran, Puliyan, Muvandan, Kalapady and Neelum were tested for the quality of pulp. Among them, Kalapady was the best.

The technology for development of a wide variety of products from papaya *viz.* squash, RTS beverage, nectar, crush, papaya pickle, papaya peel pickle, jelly, jam, fruitbar, sauce, chutney, tutty fruity, candy, halwa, powder, kondattom, peel kondattom, shreds, toffee and cheese was standardised. Products with papaya as one of the ingredients, like mixed fruit RTS, mixed fruit jam, mixed fruit squash and mixed fruit bar were also standardised. Economics of production was also worked out.



Technology for preparation of different products of jack fruit *viz.* jam, jelly, squash, RTS beverage candy, fruitbar, cheese, pickle, dehydrated products like papad, dehydrated shreds and dehydrated bulbs was standardised.

The maximum shelf life of the crisp bulbs of ripe jack fruit was obtained when stored in sugar syrup at 30 degree brix. The canned jackfruit stored at room temperature retained its normal colour and characteristic aroma even after four months of storage.

The best packaging material and storage condition for extending the storability of ready-to-eat as well as ready-to-cook jack fruit bulbs were also standardised.

Pre-cooling of vegetables enhanced their marketability and reduced the physiological weight loss. Ventillated polythene bags (for brinjal, chilli and tomato) and unventillated polybags (for amaranthus, cowpea and bhindi) were beneficial.

Storage life of sweet potato tubers could be extended up to 60 days using paddy husk, coir pith or carbon paper. However, acceptability rate of the tubers decreased with the storage period.

Variation in quality change was observed among grains of rice varieties after six months of storage. Storage devices also influenced the change.

Physiological properties of coconut oil and groundnut oil were affected while frying banana chips. Heating the oil up to twelve hours was safe, as toxic principles did not develop.

Techniques were evolved for making wafers from dehydrated mushroom powder and blackgram flour, mixed in 1:3 ratio. The wafers, rich in proteins and fibre could be stored up to five months.



Products like wine, candy, jelly and canned fruits were developed from karonda fruits.

A good quality supplementary food formulation containing par boiled rice (85 per cent), defatted soya four (10 per cent) and groundnut (5 per cent) could be evolved.

Nutritional quality, especially, protein content of bread could be improved by partial substitution of maida with soya flour.



## 15 Technology Transfer and Rural Development

Human resource management is one of the major concerns of a labour-abundant country like ours. The Kerala Agricultural University also did not remain a passive onlooker to such pressures of the land. The study to ascertain the aspiration of educated unemployed youth for self-employment in Agriculture and/or allied fields ended up with an optimistic note. The preference to develop a farm was the second aspired profession for the majority of the respondent-unemployed youth (the first being a government job, still) and vegetable production and plant nursery management were seen as highly preferred avenues. A training model based on their area, level of aspiration and training needs was also formulated in the study. The recently commenced VHSE in Agriculture (VHSEA) in the State was the focus of a major study of the University. The study was a multi-dimensional analysis of the VHSEA in Kerala. After getting a primary overview of the participants of the VHSEA courses, the study went in for finding the preferred vocational interest areas of the respondents. Commercial flower production and general agriculture were ranked first in their preference order. Vertical mobility status of the students, hurdles in the vertical mobility, factors influencing employability of VHSEA students and the constraints felt by the teachers were brought to the limelight. Among the suggestions offered by the students and teachers for improving the VHSEA system, appointment of permanent teachers, provision of proper grants etc., enhancing the job opportunities, making the public aware of the relevance of the vocational courses were seen as most important. 'The welfare schemes for agricultural labourers' were analysed in another study. Both the Kerala Agriculture workers' pension scheme and the Kerala Agriculture workers' welfare fund scheme were assessed with regard to the various socio-economic variables applicable to the beneficiaries and the awareness of the *modus operandi* of the schemes.



Significant difference between the two sets of beneficiaries was noticed. Their characteristics were found significantly related with their awareness of the *modus operandi*. A study on the food preference and dietary habits of adolescents among agricultural labourer families revealed that they had met the Recommended Dietary Allowances (RDA) with regard to the cereals and fish and almost (90 per cent) met with respect to protein, energy, thiamine and niacin. Nutritional status of girls was found better than their boy-counterparts. The study undertaken to identify the food consumption pattern of selected farm families in Thiruvananthapuram district concluded that the percentage of income spent on food was found negatively related to the land size of the respondents. Three-meal-pattern was observed in a majority of farm families and better food combination was followed among the families of larger holdings. Adults and adolescents were below the prescribed standards. Adolescents were in grade I malnutrition. Female members were found healthier and they met the RDA of energy intake. Nutritional status increased with increase in land holdings. On the 'evaluation' front of the human resources, Kerala Agricultural University had a study on the job efficiency of panchayat level agricultural officers of Kerala. It reaffirmed that 51.31 per cent of them had high job efficiency. The trend is true of all the three zones. They had relatively more favourable attitude towards their profession but the facilities and resources they enjoy were perceived to be poor. Their communication behaviour, technical competency and self-confidence were factors which contributed much (76 per cent) to their job-efficiency.

The tribes are still considered a down-trodden and neglected group. Ascertaining their socio-economic background and bringing them to the main stream of the modern society are of paramount importance to any social development agency. This University undertook a study to assess the nutritional status and dietary habits of *Irulas* of Attapady. Their general awareness about health and nutrition was graded to be very poor. They largely followed a two-meal-a-day pattern. Their children, at large, had suffered mal-nutrition. Their most popular food item was cereals. The negative consequences of the new settlements in Wayanad district on the socio-economic conditions of tribal population were, the loss of tribal land to



settlers, declining traditional employment of tribals, sexual exploitation of tribals and the habit of consuming more liquor by tribals. On the positive side, increase in per capita income of settlers, changes in the cropping pattern (increase in area under pepper, coffee and banana), acquisition of knowledge in new cultivation practices, and increased facilities for transport, education and health were the important.

Any civilised society cannot ignore the importance of child development. In this perspective, Kerala Agricultural University concentrated her research themes on child development *viz.*, the Integrated Child development (ICDS) beneficiaries and the intra-family distribution of foods. The supplementary nutrition component of ICDS programme was the most preferred component by the beneficiaries. The socio-economic characteristics had no influence on beneficiaries' participation. Nutritional status index of the beneficiary was better in relation to their participation index.

Women, more often an under-privileged class, are the focus of works among the social scientists and planners. Kerala Agricultural University could probe into some of the problems faced by them also. The nutritional status of fish vendors in Thiruvananthapuram was revealed to be below the levels of ICMR prescription and their expenditure of energy (more than 10 hours per day) was more than the recommended daily allowance. The women vendors were found to have a dual role as prime wage-earners as well as responsible house-wives. While viewing the communication behaviour of woman-headed farm families in Neyyattinkara, all the personal characteristics of women had a direct relationship with their communication behaviour. Among them, the social participation and knowledge level on improved scientific practices were directly responsible for maximising their communication behaviour. In assessing the factors influencing the job efficiency of stone-breaking women, the factors like monthly income and resting hours were found to be most relevant.

Group management - a recently introduced extension methodology - was tested through an action research. The results highlighted the effectiveness



of this approach in increasing the income from rice cultivation considerably due to less cost of cultivation and enhanced knowledge level of farmers. The field visit was the most preferred extension method by farmers, followed by training, group discussion and individual contact. The agricultural labourers play a major role in deciding and advocating farmers in adopting the new technology. Hence a study was focussed on the roles played by the agricultural labourers, in the decision making process of employer-farmer. Irrespective of the sex of labourers, the period of employment under a farmer determined to the maximum, the decision making process.

The study on the linkages between the State Department of Agriculture and the Soil Conservation Unit revealed that the linkage between these departments at lower levels was maximum, whereas, at the top level it was very less.

The acid test of any technological innovation is its continuous adoption by farmers. A study was carried out to assess the technology adoption by the coconut cultivators. While assessing the comparative performance of different development programmes under coconut, it was found that, even though the beneficiaries had more awareness, high knowledge level (on development programmes and package of practices) and more favourable attitude towards development programmes, their adoption level of practices was far below. While ascertaining the adoption of farm implements and machinery by rice farmers of Kerala, it was found that the extent of adoption of farm implements and machineries in the NARP regions varied. The common and popular implements and machinery in vogue in different regions were assessed. The problems and prospects of introducing various new implements were elucidated.

In group farming, the higher information flow took place with regard to 'Plant Protection'.

Majority of the sericulture farmers in Palakkad and Thrissur districts had above average level of 'knowledge gap'. Their major constraints were



low price for cocoons, high cost of fertilizers, high labour cost, lack of market facilities and heavy incidence of diseases.

Coconut based farming system in homesteads was the most predominant one in Thrissur district. Coconut-banana-vegetables crop combination occupied the first position followed by coconut-banana-yams.

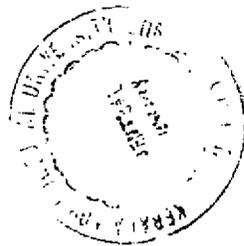
Coconut climbers were found to be employed for 218 days in an year with 164 days in coconut climbing. Their maximum employment was in March, May and February.

Farm women contributed only 18.7 per cent towards total annual household income. They had less command over the assets, except livestock.

Eighteen per cent of the agricultural labourers were "below" and 21 per cent marginally "above" the poverty line based on consumption expenditure. Anti-poverty programmes had not reached one third of the population.

In a study on long term institutional credit, it was pointed out that technical guidance should be provided to farmers to start institutional arrangements at the village level for storing farm produce.

More efficiency was found in Balanced Treatment Incomplete Block Design (BTIBD) than in RBD.



## BIOCONTROL

### Insects

Several fungal parasites have been identified against crop pests. Rice bug, (*Leptocorisa acuta*), coconut coreid bug and mealy bugs of several crops have been found to be infected by a common contaminant *Rhizopus stolonifer*. Another fungus *Fusarium pallidoroseum* was also found to be capable of attacking (Plate 28) cow pea aphid (*Aphis craccivora*). Combination trials with commonly used insecticides showed that it was compatible with dimethoate, quinalphos as well as fenthion. Integrated management using biological and chemical methods have given successful results under field conditions.

The Baculovirus was found to be quite specific in its host range as the same infected only *Oryctes rhinoceros*, leaving several other coconut pests. Another virus, which was isolated from the grub of red palm weevil was found to infect the grub, pupal and adult stages of the weevil. Hence it is important in the biocontrol of the pest.

*Bacillus* sp., isolated from the root zone of the plants showed nematocidal effect as it influenced the reproductive potential of the root-knot nematode.

### Weeds

Water hyacinth (*Eichornea crassipes*), the most severe water weed of Kerala was found to be infected by several fungi viz. *Colletotrichum gleosporioides*, *Fusarium eqiuseti*, *F. semitectum*, *F. solani*, *Curvalaria lunata*,



*Rhizopus solani* and a sterile fungus. Wheat bran was found to be a medium for the above fungi. *Fusarium* spp. and *Colletotrichum gloeosporioides* were effective in destroying the foliage of water hyacinth at concentration of  $10 \times 10^9$  spores/ml and  $2 \times 10^9$  spores/ml, respectively. Among the various pathogens, *F. semitectum* was the most aggressive one.

## Diseases

Chilli mosaic could be effectively managed by botanicals, such as extracts of *Polyalthia longifolia*, *Phyllanthus niruri*, *Clerodendrum infortunatum* and *Curcuma longa*. All of them completely inhibited the symptoms of chilli mosaic. Leaf extracts of *Vinca rosea* controled pathogens like *Colletotrichum gloeosporioides*, *Pythium vexans* and *Rhizoctonia solani*. Seed oil of neem and *Hydrocarpus magnitana* (5 per cent) inhibited the growth of *Phytophthora* spp. in laboratory studies. Another laboratory study revealed the biocontrol property of *Trichoderma* spp. against *Phytophthora* spp., which cause several crop diseases under tropical conditions. *Trichoderma* spp. was also found to be inhibitory to *Rhizoctonia solani*, causing disease in forage crops.

Seed oils of *Azadiracta indica*, *Sesamum indica* and *Elais guinensis* gave 100 per cent control of the pathogen, *Rhizoctonia solani*.

Solarisation is a non-chemical method of plant disease management. The wet soil will be covered during the hot period of the year with transparent polythene sheet. Studies indicated that there was a drastic decline in the incidence of pre and post-emergent damping off in chillies as well as in the population of nematodes in soil.

## Variability and infection of plant pathogens

*Phytophthora* spp. are fungal pathogens responsible for several destructive diseases like foot rot of pepper and bud rot of coconut. Doubts have been expressed by many, whether they are different pathogens or not.



*Colletotrichum gloeosporioides* is another pathogen which also has a wide host range. Taxonomical and morphological studies indicated the chances of occurrence of recombinants in plantations of mixed vegetation in both the cases.

### **Biofertilizer**

Two new acid tolerant cultures of the nitrogen fixing bacteria, *Azotobacter* and *Azospirillum* were isolated for the first time in Kerala. The cultures, tolerating acidity upto pH 6, were handed over to the Kerala Agro-Industries Corporation for the mass production of *Azotobacter* and *Azospirillum* biofertilizers in the State.

A technique for improving the field establishment rate of tissue culture plantlets of rose upto 65 per cent, by inoculating with vesicular arbuscular mycorrhizae (VAM), was developed. Inoculation with VAM was also found to enhance host resistance to foot rot disease (*Phytophthora capsici*) in pepper.

Efficient indigenous strains of *Rhizobium* suitable for cowpea, greengram, blackgram, *Stylosanthes*, *Leucaena* sp., *Sesbania* and *Acacia* were developed. Among the above, KAU 11 and 12 for cowpea have been made available to the Department of Agriculture, Kerala for mass production and distribution.

Inoculation with the vesicular arbuscular mycorrhiza *Glomus fasciculatum* was found to suppress the collar rot pathogen, *Rhizoctonia solani* and the root-knot nematode *Meloidogyne incognita* in cowpea.

### **MUSHROOM**

The typical tropical climate of Kerala, its rich natural resource of mushroom flora and availability of large variety of agro wastes make the



State ideal for the promotion of cultivation of tropical mushrooms. In order to solve the problems faced by the mushroom growers, like erratic yields for unknown reasons, absence of varietal choice according to season and market trends, difficulty in getting quality spawn, and pests and disease menace, the Kerala Agricultural University initiated programmes.

Eight native species of *Pleurotus* and one species each of *Volvariella* and *Tricholoma* were collected and the promising ones domesticated. A new tropical species *Tricholoma lobayense* was identified (Plate 29). The cultivation of the mushroom was standardised.

One hybrid oyster mushroom with improved qualities and highly adapted to all agro-climatic regions of Kerala was developed (Plate 30).

Locally available alternative substrates were identified and their processing technology standardised for the economic cultivation of oyster mushrooms. Red banana pseudostem, mango wood chips and *Eleocharis plantagenia*, a wet land weed are the promising ones.

An improvised air cooling system was developed for speedy sporocarp induction in dormant beds of oyster mushrooms during the cropping phase. The technique is cheap and can be adopted for small scale growers.

Low cost technology for spawn production using cheap substrates, namely, banana pseudostem bits, match works waste, potato blended gravel etc. was developed.

Techniques for an instant liquid spawn substrate was developed. Also a modified polypropylene method for economic and efficient spawn production was developed.

Techniques were standardised for blending coconut endosperm milk in culture media for enhanced growth and biomass production of *Pleurotus* spp.



A substrate influenced high yielding mutant of *Pleurotus sajor caju*, a tolerant strain against the most destructive weed mould of mushroom beds, *Trichoderma viride* and an interstock hybrid of *Pleurotus petaloides* with desirable characters were developed. The nature of attack of various pests has been described and effective management schedule developed.

Methods were also evolved for easy management of weed moulds in *Pleurotus* beds.

Coir pith, a waste product from the coir industry, inoculated with *Pleurotus* sp along with urea, is excellent for the production of mushrooms.

Cooking mushrooms for 15 minutes in 20 per cent sodium chloride, 1.0 per cent citric acid and 200 mg/l sodium metabisulphite and packing in polypropylene bags were effective in preserving them up to six months without loss of colour or taste.

## SERICULTURE

Efforts for standardising sericulture practices for the agroclimatic conditions of Kerala was initiated in 1991 at the Kerala Agricultural University.

The mulberry varieties MR<sub>2</sub>, 3-36 and 9-54 were found more suitable than the variety, K<sub>2</sub> in Kerala. A cross bred silkworm (between multi-voltine and bio-voltine) was found suitable for rearing in Kerala (Plate 31). A closer spacing (60x60 cm) under rainfed and wider spacing (75x75 cm) under irrigated condition were suitable for mulberry cultivation in Kerala. Bottom pruning in May-June and middle pruning in October-November followed by bud clipping under rainfed condition and two bottom prunings in May and September and two subsequent middle prunings under irrigated condition resulted in excellent growth of mulberry (Plate 32).

Two new diseases of mulberry viz. leaf blight caused by *R. solani* and



leaf spot caused by *Colletotricum* sp. were reported. The pathogenesis was established in both the cases.

## APICULTURE

Kerala has been contributing 60-70 per cent to the total honey production in India. The Indian honeybee *Apis cerana indica* has been the only domesticated species in Kerala for the commercial production of honey. The Indian bee has been virtually free of any disease till very recently. During 1991-92 a new disease appeared in some parts of Kerala and rapidly spread through the whole State destroying more than 90 per cent of the existing colonies of the Indian bees (Plates 33 & 34). The disease was identified as European Foul Brood / American Foul Brood by different investigating agencies in the beginning and extensive use of antibiotics was resorted to as a control measure. However, this did not give any satisfactory control of the disease. At this juncture, the Kerala Agricultural University has taken up investigations on the disease and its control. A survey on the extent of infection in the major bee keeping districts of Kerala was conducted. Symptomatology and etiology of the disease were studied. The disease was found to be caused by Thai Sac Brood Virus (TSBV). Attempts for introducing other species to the State, known to be resistant to the disease were made. Sixty colonies of the Italian bee *Apis mellifera* were introduced from Haryana (Plates 35 & 36). They are being studied for their multiplication, colonisation, adaptability and natural enemies.

The Italian bees survived well under Kerala conditions during the past three years. The maximum brood development was observed during the months of August to November.

The peak hours of foraging activity was observed to be from 9.00 am to 11.00 am. Thereafter it declined.

During 1994 honey-flow season the yield of honey per colony ranged



from 4.50 to 11.80 kg with an average of 7.89 kg. In 1995 it ranged from 13.35 to 22.00 kg with an average of 16.51 kg.

No instance of infection of *A. mellifera* with TSBV or other pathogens could be observed so far.

The following pests were noticed:

- (i) The brood mite *Tropilaelaps clareae* infests the colonies mostly during brood rearing season. Dusting of sulphur 200 mg per frame over the top bars has been found to effectively control the pest.
- (ii) The yellow banded wasp *Vespa orientalis* causes considerable loss to the bees during the period from June to October.
- (iii) The bee eater bird *Merops orientalis* is a serious predator on adult bees. The attack is severe during October to March.
- (iv) Wax moth infestation is not observed in well maintained colonies.

Suitable management practices are being worked out to achieve the full yield potential.

A Honeybee Research and Training Centre was established in 1994 at the College of Agriculture, Vellayani with the assistance of the ICAR.



## 17 Integrated Farming System

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The studies are conducted in the Farming Systems Research Station, Sadanandapuram, College of Agriculture, Vellayani and RARS, Kumarakom.

Economics of homestead farming with and without livestock components showed that livestock enterprise had a healthy and synergistic interaction with crop components in a farm.

This could be profitably exploited to form an income generating and employment generating activity in the home garden. The system including livestock was found to be more eco-friendly and also sustainable as it provided scope for better nutrient recycling and minimum use of external inputs.

Establishment of homestead models indicated that irrigation in the homesteads gave positive influence on growth and yield of coconut (main crop) and the intercrops. Yield of tapioca showed a declining trend over continuous cropping. Yield of amorphophallus was better under rainfed condition than under irrigated condition.

Survey of homesteads in Pathanamthitta revealed that women were invisible workers in homestead farms. Gender issues are gaining importance in a family set up.

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



The microclimate that prevailed in partially shaded conditions of the homegarden ecosystem was highly conducive for the incidence of pests and diseases.

Duck fish farming is found to be a lucrative system for the Kuttanad tract. Deshi variety of ducks and Cyprines variety of fish were the most suitable in the system.

An integrated farming system model under test in the Regional Agricultural Research Station, Kumarakom involves coconut, fish and livestock as the major components. The intercrops raised during different periods are also accounted. The analysis is made from the produce *viz.* coconut, banana, amorphophallus, colocasia, fodder grass, ginger, cowdung, milk and fish. Compared to the monoculture of coconut on bunds in Kuttanad there was an increase of 150 per cent in net profit in integrated farming involving coconut, banana, fodder and livestock under the bund and channel system in Kuttanad. In the experiment with 2500 m<sup>2</sup> land area, involving crop-livestock-fish, it was found that a cow could be maintained with the fodder grass grown on the fringes of bunds (1000 m<sup>2</sup>) and the interspace of coconut on the bunds could be utilised for planting banana. Cowdung was sufficient to manure the 84 coconuts, 200 banana plants and fodder (1000 m<sup>2</sup>) grown on the bunds. The channels could be utilised for fish culture.

Testing of integrated farming models for Kuttanad tract showed that integration of crops, livestock and fish was quite successful and the system was very viable, fetching 157, per cent increase in net profit over a period of three years.

Investigations on sustainable farming practices on soil properties and crop productivity indicated the superiority of conventional package of practices over sustainable systems. Subsequently, an increasing trend in crop yields was shown by all sustainable systems.



Weather is a major factor in crop growth and production and is identified as one resource which was not yet fully exploited. As a result, several crops are grown traditionally in areas without giving proper consideration for the suitability of the climate. It is possible to make adjustments with the weather to extract the maximum benefit from the resource. Knowledge on agrometeorology will help in the selection of suitable crop/variety, adoption of most appropriate agronomic and cultural practices, irrigation control and pest and disease management.

In Kerala, water availability for crops depends mainly on rainfall. Delineation of the water availability periods at different agroclimatic regions of Kerala with reference to both timing and quantity, therefore, helps to assess the farming season in a rational manner. It also serves as a guide for selecting suitable crop varieties and agronomic practices.

Daily rainfall data of about 97 stations spread over Kerala were collected on computer floppy disks from the India Meteorological Department, Pune. Computer programs are developed for finding the 75 per cent probability rainfall also known as *dependable rainfall*, and potential evapo-transpiration (PET). Another Computer program for calculating the weekly/monthly water balance was also developed. The output from the water balance computations include water surplus, water deficit, and actual evapo-transpiration (AET). The water availability periods at all the above locations will be classified based on the values of AET and PET.

Analysis of rainfall data was taken up for four stations in Onattukara region, namely, Mavelikkara, Kayamkulam, Haripad and Karunagapally

which have rainfall data for a long period. Daily rainfall data for the above four stations was obtained from India Meteorological Department, Pune, for the period from 1951 to 1990. The Potential Evapo-transpiration(PET) for the four stations was computed. Water balance elements like the Actual Evapo-transpiration(AET), Water Surplus(WS), Water Deficit(WD), and water balance indices like Aridity Index(Ia), Humidity Index(Ih) and Moisture Adequacy Index(I<sub>ma</sub>) was also computed. The dependable rainfall was calculated for the stations.

In the Onattukara region of Kerala, probability of the occurrence of a dry spell is high during the last week of August.

Daily rainfall analysis indicated 75 per cent probability of success for dry sowing of rice in the first week of May in Onattukara.

It was observed that though all the four stations come under Onattukara region, they differ in the total quantity of rainfall received. Karunagapally and Kayamkulam have an annual rainfall of about 2400 mm, whereas, Haripad has about 2981 mm and Mavelikkara has 3112 mm. During April to September, rainfall is consistently high at Mavelikara compared to the other three stations. The variation of rainfall was the lowest at Mavelikara except in summer season. Annually the coefficient of variation was only 19 per cent at Mavelikara and for Haripad, it was 26 per cent. During the rainy season also, the same trend was observed. When the dependable rainfall is considered, Mavelikara has a high rainfall regime compared to others.

The water balance studies indicate almost similar pattern of PET at all the stations. All the stations experience good amounts of water surplus during June to November. All the stations experience moderate water deficits during the months December to April. Mavelikara enjoys a better moisture regime compared to others.

The onset of the growing season in the *Virippu* season will be determined by forward accumulation of rainfall upto 200 mm for wetland preparation of growing season.





Plate 29. *Tricholoma robayense*, a new tropical species of mushroom



Plate 30. Hybrid oyster mushroom





Plate 31. A cross bred silk worm (PM x NB 18) suitable for Kerala



Plate 32. Mulberry intercropped in coconut garden



The termination of the growing season in the *Mundakan* season will be determined by backward summing of rainfall data. Computer programme for the forward and backward accumulation of rainfall and the Markov chain model are developed and analysis on these aspects is in progress.

Water melon is an important crop grown in the summer season in Kerala. As both crop yield and water requirement are affected by climatic factors, it is possible to arrive at the best season which gives the highest water use efficiency and yield by studying the crop with different sowing dates. The crop sown on November 16th was superior to others with regard to most of the crop characters. The crop weather relationship studies showed that the temperature range during flowering and early fruit development(3rd to 7th week), maximum temperature during fruit development(7th to 10th week) and relative humidity during maturity(11th to 13th week) negatively correlated with yield. While for total dry matter production there was a negative correlation between temperature range during flowering(3rd to 5th week), maximum temperature during fruit development and early maturity(8th to 11th week) and relative humidity during maturity (11th to 13th week). The results indicate that at Mannuthy and surroundings water melon can be successfully raised in rice fallows, if irrigated daily(10 litre/pit/day) and sown in the middle of November.

Risks in agricultural operations can be minimised by the provision of weather forecasts(properly interpreted for their agricultural significance) containing advisories for farm operations and disseminated well in advance of the impending weather. The Department of Science and Technology(DST), New Delhi, has sanctioned one "Agrometeorological Field Unit (AMFU)/ Agro-advisory Centre" in the Kerala Agricultural University. The main function of the Centre is to issue Farmers' Weather Bulletins once in every week, based on the medium range weather forecasts issued by the National Centre for Medium Range Weather Forecasting (NCMRWF), DST, New Delhi.

An Expert Committee was formed by the University consisting of scientists in the fields of (a) Agrometeorology; (b) Agronomy (c) Plant



pathology; (d) Agricultural Entomology; and (e) Agricultural Extension. Four nearby Krishi Bhawans have been selected for disseminating the agro-advisories. The Expert Committee is meeting on every Tuesday for finalising the Agro-advisories. The advisories are prepared in collaboration with the Dept. of Agriculture, Govt. of Kerala and disseminated to the farmers. As a part of the project, the VSAT (Very Small Aperture Terminal) developed by the C-DOT, Bangalore, was installed in the Department during June, 1992. This is being used for receiving the forecasts from the NCMRWF Super Computer Centre. This satellite communication system is also being used for transmission of feedback weather data to NCMRWF, New Delhi.

Considering the importance of the various aspects of agrometeorology of plantation crops, the Department of Science and Technology, Govt. of India, New Delhi, has sanctioned a project entitled "Agrometeorology of Coconut and Coconut-based Farming Systems in Kerala". The main objectives of this project was to study the effect of micro climate and soil moisture stress on the productivity of coconut (var. West Coast Tall) and to compare different agroclimatic models for assessing nut yield. The results indicated that the difference in soil temperature between coconut root zone and open, varied from 3.8°C to 4.3°C in un-irrigated condition while it ranged between 0.6°C and 1.7°C only when irrigation was provided. An increase in the maximum and minimum temperatures, relative humidity and vapour pressure was noticed at canopy level in coconut when compared to that of the open conditions. The net radiation at the coconut canopy (mid whorl) was about 70 per cent of the total solar radiation received above the canopy. It also indicated that the nut yield was not affected when irrigation was provided till water is available during summer. The index of moisture adequacy was found to be superior for assessing nut yield. All the yield groups in West Coast Tall showed nut yield decline in the subsequent year due to the drought occurred in 1982-83, 1984-85 and 1988-89. The percentage decline in high yielders was high (53.8) when compared to that of low yielders (32.6). It revealed that the effect of drought on low yielders was low when compared to that of high yielders. However, the number of nuts produced by high



yielders was much higher even in drought situation compared to that of low yielders under rainfed conditions.

Space based remote sensing technology, which is multi-disciplinary in nature, has now become the most important tool to study crop growth and monitor changes in the agro-climatic conditions. Hence, a few research projects relating to remote sensing are being initiated. These include acreage and production estimation of rice in Kerala, space based drought monitoring, estimation of area under healthy and root (wilt) disease affected coconut and acreage estimation of important clones of rubber.

The CERES - Rice model can be used for simulating grain yield of 'Kharif', while it needs revalidation for 'Rabi'.



There are 26 experiments in this group. The major items of study are multiple tree production systems, management of agroforestry systems and evaluation of different species for agro, socio-forestry purposes. The main centres are the College of Forestry, Vellanikkara, Livestock Research Station, Thiruvazhunkunnu and College of Agriculture, Vellayani.

Biomass yield of nine fast growing multi-purpose species at eight years of age decreased in the order: *Acacia auriculiformis* > *Paraserianthes* > *Casuarina equisetifolia* > *Artocarpus heterophyllus* > *Emblia officinalis* > *Pterocarpus marsupium* > *A. hirsuta* > *Ailanthus triphysa* > *Leucaena leucocephala*.

Bole fractions, in general, did not account for more than 50 per cent of total nutrient export. Hence, while harvesting returning the leaves and small twigs to the site may be a worthwhile option.

Litterfall ranged from 3.42 Mg/ha/yr (*Pterocarpus*) to 12.69 Mg/ha/yr (*Acacia*) and followed a unimodal distribution pattern with a distinct peak during November to January.

Based on the N content of litter, trees could be broadly grouped into two, namely, high (> 1.5 per cent) and low (<1.5 per cent) litter N content species. *Leucaena*, *Paraserianthes*, *Pterocarpus*, *Acacia*, *Ailanthus* and *Emblia* are examples of the first category. Low litter N containing species included *Casuarina*, *A. heterophyllus* and *A. hirsuta*.



Mass disappearance of litter samples followed a negative exponential relationship. Time taken for complete disappearance of decomposing mass was related to the initial N content of litter. *Leucaena* with the highest initial N content decomposed completely in the shortest period.

Based on the root system morphology, *A. heterophyllus*, *Emblica* and *Paraserianthes* are considered unsuitable for agroforestry. On the other hand, *Ailanthus* is a better candidate tree for agroforestry as it possesses relatively lower lateral spread and a deep tap root system.



There are forty four experiments in this group, which deal with various basic studies on soil fertility, soil organisms under different cropping systems and vermiculture and organic manures in relation to nutrients in soil. The main centres are the College of Agriculture, Vellayani, College of Horticulture, Vellanikkara, RRS, Moncompu, RRS, Kayamkulam and RARS, Pattambi.

Mathew's triacid extractant was found to be the best for extracting available P in laterite and coastal alluvial soils. In the alluvial soil of Kuttanad Mathew's, Olsen's and Bray No.1 extractants gave similar results. All these extractants gave the highest relationship with P uptake. Al-P of Kuttanad alluvium showed the highest correlation with P uptake and available P, extracted by the different extractants.

In banana variety Nendran, the highest bunch yield of 26.2 t/ha was recorded at 3/4 times POP recommendation of potash (225 g potash/plant), for soils high in available potash. Path coefficient analysis of yield attributes showed that the number of fingers/bunch had the highest direct effect on yield, followed by girth and weight of fruits. Quality characters of fruits, namely, total and non-reducing sugars, shelf life and flesh-peel ratio showed significant positive relationship with K nutrition. Petiole of the third leaf, upto shooting stage and that of flag leaf thereafter, was selected as the index of the K status of the plant. The critical content of K for maximum yield and maximum response was 1.30 per cent and 1.02 per cent, respectively at the early vegetative stage; 1.28 and 1.06 per cent, at the shooting stage; 2.43 per cent and 1.98 per cent at post shooting stage and 2.50 and 1.80 per cent at bunch maturation stage.



Linear regression models were developed relating soil K to fertilizer dose to find out the quantity of fertilizer to be applied to bring the soil level to the critical level.

Rice plants absorb molecular form of urea even in the presence of other readily available forms of N. Plantation crops do not prefer molecular form of urea.

Uptake of nitrogen was more when rice plants were supplied with a combination of forms. Among the different forms, ammonium and nitrate in equal proportion was the best.

Combined application of P through green manure and inorganic fertilizer met the P requirement of the rice crop throughout the growth period.

Wet land of the State, in general, has immature soil morphology. Characteristics of the wet land soils of the State are mainly derived from parent material. The wet land soils belong to the soil orders Entisols, Inceptisols and Ultisols.

Fertilizer application in the tall varieties of coconut was not found to influence the content and quality of oil.

In cassava 50 per cent substitution of potassium by sodium (on equivalent basis) increased the yield by 30 per cent. There was no deterioration in nutritive or cooking qualities of the tubers upto 50 per cent substitution. In soils rich in potassium application of common salt to substitute 50 per cent K by Na resulted in the same crop yield as that of the full dose of potassium as mureate of potash.

Importance of organic matter in sustainable agriculture is well recognized. In spite of the humid tropical climate of Kerala and good vegetation, organic matter status of the different soils is very low; normally below 1.0 per cent. As the availability of organic manure is also limited, a viable alternative will be the recycling of bio-wastes under an effective



technology. In this context vermitechnology is gaining popularity by virtue of its easy adoptability. Apart from correcting organic matter deficiency this technology reduces environmental pollution from organic wastes. In vermicomposting, biowastes are converted to biofertilizers using earthworms. The Kerala Agricultural University initiated research on vermiculture and vermicomposting in 1993. Techniques could be standardized for vermicomposting of farm wastes, market wastes and kitchen wastes using the exotic species of earthworm *Eudrillus eugineae* (Plates 37 & 38). This species was found to be the most ideal for southern Kerala in view of the short composting period (45 days), better quality of compost and the better breeding potential. Effect of vermicompost on growth, yield, quality and pest and disease resistance in different crops is being studied. Studies are in progress to standardize *in situ* vermiculture in coconut basins, banana pits and vegetable fields. Studies are also in progress to identify the most suitable indigenous species of earthworm for Kerala. The effect of vermiwash on crop growth is also being studied. A simple technique was developed for collecting vermiwash in homestead.



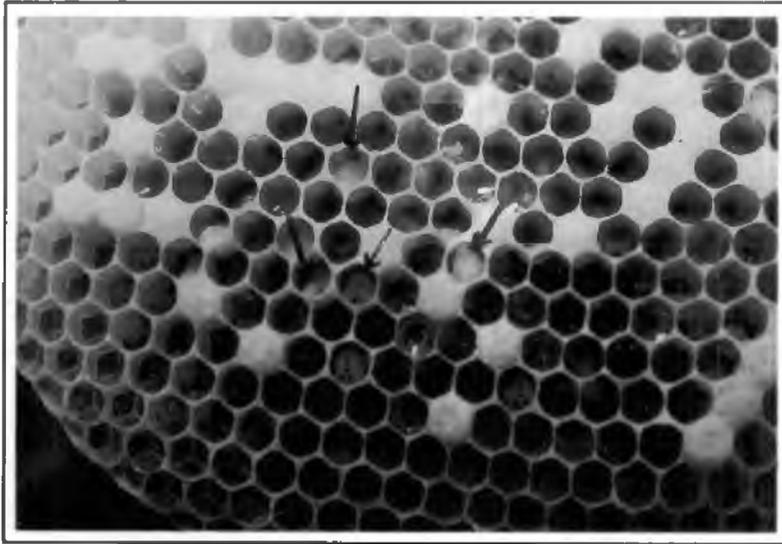


Plate 33. Thai sac brood virus infected Indian honey bee larvae lying dead on the floor of comb cells



Plate 34. Healthy (H) and Thai sac brood virus infected (D) larvae of Indian honey bees



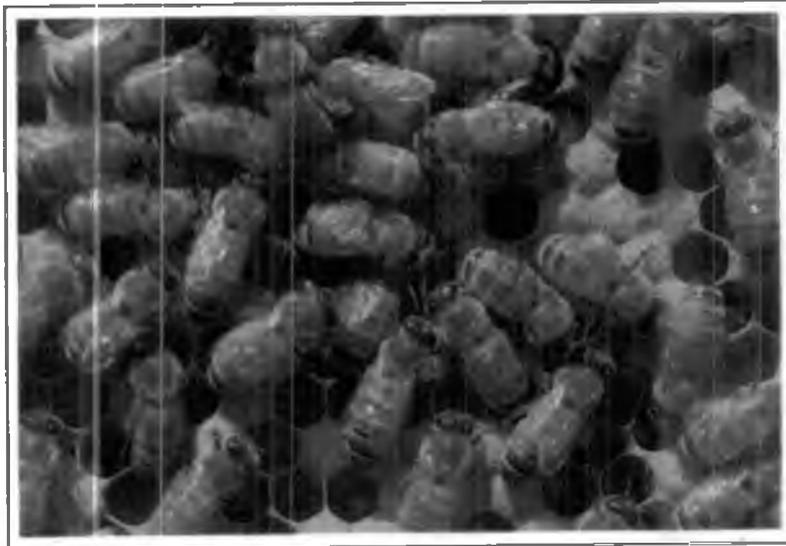


Plate 35. Italian honey bees

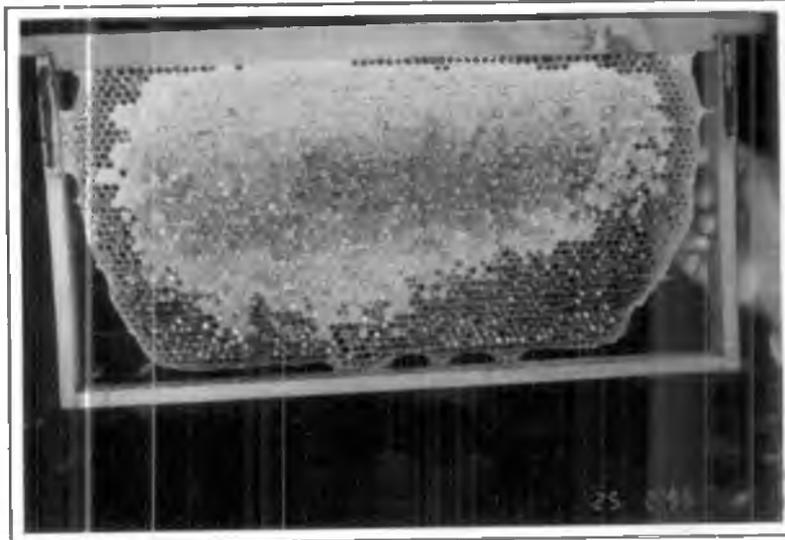


Plate 36. A comb of Italian honey bees filled with honey



This group with 25 experiments was initiated only recently. Nutrition, composition of foods, product development and quality aspects of food are being studied, at the College of Agriculture, Vellayani and College of Horticulture, Vellanikkara.

Organoleptically acceptable dehydrated products with better shelf life could be prepared with foldable type solar drier (fabricated by BARC), compared to those prepared by conventional sundrying.

Solar dryers could be used to prepare partially dehydrated pineapple having acceptable quality.

PTB 10 was more susceptible to quality changes induced by storage than Matta Triveni when stored in gunny bags.

Storage of pulses over long periods (for more than six months) brings about a decrease in protein content and an increase in urea, uric acid and moisture level. Lengthening of storage period also brings about an increase in cooking time, water uptake and a decrease in volume expansion.

Sweet potato can be stored for a period of 60 days without spoilage and significant changes in cooking quality by covering in waste carbon paper.

Karonda, an under-utilized fruit, can be used to prepare jelly, candy and wine.



Addition of 10 per cent soya flour to bread increased the protein content without altering the organoleptic quality and shelf life. The soya fortified bread can be effectively utilized as a supplement in nutrition intervention programmes.

Re-heating of oils upto 12 hours is not harmful to health, though they may exhibit physico-chemical changes.

Glyciemic response induced by tapioca was higher than that induced by rice, ragi and wheat.

There is highly significant positive correlation between iron consumption and mean intelligence test scores for both normal and iron deficient pre-school children.

Public distribution system had a positive influence on the nutritional status of regular beneficiaries. Continuation of this programme is one of the methods to improve the health profile of population living below the poverty line.



*Faculty  
of  
Veterinary  
and  
Animal Sciences*

Evolving suitable methods of immobilisation for treating fracture of long bones in calves is a thrust area of research in surgery. A study was conducted to evaluate the external immobilization and the internal fixative in the treatment of fractures. The process of healing was also evaluated by radiography and histopathology. Use of external and internal immobilization with intramedullary pinning and wiring was found satisfactory in calves.

In an evaluation of selected drugs for sedation and anaesthesia in pigeons, ketamine was found satisfactory.

A modified intradermal test evolved for the diagnosis of paratuberculosis in goat was found better than the conventional test.

Significant reduction in the udder infection rate during dry period was observed, following infusion of antibiotics.

Urea and ammonium sulphate were found to be highly effective as ovicidal agents against the common nematodes of domestic ruminants.

Downer cow syndrome incidence was higher among jersey crossbred cows during the summer. Good response to treatment was observed in majority of clinical cases of metabolic diseases within three days, except in downer cows.

Furolozolidone and sodium chloride could be identified as responsible for the Ascites syndrome in chicken (Plate 39), depending on the dose level employed.

In animals, suspected to have died of rabies, only 17 per cent of dogs, 16 per cent of cats, 45 per cent of cattle and 12 per cent of goats were positive for the disease, in diagnostic tests. A modified Seller's stain procedure was developed for better diagnostic efficacy.

It was clarified that ethmoid carcinoma could be experimentally transplanted in mouse by immunosuppression (Plate 40). The mouse was identified as the model of choice and cyclosporin A as the drug of choice for immunosuppression. Tryprimisation was found to be of value in establishing tumour tissue in cell cultures. Carbofuran and 2,4-D in sub-lethal doses were found to have immunosuppressive effect.

In a comparative study on the biological effects of aflatoxin in fish and duck, reduction in growth rate and feed consumption in both the species was observed due to the toxin. There was immunosuppressive effect of aflatoxin in ducks.

Retrospective survey studies based on autopsy data revealed that enteritis was the most important disease in cross bred livestock.

Coccidial enteritis and pneumonia were identified as the most important diseases of goats.

In studies employing duck embryos, lead acetate, even in very small doses was found to cause various types of teratological abnormalities, reduced hatchability and embryo mortality. This indicates the adverse biological effects of environmental pollution.

Aflatoxin was identified as an important dietary toxic factor which could cause serious economic loss of 88 crores rupees per year in the State.

Aflatoxin was observed in the peripheral blood of animals bearing ethmoid carcinoma. This indicates its possible role in the aetio-pathogenesis of ethmoid carcinoma.



Preparations making use of quail meat are acclaimed as delicacies internationally. Making use of quail meat, a product known as quail meat patties was developed and its quality was evaluated. Acceptability was tested by taste panel and quail meat patties was rated as highly acceptable products. The quail meat patties can be stored at 5°C up to 6 days and at -15°C up to 60 days without affecting the acceptability score, or causing any major qualitative change of deterioration.

Whey solids in condensed form could be successfully incorporated in the yoghurt as a replacement for skim milk powder. Utilization of whey solids improved the textural characteristic of the yoghurt. The cost of production could also be brought down by 20 per cent as the whey has no market value. Moreover, yoghurt was found to be a good vehicle for the incorporation of *B. bifidum*. Converting the set yoghurt into frozen yoghurt by freezing and hardening at -20°C improved its keeping quality.

A good quality ice cream like product could be prepared by substituting, partly or fully, the milk fat with coconut fat in the form of coconut kernel juice. Substantial reduction in cost could be achieved by this. The product separated in this form has been named as "Keracream". Keeping quality of "Dahi" could be increased by the addition of nisin as well as nisin producing organisms.

Paneer, Rasagola and whey drinks were prepared using filled milk, substituting milk fat and coconut fat. The quality of products was good.

Despite the phenomenal growth of poultry in the country, the poultry industry in Kerala remained largely a “backyard venture” till the eighties. Even to-day commercial egg production activity has not caught up in the State. This does not mean that poultry production activities in the State is remaining static. The per capita production has increased from 38 eggs in 1981 to 51 eggs in 1990 (increase of 32.21 per cent) during the decade of eighties. However, during the same period the per capita availability / consumption rose from 37 eggs to 62 eggs (increase of 68 per cent) indicating the rising demands for eggs and consequent growing inflow of eggs into Kerala from the neighbouring States. It was estimated that around 323.5 million eggs were brought to Kerala in 1990. During the VIIth Plan period production of eggs increased marginally from 1360 million in the first year to 1500 million in the final year, with an average growth of two per cent. During the same period there was an average growth of five per cent at all India level.

The Kerala Agricultural University made earnest efforts to make available the poultry stocks with high production potential to increase the product output within the State. Mannuthy centre of the AICRP on Poultry Breeding evolved a commercial layer with an egg production potential of 285<sup>+</sup> eggs which has won many performance tests conducted by the Government of India and other agencies. This hybrid is popularly known as Athulya. The University Poultry Farm came out with a bird for backyard; Gramalakshmi which is genetically an Austrawhite. It is also acclaimed by backyard farmers. Parent stocks of Athulya as well as Gramalakshmi have been made available to the Regional Poultry Farms under the Government of Kerala for production of commercial hybrids to boost egg production in the State.





Plate 37. Vermicompost produced using kitchen wastes



Plate 38. Vermicompost produced using *Eudrillus eugineae*



Plate 39. Ascites syndrome in chicken



Plate 40. Ethmoid carcinoma transplant



A study was carried out to assess the influence of pullet body weight on production traits in two strains of Whiteleghorn. The pullets were grouped into six classes with a class interval of 100 g starting from 1000 g based on pullet body weight (body weight at 20 weeks of age). The pullet body weight exerted a profound effect on the subsequent production traits like age at sexual maturity (ASM), egg number, egg weight and weight gain. Higher weight classes had lower ASM, better egg number and egg weight and lower weight gain compared to lower weight classes. It could be suggested that pullets with a minimum body weight of 1200 g only be retained for future production. It must be ensured that all ideal conditions are provided from 0-20 weeks of age to obtain optimum pullet body weight.

It is estimated that placing additional 22 lakhs of layers will go a long way in reducing the gap between the demand and supply with respect to table eggs within the State. This necessitated to have an alternate viable system of egg production for the conventional system of "backyard production". A new homestead cage system was tried out at the AICRP on Poultry Breeding at Mannuthy. A particular cage design was found to be very much suited for the homesteads of the State. Athulya evolved at this Centre has proved its production potential in the intensive system of egg production. Since the Kerala Agricultural University has the hybrid Athulya, best suited for intensive type of egg production, and as the cage system suitable for the homesteads has been identified (Plate 41), the Department of Science and Technology cleared a project for the introduction of cage system of egg production in the homesteads. This project is being implemented near Chalakudy.

Quail production is getting popular now-a-days. An investigation into the structural and functional roles of the shell gland of Japanese quail in the egg shell formation under different dietary calcium regimes was carried out. Egg shell quality traits like egg weight, shell weight, shell thickness, specific gravity and shape index improved with increased levels of dietary calcium. Prelaying dietary calcium level of 0.7 to 0.9 per cent and layer level of 3.0 per cent were significant for optimum shell quality.



The structure and post-natal development of the oviduct of quail were investigated using female quails. Coiling of the tube started in 25 days and rapid change was noticed between 30 and 40 days. Within 45 days the oviduct of female quail gained the adult structural pattern.

Separation and quantification of immunoglobulin in serum, bile, mucosal washings of trachea and intestine of duck were done by salting out.

An investigation on mortality of ducks in Kuttanad was carried out and *P. anatipestifer* was identified as the causative organism.



Cytogenetic study was conducted on crossbred bulls. All the bulls, except one, exhibited diploid chromosome complement.

Studies on blood groups and biochemical polymorphism in cattle were carried out and fifty eight monovalent blood typing reagents had been produced.

The progeny testing scheme was undertaken to develop a methodology for evaluation of breeding bulls and also to bring in genetic improvement in cow population. Monthly recordings of milk is accurate enough for application in the field.

As a part of conservation of germplasm of Vechur cattle of coastal area and dwarf cattle of high range of Kerala, the Department of Animal Breeding and Genetics has succeeded in conserving a unique genetic resource of Kerala.

By the injection of oestrogen and progesterone, lactation could be induced in cows and heifers which were infertile. The chemical composition of milk was normal.

Microbiological load in frozen bull semen and antibiogram of isolates have been studied from bull stations. The major microbiological load was constituted by bacteria.

Characterisation and biotyping of staphylococci isolated from bovine mastitis were carried out. Resistance to antibiotics and heavy metals of the

isolates was studied using eighteen antibiotics and six heavy metals. Single multiple resistant organisms were seen. Two isolates were resistant to all the antibiotics tested. The plasmid preparation of the isolate was studied. Two of the isolates yielded no plasmids. The plasmids of some of the isolates were separated and subjected to electrophoresis along with standard markers to find out the various plasmids bands. The nuclear weight of the various plasmids varied from one to five.



A composite sow index was constructed. The effects of sire, parity and season on this index were studied. Composite sow index was found to be very efficient. Effect of season and parity on various characters of this index was tested. No significant effect of season as well as parity was observed.

Study of *Campylobacter jejuni* isolated from pig and man indicated high prevalence of *C. jejuni* in pig.

A three phase experiment was carried out to assess the level of cyanogenic glycosides (CNG) content in varieties of tapioca, its removal by various processing methods and its effect on metabolism in rats and kids. CNG content in terms of cyanide varied from  $40.86 \pm 2.79$  to  $186.31 \pm 5.30$   $\mu\text{g/g}$  of fresh tuber with the lowest concentration in M-4 and highest in H-165 and Karkidakam. Boiling and sun drying of the tubers lowered the CNG content by about 50 per cent.

#### **Rat experiment**

Digestibility of dry matter was not affected by CNG. In all the groups it was inversely related to the quantity of feed consumed.

Performance (growth rate, feed consumption and feed efficiency for 12 weeks) of rats was poor on tapioca-based diet, the case being worse in protein deficiency.

Iodine (with protein) supplementation almost abolished:

- (a) the poor performance (growth rate, feed consumption and feed efficiency)
- (b) the countering effects of CNG on availability of dietary protein for haemoglobin synthesis
- (c) the inhibitory effects of cyanide and thiocyanate in the thyroid, evidenced by:
  - (i) the blood parameters (elevations in the level of serum total protein, cholesterol and lipid concentration - all indicating hypothyroidism)
  - (ii) histopathological examination of thyroid (elevated DNA: protein ratio, low level of thyroxine, hyperplasia/hypertrophy)

The intensity of pathological changes was more severe in rats fed on protein-deficient tapioca diet. No significant cytological alterations could be seen in the organs of iodine-fed rats.

The DNA: protein ratio/gram of pancreatic tissue was increased in groups fed on low levels of dietary proteins.

Blood glucose and insulin changes did not show any definite pattern of response.



A detailed study on kids to identify the specific cause of death was carried out. Important diseases have been identified. Coccidial enteritis and pneumonia were the most common diseases.

Different antigenic preparations such as crude extract, potassium thiocyanate extract and sonicate antigen prepared from two isolates of *Pasteurella multocida* of rabbit were subjected to physical, chemical, serological and immunological characterisation. Sonicate antigen was superior in eliciting high level of antibody and to confer immunity. Out of the two isolates, R 235 was shown to confer solid immunity in rabbit. Hence, it was considered as a better immunogenic strain.

A three phase experiment was carried out to assess the level of cyanogenic glycosides content in varieties of tapioca, its removal by various processing methods and its effect on metabolism in goat and kids.

There was no significant effect of CNG:

- (a) either on the performance (body weight gain, dry matter intake and feed efficiency)
- (b) on the thyroxin and insulin levels, blood glucose, serum total protein, cholesterol, lipid and haemoglobin levels, in 2.5 - 3.0 months old Alpine - Malabari kids of both sexes.

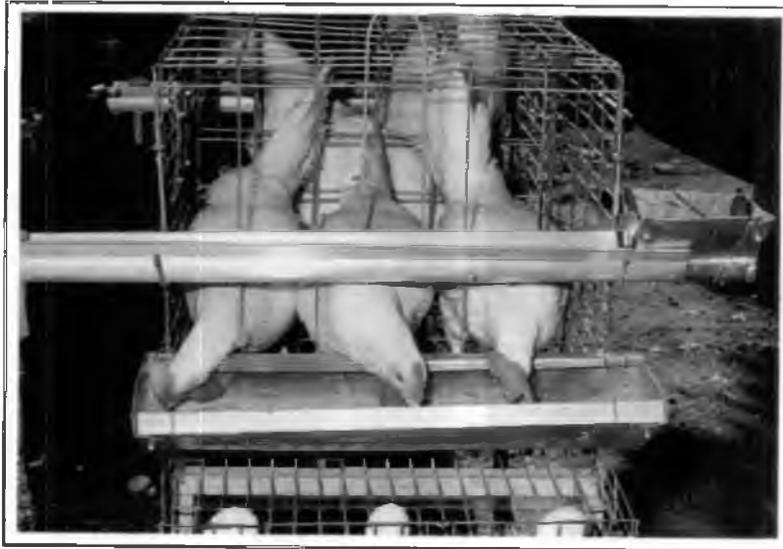


Plate 41. Commercial poultry hybrid Athulya in homestead cage



Plate 42. A catch of *Macrobrachium rosenbergii*





Plate 43. Harvested "Poomeen" and "Thirutha"

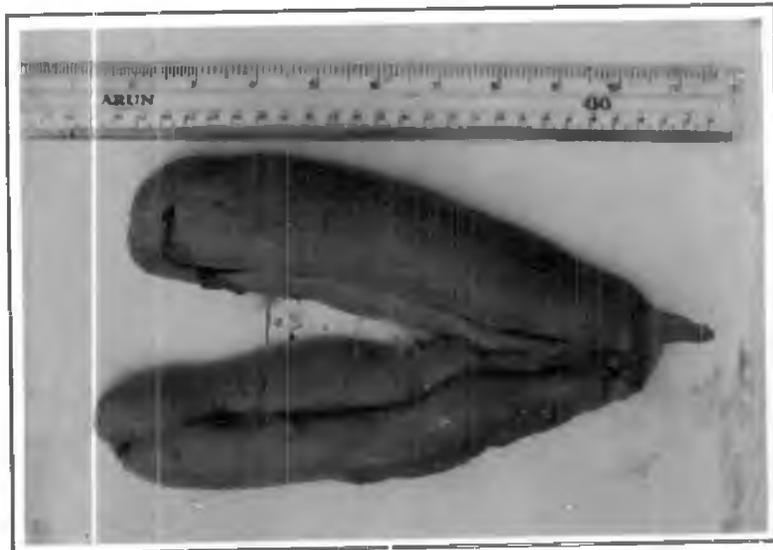


Plate 44. Fully mature ovary of *Mugil cephalus* reared in pond



*Faculty  
of  
Fisheries*



## Fisheries

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Survey on the seed resources of the cultivable brackish water predatory fishes is an important area of research in the faculty of fisheries. The other important areas are fresh water fish and prawn culture and brackish water fish culture. Integrated farming research includes simultaneous cropping of rice and fishes as well as fish cum duck farming in channels of coconut gardens. Ornamental fish culture is also an important area of research.

Studies showed that there is immense potential for the culture of giant fresh water prawn (*Macrobrachium rosenbergii*) in pokkali fields. Under mono-culture, the prawn stocked @ 30,000 post larvae/ha, showed a production rate of 808 kg/ha in 153 days with a retrieval rate of 73.43 per cent and a final size of 36.69 g (Plate 42). In poly-culture, the prawn stocked @ 9,500 post larvae/ha, with fishes @ 3,000/ha gave a production rate of 126 kg/ha in 158 days along with a fish production potential of 132 kg/ha. The studies indicated the feasibility of culture of the prawn in coastal areas of Kerala where fluctuating salinity and low pH are encountered.

In the diet of *Chanos chanos* seed, de-oiled silkworm pupae is better than fish meal to serve as animal protein. Biculture of *C. chanos* (Poomeen) and *Mugil cephalus* (Tirutha) produced 1.5 to 2.0 t/ha/year in ponds of Puduveyppu (Plate 43).

In the diet of *Etroplus suratensis* an effective substitute for fishmeal is *Spirulina fusiformis*. Povidone iodine (0.5 per cent w/w available iodine) application is effective in containing EUS infection in fishes which were moderately ulcerated.

A novel method for protecting fish crop from poachers and otter



menace using barbed wire was developed. The wire can be taken out from the pond at harvesting time and re-used after cleaning and coating with primer for 2-3 years.

*Mugil cephalus* is an ideal species for culture in brackish water ponds. Large scale seed production of the species through induced breeding is possible if the breeders can be reared in ponds. Studies showed that the fish could be successfully reared to maturity in brackish water ponds. Fingerlings collected from nature and reared in brackish water ponds showed full gonadal maturity (Plate 44) during July-August in the 4th year.

There is an increasing popularity for ornamental fishes, especially in urban areas. Tremendous trade potential exists within the country and abroad. Technologies could be developed for the large scale production of important ornamental fish varieties like angel fish, gold fish, koi carp and pearl gourami. A veil-tail variety of angel fish was developed, through selective breeding (Plate 45). It has great trade potential in domestic and export markets.

Studies in *Macrobrachium rosenbergii* indicated that the protein level in the diet could be reduced from 35 to 30 per cent by increasing carbohydrate level from 20 to 30 per cent.

The major determinants of head drooping in prawn were found to be the biological decomposition of the arthrid member and the easiness with which the hydrolytic enzymes of the hepato pancreas was released on post mortem handling and processing.

Duration and survival rate of *Penaeus indicus* seed during transport in oxygen packing increased by lowering the temperature from 30°C to 23°C and maintaining a salinity of 25 ppt. The survival percentage was 100 for a duration of about five hours at a packing density of 500 first larvae per litre of water. Progesterone injection (0.2 mg/g body weight) gave an impetus to ovarian development.



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Plate 45. Veil-tail variety of angel fish



Plate 46. 15 hp "Petti & para" pump in Kuttanad field





Plate 47. Portable rasp bar paddy thresher cum winnower

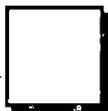


Plate 48. Self propelled 5.0 hp paddy harvester



Plate 49. Tractor mounted paddy reaper windrower





## Agricultural Engineering and Technology

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Developing suitable agricultural implements for Kerala, designing improved axial and other pumps for de-watering operations and utilising wind power as prime mover were among the thrust areas of research of the Faculty of Agricultural Engineering.

### **Studies on “petti and para”**

Kuttanad, the rice bowl of Kerala, has specific requirements for drainage and other water management practices for supporting sustainable agriculture. Introduction of the locally made propeller pump, known as “petti and para” (Plate 46) revolutionised the drainage pumping of the region in the early twentieth century. However, the pump is operated at low efficiency. The operation procedures and agronomic practices need to be standardised for economic crop yield in the different cropping regions of Kuttanad.

The performance of “petti and para” was evaluated, based on extensive field and laboratory investigations. Soil and water properties, in representative agronomic regions were analysed. A test bench was specially designed and constructed to evaluate the performance of the high discharge low head pumping units under controlled conditions.

Functional relationships of the variables influencing the performance of the pump were developed. The regression equations obtained were compared with standard rational relationships and their predictability ascertained based on the values of correlation coefficients. Specific



recommendations on suitable range in pump speed and operating head to obtain high levels of efficiency have been derived.

Field studies revealed that the efficiency of the unit was very low (19.27 to 21.85 per cent). The efficiency was slightly higher (19.10 to 23.88 per cent) when the unit was operated without the bottom "para".

Within the range of pump speeds included in the tests (245 to 340 rpm) there was an increase in discharge capacity of pump as well as pump efficiency with increase in pump speed.

The optimum speed for high level of efficiency at relatively higher head (100-200 cm) has been found to be 330-340 rpm for a 15 hp pump. Beyond 340 rpm the pump gets over loaded.

Possible operational ranges of discharge, total head, input power and efficiency at different operating speeds have been determined for the 15 hp "petti and para" unit (Fig. 1). The information is to result in substantial saving in energy and expenditure in drainage pumping which is the most expensive component of farming in Kuttanad.

### **Power tiller operated paddy transplanter**

An improved version of power tiller operated paddy transplanter was made with modifications on components, proper material substitution and high quality of fabrication. Basic structure was strengthened and streamlined. Incorporation of rails and rollers on the seedling tray and special sockets for planting fingers improved the performance of the machine.

With a field capacity of 0.13 ha per hour savings of 50 per cent in cost and 85 per cent in labour, were achieved. This definitely promises the feasibility in Kerala. The cost of the transplanter is Rs. 15,000.



### **Portable rasp-bar paddy thresher cum winnower**

The commercially available flow-through type threshers are not suitable for paddy crop in Kerala, because of its higher moisture content. The thresher with the newly developed concave was found more efficient even for the moist and long crops.

The 8.0 hp thresher (Plate 47) was found to handle crops of 0.30 ha per hr and delivers straw, chaff, stone and clean paddy in separate outlets. A saving of Rs.950 per ha and 135 man-hrs per ha was achieved compared to manual threshing. The cost of thresher without engine is Rs. 30,000/-.

### **Self-propelled 5.0 hp paddy harvester**

Several improvements like steering clutches, modified power transmission and correct balancing were incorporated in the self propelled 5.0 hp paddy reaper-windrower (Plate 48). Extensive evaluations in different field conditions established its feasibility in Kerala. The walking type harvester has a cutting width of one metre and leaves the harvested crop in a neat windrow.

With a field capacity of D. 18 ha per hr a saving of Rs.800 per ha and 125 man-hrs per ha was obtained, compared to manual harvesting. The cost of the reaper is Rs. 40,000/-.

### **Tractor mounted paddy reaper windrower**

Improvements on crop dividers, cutter bar, knife guard fixtures, conveying, hitching, lifting and transmission assemblies on the 2.2 m wide tractor front mounted paddy reaper windrower was carried out. Extensive



field evaluation in different field conditions were carried out. The straw and grain recovery was more, compared to manual harvesting.

The reaper (Plate 49) has a capacity of 0.5 ha per hr and saves an amount of Rs. 950 per ha and 135 man-hrs per ha, compared to conventional harvesting. It costs Rs.20,000/-.



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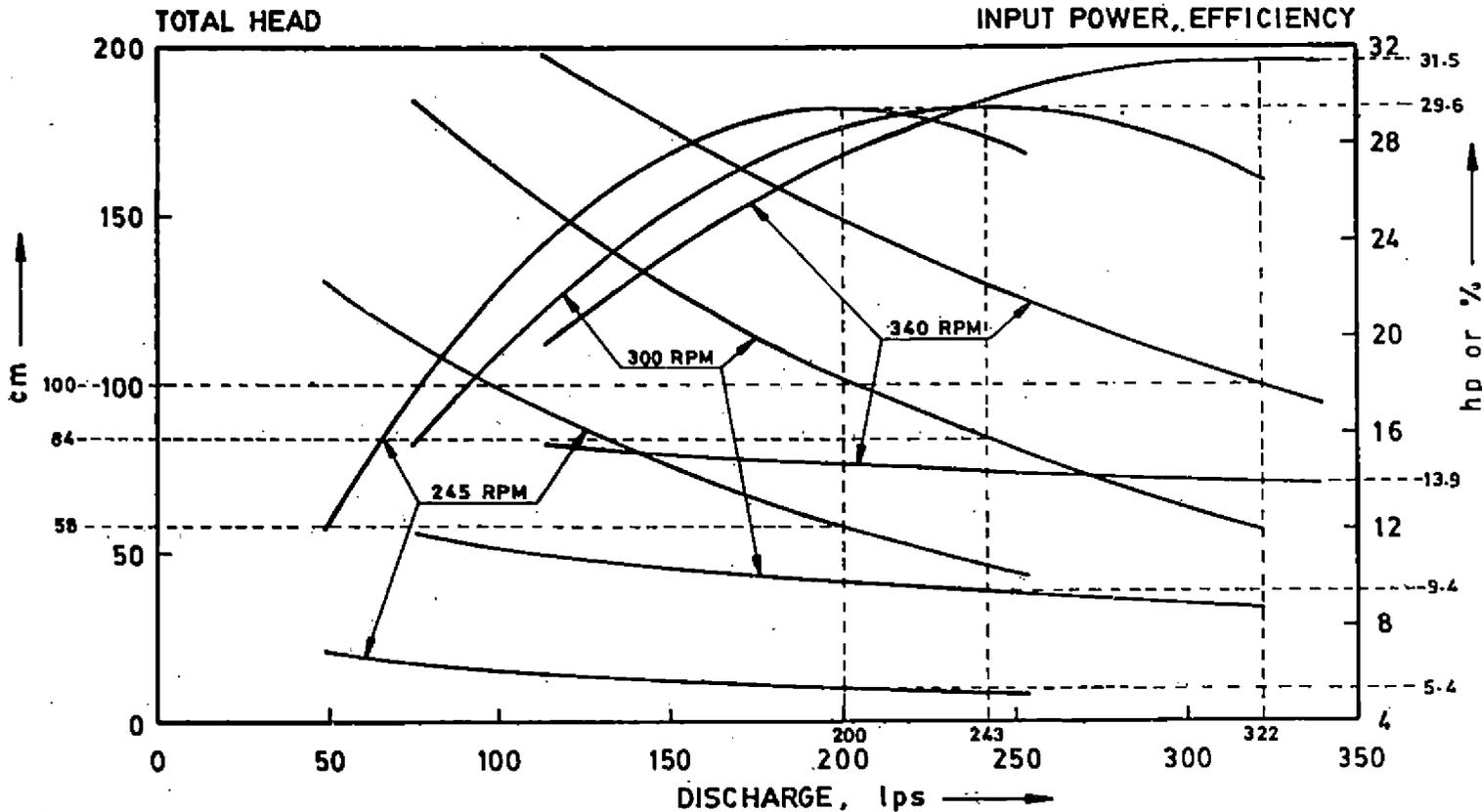


FIG.1. HEAD, HP, EFFICIENCY AND DISCHARGE RELATIONSHIPS