NATIONAL AGRICULTURAL RESEARCH PROJECT IN KERALA

Directorate of Research
Kerala Agricultural University
Vellanikkara - 680 654
Thrissur, Kerala, India

English

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Chief Editor

Dr. N. Mohanakumaran
Director of Research (i/c)
Kerala Agricultural University
Vellanikkara 680 654, Thrissur

Editor

Dr. P. Balakrishna Pillai
Associate Director of Research
Kerala Agricultural University
Vellanikkara 680 654, Thrissur

Assistance

K. E. Usha and A. S. Anilkumar
Assistant Professors
Kerala Agricultural University
Vellanikkara 680 654, Thrissur

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FOREWORD

The National Agricultural Research Project was launched in the early eighties to strengthen the regional research capabilities of the State Agricultural Universities. The development of regional research stations in the different agro-climatic zones in terms of research manpower and infrastructure facilities was the essential feature of NARP. The project at the Kerala Agricultural University was approved by the ICAR in May 1980. The University could implement the Phase - I and Phase - II of NARP successfully. The objectives were achieved through rationalisation of research programmes and the research set up of the University as well as by strengthening the capability of the University to undertake research on location - specific problems.

Agriculture in Kerala has certain distinguishing features in systems and practices of crop production due to particular physiographical features of the land and variations in local environments. The status reports of all the five Agro-climatic Zones of the state which embody these features were published earlier.

The objectives and approaches of NARP, characteristics of Kerala Agriculture, special characters of the agro-climatic zones, NARP components, infrastructure facilities developed, salient research achievements, impact of the project and research publications under NARP are documented in this publication.

It is hoped that this publication will be of considerable use to the scientists, extension workers and students in the field of agricultural research and development. Information on the research achievements made under NARP will be of help to the farming community for raising the productivity of crops in Kerala as well as the West Coast Region.

A.M. MICHAEL
VICE-CHANCELLOR
KERALA AGRICULTURAL UNIVERSITY

PREFACE

The Kerala Agricultural University has successfully implemented the World Bank/ICAR - assisted National Agricultural Research Project (NARP) in the five agro-climatic zones of the State. On the developmental side, the Department of Agriculture implemented the World Bank - assisted "Training & Visit" System (T&V) during the period. These two major programmes were complementary to each other. During the Phase I and Phase II period of NARP, the Kerala Agricultural University could integrate its research and extension education activities at the zonal level. The strengthening of the Regional Stations and Sub Stations by providing infrastructure, scientific, administrative and supporting staff, laboratory, field and transport equipment, research operating cost, etc. enabled the KAU to achieve the goals set by the project.

This publication is a basic document embodying the valuable information on the agricultural sector of the State in general and the agroclimatic zones in particular. This publication brings together a wealth of information on Kerala Agriculture. I trust that this will be of immense use to all those who are concerned with planning, development and future of Kerala Agriculture.

The Zonal Associate Directors and their team of Scientists have spent considerable time and energy in collecting the details and presenting the information in the present form. I congratulate them for their sincere and devoted efforts.

We are grateful to the World Bank and the ICAR for providing the necessary funds for strengthening and streamlining the research machinery and also for preparing the publication.

Our sincere appreciation and thanks are due to the Associate Directors of Research (Headquarters), the Central Computer Facility and M/s. Ebenezer Printers for their efforts in preparing this document and in getting the printing of this publication in time. We also thank Sri.V. Chandranandan, Artist, College of Agriculture, Vellayani for designing the cover.

N. MOHANAKUMARAN,
Director of Research

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NATIONAL AGRICULTURAL RESEARCH PROJECT IN KERALA

1. INTRODUCTION

The National Agricultural Research Project (NARP) was formulated by the ICAR for strengthening the regional research capabilities of the State Agricultural Universities. Assistance for the project was provided by the International Development Association (IDA), an affiliate of the International Bank for Reconstruction and Development (IBRD). The project was being administered by the ICAR through a Project Funding Committee (PFC).

2. OBJECTIVES AND APPROACH OF NARP

The main objective of the NARP was to improve the regional research capabilities of the State Agricultural Universities permanently. For this purpose, intensification of research efforts had to be promoted in respect of (i) food-grains (cereals and millets), pulses and oil seeds, particularly those that are grown under rainfed conditions; (ii) farming systems involving crop-livestock and crop-fish production systems; (iii) agronomic practices; (iv) soil and water conservation techniques and (v) land use patterns for more efficient use of natural resources and ecological potential.

These objectives would be achieved through rationalisation of the research programmes and the research set-up of the university as well as by strengthening the capability of the SAU to undertake research on location-specific problems. The main approach for this comprised :

Development of at least one main station in each agro-climatic zone in the service area of the university supported by sub-stations wherever it is necessary, by providing resources for staff, equipment and infrastructure needed for the on-going research as well as to pursue new applied research problems.

Provision of resources including infrastructure for verification of research results both at the main station as well as at the sub-stations.

Provision of resources to initiate, strengthen and accelerate basic research on topics which are crucial for the long-term agricultural development of the State.

The eligibility of the Kerala Agricultural University was approved by the PFC in May, 1980 on the basis of detailed background paper submitted by the Kerala Agricultural University containing an account of its research capabilities. The University could implement the Phase-1 and Phase-2 of NARP successfully by achieving most of its objectives.

3. CHARACTERISTICS OF KERALA AGRICULTURE

Kerala occupies the South-West corner of the Indian peninsula. It is located between 8° 18′ and 14°48′ North latitude and 74°52′ and 77°27′ East longitude. It is bound in the West by the Arabian Sea and in the East by the Western Ghats. The area of the State is 38864 sq. km., which is roughly 1.03 per cent of the total area of India. However, it supports a population of 29.1 million (1991 Census) which is 3.89 per cent of the total population of the country. The proportion between this area and population is reflected in the high density, 749 persons per sq. km., which is the highest among the States in the Indian Union. The State which consists of fourteen districts is largely agrarian in character. Nearly 88 per cent of the population in Kerala live in villages. The percentage of population engaged in Agriculture including livestock, fisheries and forestry is 55 percent. This includes cultivators as well as landless labourers.

3.1. Physical characteristics

3.1.1. Topography

In terms of physical features, Kerala State can be divided into three regions; (i) the high lands, (ii) the mid lands and (iii) the low lands. The topography of the high land region is mountainous with altitudes ranging from 400 to 2,000 m. above M.S.L. The mid land region has a rolling topography with hills and valleys. The land of the coastal area is made of river deltas, back waters and shore of the Arabian Sea. The entire landscape is traversed by not less than 44 rivers which originate in the Western Ghats and flow towards the back waters or the sea in the West. The districts of Thiruvananthapuram, Kollam, Thrissur, Malappuram, Kozhikode, Kannur and Kasaragod have all the three major physiographic regions. The Idukki, Pathanamthitta, Kottayam and Palakkad districts comprises mid lands and high lands region, while Alappuzha and Ernakulam have both the low land and mid land regions. The Wayanad district comprises of high lands only.

3.1.2. Soils

The soils of Kerala can be broadly classified into seven groups. They are laterite soil, forest soil, sandy soil, red soil, peaty (*Kari*) soil, alluvial soil and black soil. The most important soil type is the laterite. The laterite soils are loams which are acidic in reaction (pH 5.0 to 6.5), poor in organic matter and deficient in all the essential plant nutrients. The laterites found on the hills are gritty and shallow and those in the plains are deeper and of finer texture. These are well drained and respond to good cultural management. The constraints in rainfed agriculture in these soils are low fertility, high acidity, preponderance of iron and low water holding capacity. The forest soils constitute about 25 per cent of the total land area of the State. They are characterised by a surface layer which is dark brown due to the presence of organic matter derived from the luxuriant forest vegetation. The soils are acidic and are rich in total nitrogen but poor in bases due to heavy leaching. Soil erosion and high acidity are the major constraints to production.

The sandy soils are highly porous with very little water holding capacity. They vary in texture from sandy loam to pure sand. They are acidic, extremely deficient in the major plant nutrients, and occur as a narrow belt along the West coast. Low fertility, poor water holding capacity and water logging during the rainy season are the major problems facing crop production in these soils. The alluvial soils are heavy in texture, highly acidic (pH 4.5 to 5.5), well supplied with organic matter,

nitrogen and potash but are deficient in phosphate and lime. The entire *Kuttanad* tract in Alappuzha and Kottayam districts, the *Kole* lands in Thrissur and Malappuram districts and the *Kaipad* land of Ernakulam and Kannur districts are covered by these soils. These are ill drained with toxic reduction compounds present, which limit crop production. The peaty soils are popularly known as *kari* soils. They are characterised by deep black colour, heavy texture, high organic matter and low pH (3.3 to 5.0). The high acidity coupled with salt water ingression and water logging reduce productivity.

The red soils are of deep red colour due to the presence of haematite. No clear horizon differentiation can be seen in these soils. They are acidic in reaction, deficient in organic matter and low in the major plant nutrients. Typical red soils are found in the Thiruvananthapuram and Neyyattinkara taluks of Thiruvananthapuram district. The black soils constitute an extension of the black soils of the Deccan in Chittoor taluk of the Palakkad district. These clays, which expand on wetting and shrink on drying, are alkaline in reaction (pH 7.0 to 8.5), deficient in organic matter and low in nitrogen and phosphorus. Levels of potassium and calcium are satisfactory. Erratic rains limit crop production in such areas.

3.1.3. Micro-nutrient status

The soils of Kerala, except the black (cotton) soils of Chittoor taluk, are acidic in reaction and therefore one may assume that the availability of micronutrients in the soils of Kerala, in general, is quite satisfactory. But the heavy leaching consequent on high rainfall and low nutrient retentivity of the soil has modified this picture.

Preliminary studies indicate that the soils are adequately supplied with available forms of Fe and Mn. Though representative soil samples from some areas indicate optimal availability of Zn and Cu, field responses to the application of these elements have been reported from Kuttanad. The districts of Kottayam, Kollam, Ernakulam and Thrissur are reported to be 100% deficient in Cu, while Palakkad is the most deficient in Zn. There is, hence, a need for a detailed survey of the State for its micronutrient status of the soils.

3.2. Climate

Being in tropical belt, Kerala State receives plenty of solar radiation. In terms of the standard climatic types, the different regions of the State can be considered to be of the humid type, except the high mountainous regions. The weather parameter that builds the climate of the State is rainfall, although humidity and cloudiness are also important from the agricultural point of view.

3.2.1. Rainfall

Situated on the windward side of the Western Ghats and falling within the direct sweep of the South West monsoon, Kerala receives heavy rainfall, the annual precipitation working out to an average of 3003.8 mm. The State derives the benefit of two monsoons, the South West and the North East The bulk of the rains is received in the months of June (676.1 mm), July (702.9 mm) and August (426.3 mm) during the South West monsoon period and the rest during the North East monsoon period from September to November and as hot weather showers in the summer months.

It may be seen that almost 60% of the rainfall is received in the three months of June, July and August. The total precipitation during the normal year is apportioned as follows:

Monsoon	Season	Precipitation (mm)
South West	Early *kharif* (*Virippu*)	1805.3
North East	Late *kharif* (*Mundakan*)	724.5
Summer	Rabi (*Puncha*)	474.0

The South West monsoon rains increase as one goes from South to North of Kerala while the North East monsoon and summer showers decrease. The second crop in most of the districts is very often affected by drought in the flowering period due to erratic nature of the North East monsoon rains. Inadequacy of rainfall from December to May affects production of rainfed perennial crops and limits the scope for cultivation of annual crops during this period.

3.2.2. Temperature

Extreme heat and cold are unknown in Kerala. The months of March and April are the hottest, and the month of January, the coldest. The average maximum temperature varies from 24.8°C to 31.4°C and the minimum from 20.1°C to 22.7°C, with a mean range from 20.8°C to 27.5°C.

3.2.3. Humidity

Highest humidity is observed in the State, the average working to 82%. The three months of June, July and August record more than 90% humidity.

3.2.4. Wind

During May to September, the surface winds are North-Westerly, whereas from January to April and from October to December, the winds are North-Easterly in the morning and South-Westerly in the evening.

3.2.5. Evaporation

Due to high humidity and low wind speed, the annual evaporation is less, against the annual precipitation of 3003.8 mm. Though the soil may have net residual moisture during the summer, extreme moisture stress during January to March is a regular feature.

3.2.6. Special weather phenomenon

Depression storms which are not uncommon during October and November in the Arabian Sea, cause rains over the entire state. Thunder is observed frequently during the pre-monsoon period.

3.3. Irrigation

The total irrigated area is 6,51,447 ha which works out to 21.52 percent of the total cropped area; the bulk of this area (2,28,166 ha) is irrigated by Government canals. Private canals, tanks and wells

irrigate 10,160 , 76,308 and 5460 ha respectively. An area of 14,455 ha is irrigated by other sources. Ninety percent of the total irrigation is diverted for growing food crops. This includes about 80 per cent on paddy and 10 per cent on other food crops.

A number of irrigation projects have been taken up in Kerala. Water has become available from these projects to about 80,000 ha in the central and southern zones.

3.4. Socio-economic characteristics

Kerala supports a population of 29.10 million according to the 1991 census. Rural population is 326.01 million. The coastal districts of Alappuzha has the highest density of population, ie. 1128 persons per square kilometre. A tribal population of 2,69,356 in Wayanad accounts for about 1.26% of the total population of the State. Scheduled caste accounts for about 8.3 per cent of the population. Kerala leads all the other states in India in literacy. The total number of workers is reported to be 62.2 lakhs, out of which 34.5 lakhs are either cultivators or agricultural labourers or attend to livestock, forestry, fisheries, plantation and other activities related to agriculture. It shows the predominance of agricultural workers.

3.4.1. Land tenure system

The per capita land cultivated is only 0.10 ha. The holdings continue to be fragmented and sub-divided as a result of the pressure of population and the laws of inheritance. Most of the holdings have ceased to be economically viable units. The total number of operational holdings is 28,22,781 of which 15,17,640 are below 0.04 ha. The total number of holdings having an extent of more than 50 ha is 426.

The majority of the operational holdings (10,81,130) has an area falling between 0.04 and 0.25 ha. Land used under total crop area is about 30,40,000 ha. The net area sown is 21,89,000 ha. Area sown more than once comes to about 8,51,000 ha. The intensity of land use is 140.

3.4.2. Land use and cropping pattern

Out of the total geographical area, forests occupy 10.81 lakh ha. which accounts for 29%. Permanent pastures and other grazing lands constitute hardly 86,000 ha. Cultivable waste comes to 11.3 lakh ha. A disturbing pattern noticed is the increase in land put to non-agricultural use by which there may not be much scope for increasing the area under cultivation. Hence, there is an urgent need for increasing productivity per unit of land.

A wide variety of crops is cultivated in Kerala including plantation crops like coconut, arecanut, cashew, pepper, coffee, tea, rubber; crops like rice, tapioca, pulses, sesamum, cotton, ground nut, ragi, tobacco and horticultural crops like mango, banana and cardamom. The major crops are rice & tapioca (food crops), coconut, groundnut & sesamum (oil seed crops), cowpea, blackgram & redgram (pulses). The main cereal crop, rice, occupies a total area of 5.6 lakh ha. producing about 10.9 lakh t of grains annually. It is grown in all the three seasons in the State. Coconut is grown in an area of 8.6 lakh ha. with a total production of 45.29 million nuts. The plantation crops account for 10% total cropped area (2.34 lakh ha.). Tapioca, an important subsidiary food crop, occupies about 3.16 lakh ha. with an annual production of 1513 lakh t.

3.4.3. Agricultural features

Agriculture in Kerala has certain distinguishing features in the systems and practices of crop production due to the particular physiographical features of the land and variations in the local environments. The features are:

i. The homestead system of cultivation with mixed cropping of perennial and annual crops and/or integrated farming of crops-livestock-fish.

ii. Rice cultivation in areas of utmost adverse conditions viz. lands below sea level and subjected to inundation by sea water and extreme salinity as seen in the Kuttanad and Pokkali lands of the State.

iii. The cropping systems can be largely grouped into three major groups

Coconut based cropping systems including a number of intercrops like pepper, turmeric, cocoa, cardamom, banana, fodder and in some areas rice, pulses and groundnut.

Rice based cropping systems including single cropping, double cropping, crop rotation, paddy-cum-fish or prawn culture, etc.

Homestead farming system of growing a mixture of annuals, perennials, fruits, tubers and spices with coconut as the main crop.

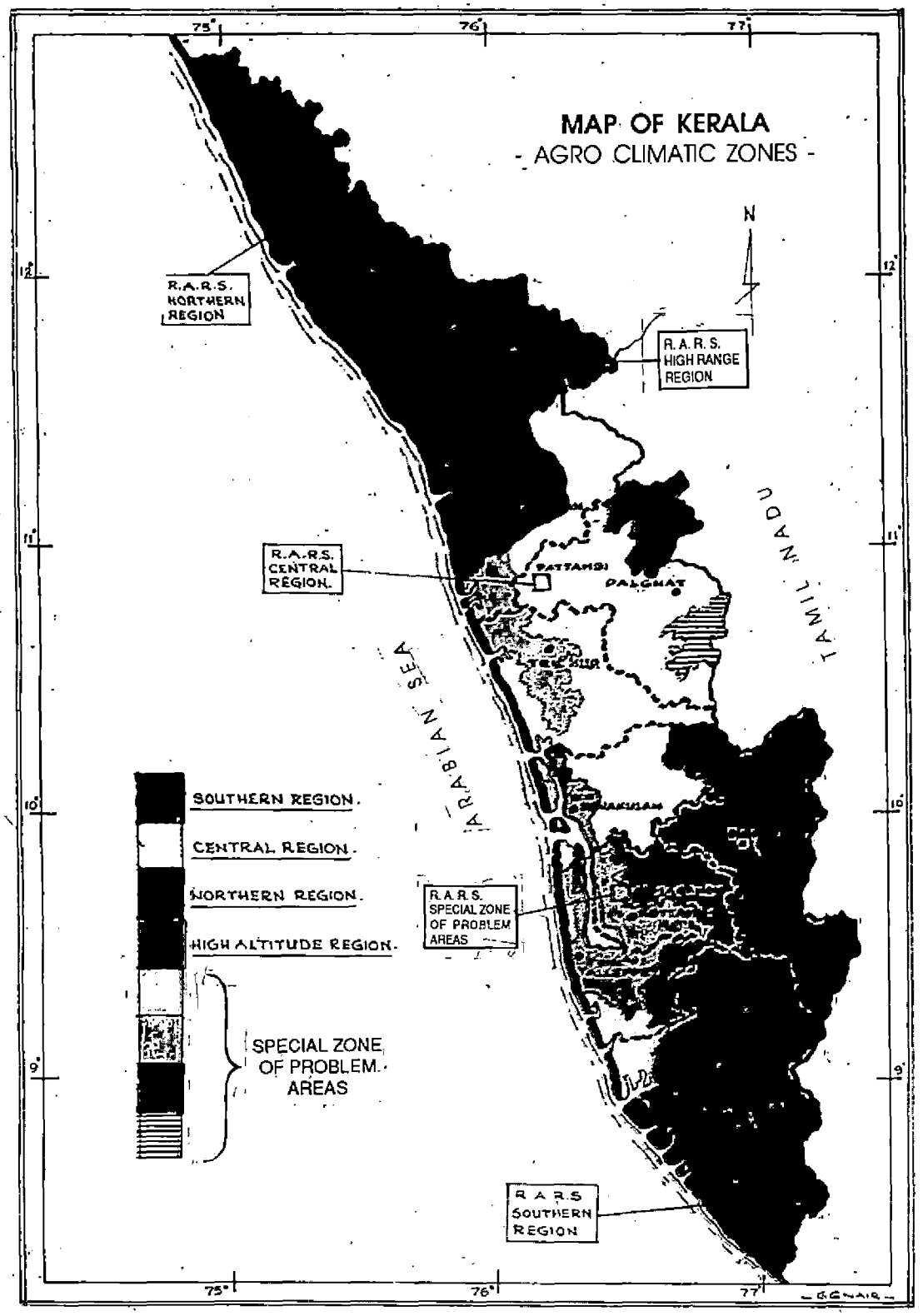
3.4.4. Animal wealth

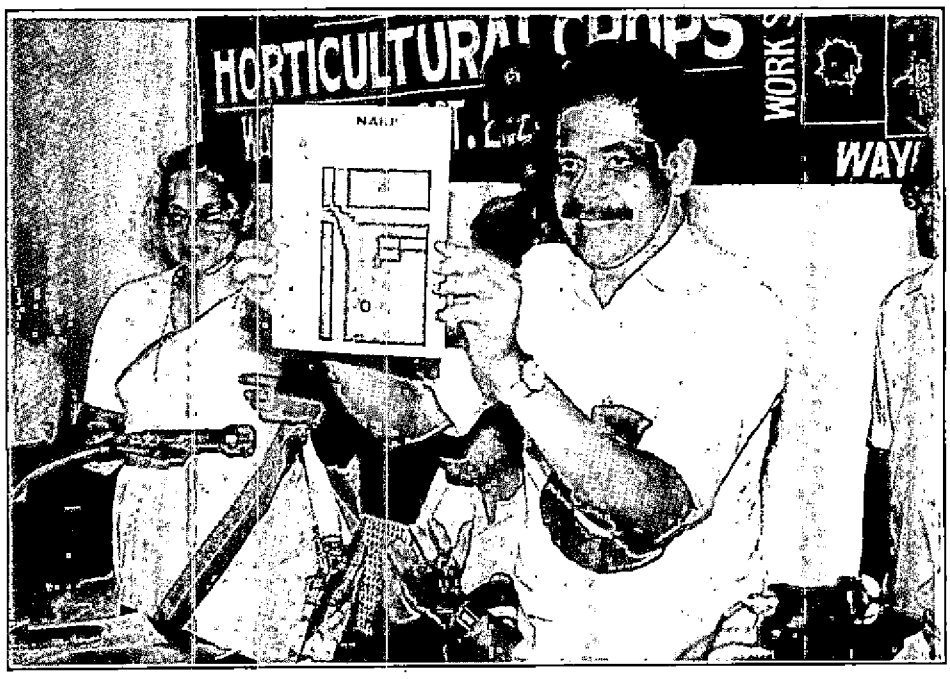
Kerala is rich with a wide population of cattle, goat, buffalo, pig, poultry etc. The effect of cattle improvement programmes can be observed in the distribution of desi and improved (mostly exotic cross breeds) cattle. It appears that goats are raised more for the supply of meat than milk. Concrete steps are to be taken towards improving meat yield from goats. The principal species of poultry are fowls and ducks which together account for over 99% of total poultry. There is scope for improving poultry production since there is considerable demand for eggs as well as broiler chicken meat.

There has been very little attempt at harnessing major byproducts from the livestock sector. Similarly the potential for the manufacture of milk-based products has not been sufficiently tapped. Research and developement efforts are needed to put the use of livestock products and byproducts on scientific lines to cater to the growing consumer demand.

3.4.5. Fisheries

Kerala ranks first in India in fish production. Kerala has a coastal line of 580 km, with 38,000 sq.km area suitable for exploitation. The State has also got 3,55,000 ha of inland water bodies. There is ample scope to increase the present marine production by three times and the inland production by eight times.


MAP OF KERALA
- AGRO CLIMATIC ZONES -
N
R.A.R.S. NORTHERN REGION
R. A. R. S. HIGH RANGE REGION
R.A.R.S. CENTRAL REGION.
PATTAMBI
PALGHAT
TAMIL NADU
ARABIAN SEA
SOUTHERN REGION.
CENTRAL REGION.
NORTHERN REGION.
HIGH ALTITUDE REGION.
SPECIAL ZONE OF PROBLEM AREAS
R.A.R.S. SPECIAL ZONE OF PROBLEM AREAS
R A R S SOUTHERN REGION
75°
76°
77°
12°
11°
10°
9°



Sri. Mullappilly Ramachandran, Hon'ble Union Minister of State for Agriculture releasing the **NARP Status Report** in the presence of Smt. K.C. Rosakutty, M.L.A.

Distribution of ***Kerasree*** to tribal woman by Dr. S. Gangopadhyay in the presence of Dr. M. Balasubramonian, Consultant, World Bank.

4. AGROCLIMATIC REGIONS

Five agro-climatic zones have been identified in Kerala based on soil and climatic conditions, cropping patterns and socio-economic characteristics. The zones identified are (i) Southern Zone (ii) Special Zone of Problem Areas (iii) Central Zone (iv) Northern Zone and (v) High Range Zone.

4.1. SOUTHERN ZONE

This zone comprises four southern districts of Kerala viz. Kottayam, Alappuzha, Kollam and Thiruvananthapuram. The high ranges, coastal saline soil tract, Onattukara sandy soils and the problem soils of Kuttanad are not included in this region.

The southern mid land comprises 24 community development blocks and five municipalities. The area of this zone is 3,12,358 ha. The soil is of lateritic origin and highly acidic in reaction. The southern most area of this zone has deeply ill-drained soil which is rich in iron and aluminium. Poor drainage aggravates soil problems. The red loam zone comprises three community development blocks and one municipality with an area of 31,699 ha. The soil is red loam. Rainfall is well distributed. Rice, coconut, tapioca, sesamum, pulses, ginger, rubber are the major crops.

4.2. SPECIAL ZONE OF PROBLEM AREAS

In the state of Kerala there exists certain problem soils characterised by high salt content, extreme acidity, high content of soluble iron, aluminium or sulphur with accumulation of organic matter under impeded drainage. Soils are predominantly sandy with low water holding capacity or having high exchangeable sodium percent.

The areas included under this Special zone are:

Kuttanad area of Alappuzha and Kottayam districts.
Kole lands of Thrissur and Malappuram districts.
The acid saline Pokkali soils of Ernakulam district.
The sandy soil tracts of Onattukara, spread out in Alappuzha and Kollam districts.

Kuttanad

The narrow stretch of coastal area from Thiruvananthapuram to Kannur is interspersed with lakes, lagoons, estuaries and marshes. These irregular stretches of backwaters lying at a level of 1.0-2.5 m below mean sea level encroach here and there into the mid land region as well. These submergible areas of the backwater systems found in the districts of Alappuzha and Kottayam are known as Kuttanad. Since major portions of this area lie below the mean sea level, they get flooded, especially during the South West monsoon season making it impossible to raise any crop during the period from June to August.

As these areas are connected to the sea through back water lakes, they are subjected to sea water inundation periodically. Thus in addition to water logging, salt water intrusion also becomes a problem to this region.

The area known as Kuttanad covers an extent of about 28359 ha. spread over a number of community development blocks in the two districts of Alappuzha and Kottayam. The area is between alternating, dry lands and wet lands. Although the proportion between dry lands and wet lands varies between micro zones, roughly for the whole region, dry lands constitute ⅓rd of the area while ⅔rd is accounted for by wet lands. Rice is extensively grown in wet lands while dry lands are utilized for crops like coconut, cocoa and spices as well as for human habitation and supporting livestock.

Taking advantage of certain natural factors such as the recess in the rainfall during August-September and tidal action, an indigenous way of raising a rice crop by erecting bunds and dewatering the land has been developed over generations.

Paddy lands comprise the area reclaimed during different periods of the past from the back waters and are called "Padasekharams" - literally meaning groups or blocks of rice fields, separated from canals and rivers by protective ring bunds of embankments. Based on the soil characteristics and topography, the Padasekharams are broadly classified into five groups.

Single crop puncha lands

These are areas silted up over a long period of time and left as waste lands, but reclaimed later for rice cultivation. These lands lie at a higher level than the Kayal lands; but lower than the Karapadams and require outer bunds with height of about a meter. After raising a single rice crop during September-January, the fields are left as fallows under flooded conditions till August.

Kayal lands

Kayal lands are the lowest lying and recent reclamations from the lake areas. Here, the outer bunds should have a height of at least 2.5 meters to contain the flood water from inundating the fields.

Karapadams

These are lands lying farthest from the lake and cover the major portion of Kuttanad. These lands were the earliest to get gradually silted up as they are nearer to river mouths. The fields lie at a higher level than the single crop Puncha lands and monsoon floods affect only at comparatively shallow depths.

Double crop lands

The shallowest parts of Karapadams occupying the eastern most portion of Kuttanad area form the double crop lands. In addition to the usual puncha, a deep water rice crop is raised during the period from April to September using a local variety.

Kari lands

Kari lands are characterised by extreme soil acidity and accumulation of peat like materials in the soil profile. These lands lie at the same level as the single crop puncha lands. They occur in large isolated patches on the South West and North East margin of Kuttanad. Because of the peculiar nature of the soil, over a large part of the area, mound or heap system of rice cultivation is followed.

The main cropping season of Kuttanad known as puncha starts from August-October and harvesting is completed by March at the latest according to the progress of salinity. In September, the level of water in the fields which have accumulated during monsoon months recedes and goes down to 80 to 90 cm. Then, outer bunds of padasekharams are constituted by earthing up clay and using other building materials to the required height. This is followed by pumping out the water from the field without interruption for 20 to 30 days till the fields get completely drained of all excess water. Preparatory cultivation and sowing/transplanting are then taken up. Fresh water is let in (pumped in) as and when required. Throughout the crop growth period water stands outside the main bunds several meters above the level of the fields. A second additional crop is also grown during the virippu season which has become popular due to low incidence of pests and diseases.

In spite of adverse soil and hydrological conditions existing in this region it can be seen that a cropping system has been developed from cultivation practices adopted through generations. There is still areas where modifications are needed for improving the cropping system followed at present in this zone.

Kole lands

Kole lands are almost similar to Kuttanad in their topography, soil type and the problems encountered during cultivation operations. But there are certain distinctive characteristics which differentiate this region from Kuttanad. Kole lands lie in a slightly higher elevation than Kuttanad. The extremely acidic peaty soils (kari) found in Kuttanad are absent in the Kole areas. The kole areas are interspread by garden lands of higher elevation with soil types from sandy to laterite. The main cropping season in kole area is from January-February to April-May. Other adverse conditions of Kuttanad like acidity, salt intrusion, poor drainage, presence of toxic salts etc. exist in kole areas also.

Kole lands are spread over in Vellangallur, Irinjalakuda, Cherppu, Anthikad and Puzhakkal block areas of Thrissur district and Andathode and Ponnani block of Malappuram district.

The main crops are rice in kole lands and coconut, spices and other perennial crops in the garden and dry lands. The main cropping season being January-May, it is subjected to drought hazards if supply from irrigation systems fail during the maturity phase of the crop.

Onattukara and Pokkali lands

The Onattukara region comprises six community development blocks in Kollam and Alappuzha districts while the pokkali lands are spread out in five blocks of Ernakulam district. The main feature of Onattukara is the sandy soils of the tract. The soil being sandy is poor in plant nutrients and the reaction is acidic. It is rich in iron and aluminium. The organic matter content is low and its water holding capacity is poor. The soil responds well to fertilizer application. The soil is sandy and the

water table is high. The water is saltish and during summer months the soils become salt affected. Pokkali soils are acid saline frequented by the sea water inundation due to tidal currents. The lands are submerged during monsoon period. It is poor in phosphorus, do not respond to nitrogen application and is medium in potash content.

The main feature of Onattukara is that the rice crop is raised under dry conditions which turn up into water logged conditions during the latter part of the crop. Water table being high, there is problem of drainage during the monsoon season. In the sandy soils of Cherthala, besides acidity, the salt content arising from the groundwater is also a problem. Rice and other annual crops like sesamum are raised on mounds with the on-set of monsoon. In the middle of November the lands are left for prawn culture.

In this area rice is the main crop in the low-lands and coconuts, spices and cocoa in uplands. In Onattukara area, the first crop rice is raised as dry sown from April-May and harvested during August-September. Second crop is transplanted and is raised during September to December. Sesamum is usually raised as a third crop.

In Pokkali area, only one rice crop is raised during May/June to October/November. After November middle, the lands are used for prawn culture. Rice is raised on mounds prepared during May to wash down the excess salt content by the monsoon showers. The seeds are put on the top of mounds during June and when the seedlings have achieved growth for 30 to 45 days, the mounds are broken and the seedlings arranged on the broken mounds in level with the fields. During the peak periods of monsoon, the fields will be flooded for a duration of 10 to 18 days. The crop is harvested before November and fields left out for prawn culture till April.

Coconut is the main crop of uplands. The entire area is covered with the complex disease of coconut. Intercropping with cocoa is being introduced now. Spices and other perennial crops are also raised as intercrops in the uplands and homesteads.

4.3. CENTRAL ZONE

The central midland-Palakkad red loam and Chittoor black soil zones form parts of the central region which occupies an area of 4,45,433 ha. in 27 Community Development Blocks and seven Municipalities. The main soil type is lateritic loam, acidic in reaction and low in plant nutrients, particularly nitrogen and calcium. Palakkad zone has an area of 127950 ha. in four Community Development Blocks and one Municipality. The soil is red loam and acidic in reaction. Rainfall is low and well distributed. It has however, a well developed irrigation system and this offers considerable scope for increasing and stabilising production of rice, which is the principal crop of the area. The Chittoor black soil zone with an area of 58747 ha. (Chittoor and Kollenkode blocks of Palakkad district) completes the central region. This area is characterised by low rainfall and black soil. The soil is alkaline.

The main crop of the region is rice which is cultivated in the lower valleys and central plain lands and to some extent in the coastal sandy soil. Rice and arecanut are cultivated in the uplands as rainfed crops synchronising with the South-West monsoon. Arecanut is also grown as an irrigated crop in the valleys and river banks, especially in Trichur. Coconut is grown mainly in homesteads around Thrissur and Ernakulam districts.

Groundnut is concentrated (12655 hectares) in the Palakkad area. Sesamum is cultivated mostly in Ernakulam and Thrissur districts and to a lesser extent in Palghat. Pulses occupy considerable area in this region though concentrated around Palakkad. Tubers cover an area of 51,400 ha. mostly in Ernakulam and Palakkad districts. Of the tubers, tapioca occupies the largest area. Other tubers include elephant yam, colocasia, coleus etc.

4.4. NORTHERN ZONE

The northern region comprises the three northern districts of Kerala viz., Kannur, Kozhikode and Malappuram. The total area of the region is 10,92,060 ha. The major soil type of the region is laterite with a sandy coastal belt. The land is poor in fertility and the cultivation is mainly rainfed. The zone is characterised by heavy rainfall during the South West monsoon period (May to September) which casuses severe run off because of the undulating topography. The prolonged dry spell from the end of November to the beginning of May results in severe moisture stress, leading to considerable yield decline in almost all annual and perennial crops.

The important crops of this region are coconut and paddy. Cashewnut, arecanut, banana and rubber are also grown in plantations. Tobacco is also grown to a certain extent in Kannur district. As in other parts of Kerala, polyculture is practised which consists of annual and perennial crops raised mostly in the homestead gardens with coconut as the pivotal crop. Pepper forms the important companion with coconut while other crops like cocoa, cardamom, ginger, banana, turmeric, pulses and grasses are grown according to the altitude and soil conditions.

4.5. HIGH RANGE ZONE

High ranges are the high plateau of the Western Ghats comprising two hill districts of Wayanad and Idukki, and parts of Palakkad, Kollam, Pathanamthitta and Thiruvananthapuram districts. This region covers 3,14,015 ha. The climate is mild sub-tropical to tropical humid, conducive for growing both subtropical and tropical crops. Rainfall is received in almost all the months in Wayanad and Idukki districts.

Plantation crops like coffee, tea, pepper occupy large areas. Cardamom, orange and other annual and seasonal crops like rice, ginger, tapioca and vegetables are also grown. The most important improved annual crop is rice with an area of 26,000 ha. It is grown in the valleys between mountains.

5. NARP COMPONENTS

The NARP Phase - I was implemented during 1980-81 in all the five agro-climatic zones and the following were the components identified for research in each of the zones:

Food crops
Oil seeds
Farming systems
Basic research

The NARP Phase -II was implemented in April, 1988 with the following major components.

Horticulture & Post-harvest Technology
Soil and Water Management
Farm Machinery
Animal Nutrition and Management
Agro-forestry

5.1. Lead and verification functions

Based on the NARP concepts developed for the Country, the lead functions and the verification functions of the research stations were identified in addition to the setting up of the Regional Research Stations. The details of the Regional Research Stations and lead centres/verification centres in the five different zones of University are furnished below.

Research Centre	Lead function	Verification function
SOUTHERN ZONE		
Vellayani	Research under partially shaded conditions. Export-oriented vegetable & cutflower production	Rice, fruits, homestead farming, coconut, tuber, vegetables, farm machinery for garden lands
Farming Systems Research Station, Kottarakkara	Homestead farming, Soil & Water Conservation & Management	Tuber, coconut, rice, horticulture, agroforestry, cashew.
Coconut Research Station, Balaramapuram	Agro-techniques for coconut and coconut-based farming system in red soils.	
Cropping Systems Research Centre, Karamana	Rice based cropping system	Agrotechniques (rice), integrated farming systems with rice/fish/poultry/cattle.

Research Centre	Lead function	Verification function
SPECIAL ZONE		
Kumarakom	Integrated farming	Rice in Kayal lands, root (wilt) management, homestead farming in Kuttanad.
Sugarcane Research Station, Thiruvalla	Sugarcane	Vegetables (Cucurbits)
Rice Research Station, Kayamkulam	Rice in Onattukara, annual oil seeds and pulses	Vegetables (including cassava) in homesteads, mushrooms
AICRP on Agrl. Drainage, Karumadi	Agricultural drainage	-
Rice Research Station, Moncompu	Rice in Kuttanad	-
Rice Research Station, Vyttila	Pokkali rice and rice-fish farming system	-
CENTRAL ZONE		
Pattambi	Rice and rice based cropping systems, pulses, seed technology, organic farming in rice.	Vegetables in rice fallows, animal management, agro-forestry, crop weather modelling, mechanisation in rice culture and orchards.
Agricultural Research Station, Mannuthy	Rice for kole land management system, research in rice and coconut	Vegetable and organic farming research.
Banana Research Station, Kannara	Banana & banana based cropping systems	Vegetables
Agronomic Research Station, Chalakudy	Water management for rice and rice-based cropping system and other annual crops	Agro-techniques in rice and rice-based cropping system.
Aromatic & Medicinal Plants Research Station, Odakkali	Essential oils	Medicinal plants
Cashew Research Station, Madakkathara	Cashew	-
Cashew Research Station, Anakkayam	-	Cashew, vegetables in cultivators' field.
NORTHERN ZONE		

Research Centre	Lead function	Verification function
Pepper Research Station, Panniyur	Pepper	-
HIGH RANGE ZONE		
Ambalavayal	Pepper and pepper based cropping in high ranges, hill paddy, cool season vegetables. Soil and water management, sub tropical fruits, trees spices, coffee based cropping system	-
Cardamom Research Station, Pampadumpara	Cardamom	Pepper, tree spices

5.2. Relevance of technical programmes of research

The constraints in the production of crops, animals, fishes etc. were identified in close collaboration with the development departments in Government, non-Governmental organizations, progressive farmers etc. Based on these problems, research projects relevant to the situations were formulated. The emphasis was to optimise the use of resources and to maximise the farm income by developing appropriate technology based on farming systems.

6. PROGRESS OF IMPLEMENTATION OF NARP

6.1. Physical facilities

Utilizing the funds provided under the NARP Phase-I and Phase-II, the University could strengthen certain on-going programmes and initiate many new programmes by creating new posts of staff, infrastructure such as laboratories, equipment, libraries, workshops, glasshouses, trainees' hostels, staff quarters, land development, irrigation, fencing, meteorological observatory, computer centre, reprographic facilities, transport, farm machinery etc.

Financial outlay

Phase I

Zone/Station	Sanctioned	Released	Utilized	%Utilisation
Southern Zone	89.98	89.98	99.62	110.71
Special Zone	113.91	113.89	144.35	126.72
Central Zone	84.46	82.26	81.25	96.20
Strengthening Directorate of Research	10.83	10.71	10.87	100.37
Chalakudy	21.72	20.77	19.40	89.32
Northern Zone	103.70	109.30	119.98	115.70
High Range Zone	33.37	33.37	39.62	118.73
Total	457.97	460.28	515.09	112.47

Phase II

Zone/Station	Sanctioned	Released	Utilized	% utilisation
Southern Zone	41.08	41.08	43.86	106.77
Special Zone	56.02	51.18	62.83	112.16
Central Zone	60.79	60.57	64.55	106.19
Northern Zone	48.16	42.13	46.93	97.45
High Range Zone	51.30	50.77	50.79	99.01
Total	257.40	245.73	269.00	104.51

Total for Phase I and II

Sanctioned	Released	Utilised	% utilisation
715.32	706.01	784.05	109.61

Additional/supplementary funds

Sanctioned	Released	Utilized	% Utilisation
236.785	236.785	230.865	97.5

6.1.1. Staff

Following the NARP concept, the University created one post of Associate Director of Research for each zone and three in the headquarters to assist the Director of Research. In addition, the University created one more post of Associate Director of Research (Veterinary & Animal Sciences) utilizing its own funds.

Sanctioned staff position

Zone	Station	NARP - I		NARP - II		TOTAL	
		Scientists	Supporting	Scientists	Supporting	Scientists	Supporting
Southern zone	RARS Vellayani	10	21	5	2	15	23
	FSRS Kottarakkara	7	7	3	5	10	12
Problem zone	RARS Kumarakom	15	21	2	2	17	23
	RRS Moncompu	7	7	-	-	7	7
	RRS Kayamkulam	2	-	1	1	3	1
	RRS Vyttila	1	-	1	2	2	2
	SRS Thiruvalla	-	-	1	-	1	0
Central zone	RARS Pattambi	9	3	3	-	12	3
	BRS Kannara	-	6	6	1	6	7
	ARS Chalakudy	5	2	1	-	6	2
	ARS Mannuthy	2	3	1	-	3	3
	RS Eruthiampathy	2	-	-	-	2	0
High Range zone	RARS Ambalavayal	6	8	5	2	11	10
	CRS Pampadumpara	2	3	-	-	2	3
Northern zone	RARS Pilicode	24	5	6	2	30	7
	PRS Panniyur	1	-	1	-	2	0
Total		93	86	36	17	129	103

6.1.2. Infrastructure

. Progress of civil works are summarised below:

Zone	Sanctioned amount	Expenditure
Southern zone	9.90	11.00
Special zone	20.89	24.11
Central zone	15.25	16.20
Northern zone	17.42	18.78
High Range zone	18.88	21.01
Total	82.34	91.10

SOUTHERN ZONE

During the NARP Phase-I period, the zonal station could set-up an air-conditioned Central Instrumentation Laboratory, as a common facility. Re-modelling of the laboratories of Soil Science and Agricultural Chemistry, Agronomy, Plant Breeding, Extension, Home Science, Horticulture, Entomology, Plant Pathology and Statistics was achieved at a total cost of 18.8 lakhs. One glass house (75 sq.m.) and one green house (25 sq.m.) were constructed at a cost of Rs.2.13 lakhs and Rs.0.46 lakhs, respectively. An area of 8.96 ha open garden land was acquired to start the NARP Special Station at Kottarakkara. A Field Laboratory-cum-Office building with an area of 225 sq.m. was constructed in 1986. Two Scientists' quarters Type-V (196 sq.m.) and Type-IV (120 sq.m.) were constructed.

During Phase-II, an engineering workshop with an area of 100 sq.m. was constructed at a cost of Rs.1.45 lakhs to enable fabrication and testing of farm implements. Two quarters, Type-IV (112 sq.m.) and Type-II (50 sq.m.) were constructed at the FSRS, Kottarakkara at a cost of 2.95 and 1.33 lakhs, respectively. A Trainees' Hostel (300 sq.m.) was also constructed at a cost of Rs.3.45 lakhs. A Seminar Hall (50 sq.m.) was constructed and furniture procured at a cost of Rs.1 lakh.

SPECIAL ZONE

During the NARP Phase-I period, a laboratory (1235 m^2), farm structures (505 m^2), Trainees Hostel (375 m^2) were constructed at the RARS, Kumarakom. A laboratory (140 m^2) and a farm structure 47 m^2) were set up at RRS, Kayamkulam.

During the Phase-II period, residence (Type V - 196 m^2, Type IV - 110 m^2 and Type II - 100 m^2), vehicle shed (50 m^2) were built at the RARS, Kumarakom. At the RRS, Moncompu residence (Type II - 2 nos. of 100 m^2), jeep shed (50 m^2) and boat shed (90 m^2) were constructed and a residence (Type IV- 196 m^2) at the RRS, Kayamkulam. A laboratory (200 m^2) , residence (Type V - 196 m^2 and Type II - 50 m^2), vehicle shed (50 m^2), store (50 m^2) and waiting shed (60 m^2) were provided at the SRS, Thiruvalla.

CENTRAL ZONE

Trainees' Hostel, Seminar Hall, Engineering Workshop, Cattle shed, Vehicle shed, Store rooms, Field laboratories, Staff quarters were constructed in the cental zone.

NORTHERN ZONE

The following major items were constructed : Residence (196 m^2, 220 m^2), laboratory (60 m^2), workshop (100 m^2), Training Hall (120 m^2), vehicle shed (120 m^2), goat shed (50 m^2) at the RARS, Pilicode and residence (196 m^2), Office-cum-Lab (100 m^2), green house (100 m^2), waiting shed (60 m^2) at the PRS, Panniyur.

HIGH RANGE ZONE

Residential quarters (5 numbers), Conference Hall, Trainees' Hostel, seed store, rabbitry shed, vehicle shed were constructed in the high range zone.

6.1.3. Farm Development

Every sub station of each regional research station was provided with funds for farm development including land shaping and improvement, contour bunding or terracing, augmenting irrigation facilities, fencing etc.

Zone & Station	Amount sanctioned	Amount spent	% Utilization
SOUTHERN ZONE			
RARS, Vellayani	9.14	9.14	100.00
FSRS, Kottarakkara	9.89	9.89	100.00
SPECIAL ZONE			
RARS, Kumarakom	3.00	3.70	123.00
RRS, Moncompu	2.00	2.00	100.00
RRS, Kayamkulam	2.70	2.70	100.00
RRS, Vyttila	2.00	1.71	86.00
SRS, Thiruvalla	1.00	1.26	126.00
CENTRAL ZONE			
RARS, Pattambi	5.00	4.93	99.00
ARS, Chalakudy	2.5	2.39	96.00
BRS, Kannara	2.00	2.02	101.00
NORTHERN ZONE			
RARS, Pilicode	6.00	6.31	105.00
PRS, Panniyur	5.00	5.07	101.00

Field Laboratory cum Office building, Farming Systems Research Station, Kottarakkara.

Scientists' quarters at RARS, Pattambi

Trainees Hostel at RARS, Ambalavayal.

Seminar Hall and Trainees Hostel at RARS, Pattambi.

Biofertilizer Unit, RARS, Pilicode

Soil Science Laboratory at RARS, Pattambi

Spectronic - 2000 of the Central Instruments Laboratory, RARS, Vellayani.

Leaf Area Meter of the Central Instruments Laboratory, RARS, Vellayani.

Zone & Station	Amount sanctioned	Amount spent	% Utilization
HIGH RANGE ZONE			
RARS, Ambalavayal	6.00	6.92	115.00
CRS, Pampadumpara	7.40	6.48	88.00
TOTAL	51.60	52.47	102.00

SOUTHERN ZONE

Reclamation of Kayal land and development of garden land were undertaken at the RARS, Vellayani. To meet the enlarged requirements of field experiments under NARP, an area of 4.5 ha. wetland was reclaimed from the adjoining Vellayani lake. The area has been protected from floods by an earthen bund, enabling scientists to successfully raise two or even three crops of paddy annually, as against a single crop raised earlier under risk. A pond with perennial water supply was deepened, a pump (7.5 HP) installed and a ground level tank constructed at the highest point. An area of 10 ha. garden land has also been developed and protected by barbed wire fencing. A separate well has been sunk and a 10 HP pump installed to enable irrigation. Three surface tanks were also constructed. An amount of Rs.9.14 lakhs was spent for the land reclamation. An indigenous pumping device `Petty and Para' was also installed at a cost of Rs. 40,440/-.

At the FSRS, Kottarakkara, the entire area of 8.96 ha. lying in two plots of (1) 4.03 ha. and (2) 4.93 ha. has been protected by barbed wire fencing. A net house has also been constructed to raise nursery. Metalling and bitumenization of the circular road and approach road to the Trainees' Hostel were done at a cost of Rs. 5.07 lakhs. Water supply, construction of open well, pump house, farm implement store and drains etc. were provided at a cost of Rs. 2.91 lakhs and approach road to pump house in Block-B of the station, at Rs. 1.91 lakhs.

SPECIAL ZONE

Construction of foot bridge, gate, retaining wall, watchman's cabin, overhead tank; fencing; reclamation of land; electrification of farm roads were taken up at the RARS, Kumarakom. At the RRS, Moncompu a pump house, retaining wall and a house of axial flow pump were constructed. Fencing, gate, levelling premises, formation of road and black topping were also taken up. Lining water tank, construction of pump house and fencing were the major activities at the RRS, Kayamkulam. Construction of foot bridge, strengthening field bunds and outer bunds and renovation of ponds were done at the RRS, Vyttila. At the SRS, Thiruvalla fencing, lining irrigation channels and construction of farm roads were completed.

CENTRAL ZONE

Check dam, compound wall, fencing, net house, approach road, drainage channel, drinking water facilities were provided at the RARS, Pattambi.

NORTHERN ZONE

Barbed wire fencing in the new area, rectifying the existing mud walls, installation of oil engine pumpset in the new area, installation of pumpset and laying out irrigation supply lines for the borewell in the old area, deepening existing wells, water supply to quarters and office at Nileswar, construction of ground level tank in N5 block of the old area, drying yard in the new area, construction of a compound wall at farm side and guest-house side at Nileswar, construction of pump house, installation of pumpset, electric motor and layout of irrigation lines in the new area, construction of a culvert and partial compound wall for the new area, construction of ground level tank in the new area and installing the granite posts with concrete foundation around the boundary of the new area were taken up at the RARS, Pilicode.

Nursery, irrigation, sprinkler etc. deepening and widening existing pond and providing irrigation in the new area, retaining compound wall and bared wire fencing, farm fencing in the new area, improving farm roads, deepening well in the old area, construction of a pumphouse, metalling farm roads and rubble packing side were provided at the PRS, Panniyur.

HIGH RANGE ZONE

Compound.wall, ground level tank, pump house, sprinkler irrigation unit, black topping road, irrigation pipeline system were the activities in the high range zone.

6.1.4. Strengthening meteorological observatories

The meteorological observatories in the Regional Stations were strengthened and new B/C type observatories were set up in the FSRS, Kottarakkara (0.20 lakh) and RRS, Vyttila. The weather data recorded in each zone are being used for crop weather modelling, pest and disease predictions etc.

6.1.5. Computer facility

An amount of Rs. 28.73 lakhs was sanctioned and utilized for providing computer facilities to the Regional Stations and the Directorate of Research. An Electronic Data Processing and Information Centre (EDP & IC) has been functioning at the RARS, Vellayani since 1992. One week training (Text Processing) has been imparted to 60 Scientists in the College of Agriculture, Vellayani and the Scientists of other stations. The computers are utilised for developing models for various research programmes including farming systems, crop weather studies, pest and disease monitoring, cataloguing genotypes etc. The details of the research projects of the entire university have already been fed into the computer. The University organises training programmes for the Scientists of the various research stations on the use of computer facility for evolving various models.

6.1.6. Equipment and machinery

The equipment and machinery provided to each station are being utilized effectively for various research purposes. Several sophisticated items of equipment including AAS, Spetronic 2000, High Speed Centrifuge flame photometer, etc. were purchased.

6.1.7. Vehicles

The Directorate of Research, the Regional Research Stations and the Sub Stations were provided with additional vehicles. All the vehicles are maintained properly and used for research and extension purposes. One car, one jeep and one mini bus were procured for the mobility of the scientists in the southern zone during phase I period at a cost of Rs. 0.75 lakh, 0.95 lakh and Rs. 1.93 lakhs, respectively for the mobility of the scientists. Of these one Jeep was transferred to the FSRS, Kottarakkara. During 1993-94 one more Jeep was purchased at a cost of Rs. 2.75 lakhs. Two Jeeps were purchased for the RRS, Kayamkulam & Vyttila; one jeep and one trekker were purchased at Pilicode; a jeep and a car were purchased for Ambalavayal.

6.1.8. Library

The southern regional station could set up a good library with several reference book and back volumes of a few periodicals purchased during Phase II at a cost of Rs. 0.70 lakhs. The library serves as a common facility. 3800 books were purchased in the central zone. Books and journals were purchased for Rs.0.85 lakhs at Pilicode.

6.1.9. Reprographic facilities

The Zonal Research stations were strengthened with reprographic facilities.

6.1.10. Research operating cost

The expenditure on laboratory and field experiments including the cost of labour, chemicals, glassware, fertilisers, pesticides, fuel, stationary etc. was met from the research operating cost (ROC) provided. The amount utilised by the scientists ranged from Rs.2.39 lakhs in Kumarakom to Rs. 5.82 lakhs in Pattambi. The per scientist operational cost was highest in the Research Stations of the High Range Region. The cost of labour is high in the State and the inputs such as chemicals, glassware etc. cost more due to the increased transport costs. A critical analysis of the research operating cost in the various zones indicate that the amount provided was inadequate for the conduct of the required number of field and laboratory experiments for the successful conclusion of the technical programme within the given time frame.

6.2. Salient research achievements

A quantum jump could be noticed in the productivity from 1980-81 to 1990-91 based on the new technologies developed by the University in various zones. The change in the crop intensity over the last 13 years was also analysed in terms of the adoption of better genotypes of many crops. The following are some of the important achievements made by the Kerala Agricultural University.

SOUTHERN ZONE

Crop improvement

New crop varieties released

Rice -	Arathy, Remya	Bhindi -	Kiran
Amaranthus -	Arun	Guinea grass -	Haritha, Marathakom
Veg. cowpea -	Malika, Sharika	Sesame -	Soma, Surya, Thilak
Sweet potato -	Kanjangad, Jawalasakhi	Cowpea -	V-26

Crop varieties suitable for growing in the partial shade conditions in coconut gardens.

Guinea grass	Haritha, Marathakom	Cowpea	V-26 and HG-22
Horsegram	HPK-2, Cul. NBPGR-539	Grain cowpea	Chharodi-1
		Blackgram	TAU-2
Groundnut	TG-3, TG-14, Spanish Improved, TMV-2 & TMV-7	Tapioca	Sree Visakom

Jyothi and Triveni were the best suited short duration rice varieties for the three agricultural sub divisions in the Thiruvananthapuram district. Onam and Bhagya for the Sub divisions of the Pathanamthitta district and Attingal Sub division, and Bharathi for the Nedumangad Sub-division. For the modan (upland) areas of Kollam and Pathanamthitta, Suvarnamodan was identified as the best (modan) variety. Cowpea variety V-26 was found promising as a companion crop with tapioca variety M-4. Six species of mushrooms were identified, characterised and described as edible species.

Crop management

The nutritional requirement of Red Banana, a long duration variety of great demand and specific to the southern zone, has been formulated as basal dose of 10 kg organic matter and top dressing (in 3 splits at 4th, 6th and 8th month after planting) of 370:40:380 g/plant NPK together with 10 kg FYM and 100 g ground nut cake, along with top dressings of NPK.

The recommendation of NPK 40:20:20 kg/ha prescribed for the farmer-acceptable local rice variety Cheradi was modified as 70:35:35 kg NPK/ha which gave significant increase in yield. For coconuts grown in the red loam tract in the zone under good management, NPK at a dose of 680 g, 2330 g and 900 g, respectively per palm per year was found to be optimum. A mixture of sand, soil and cowdung in the ratio 1:2:2 was found to be suitable for growing brinjal, bhindi and tomato. A population of 8000 plants per ha and a dose of 50:50:100 kg NPK/ha was recommended for tapioca grown as intercrop in coconut gardens. Crop models for Farming Situation-2 under rainfed and irrigated situations which could fetch optimum returns were developed. These are being tested in farmer's fields. Application of 2,4-D @ 1 kg a.i/500 litres of water/ha, one month after sowing was effective in the control of striga. For the seed treatment of blackgram, two Rhizobium cultures, KAU BG-2 and KAU BG-12 were recommended.

Crop protection

Sevin 0.2% gave the best control of coried bug infesting coconuts. Sheath blight and sheath rot diseases of rice could be minimised by the application of Carbofuran (at nematicidal doses) and higher

potash (50% more than the recommendation). Inclusion of the fungicide Vitavax further increased the efficiency of Carbofuran and higher potash.

For the integrated control of sweet potato weevil, removal and destruction of the residues from the previous crop; use of healthy and weevil-free setts for planting; application of leaves of *Chromolaena odoratum* as mulch (@ 3 t/ha at 30 DAP); drenching with 0.05% Endosulfan, Fenthion or Fenitrothion at 65 DAP and re-ridging at 80 DAP and trapping the adults using sweet potato cut tubers (size - 6 cm diameter in the central portion) of 100 g size, kept 5 cm apart during 50 to 80 DAP at 10 days interval have been recommended.

For the control of the pollu beetle of pepper, any of the following insecticides: Endosulfan, Dimethoate, Quinalphos or Monocrotophos all at 0.05% concentration is recommended at the time of spike emergence, at berry formation and once again, at berry maturing stage.

Filling the manure pits to a height of 15 cm from the floor with soil mixed with HCH @ 0.2 kg a.i/cubic metre or Aldrin @ 0.1 kg a.i/cubic metre has been recommended for the control of the rhinoceros beetle affecting coconut.

Residue analysis of Carbaryl (0.2%), Fenthion (0.05%), Fenitrothion (0.05%), Quinalphos (0.05%) and Malathion (0.05%) sprayed on brinjal, bittergourd and bhindi during both dry and rainy seasons, indicated the waiting periods to be between one and five days, except in the case of Carbaryl sprayed to bittergourd, where it ranged between 6 to 10 days.

Improvement in farming systems

Cowpea varieties with ideal plant type were sought to suit the interspace of tapioca (M4) during the early growth phase of the latter. V-26 was found promising. The groundnut varieties TG3, TMV-2 and TMV-7 have been found to be suitable for intercropping under partially shaded situations in coconut plantations during kharif. The following tapioca-based intercropping systems, viz., cassava + cowpea, cassava + groundnut and cassava + blackgram were identified as the best for April-May planted tapioca. Sreevisakhom was recommended as the tapioca variety of choice for intercropping in coconut gardens. A population of 8000 plants/ha (at 90 x 90 cm) was found to be the optimum for growing tapioca as an intercrop in coconut gardens. A dosage of 50:50:100 kg/ha of N, P_2O_5 and K_2O has been recommended for realising the maximum net profit from tapioca grown as an intercrop in coconut gardens.

Enhancing the income from holdings

Six species of mushroom *Termitomyces robrustus, Termitomyces mammiformis, Termitomyces microcarpus, Pleurotus cornucopiae, Pleurotus squarrosulus and Boletus edulis* were identified, characterised and described as edible species. The procedures for cultivation of the oyster mushroom, *Pleurotus sajor caju* were standardised and recommended.

SPECIAL ZONE

Crop improvement

Three rice varieties, namely, Bhagya, Onam and Lekshmi were released from the Rice Research Station Kayamkulam in the year 1985 to suit the conditions prevailing in the *Onattukara* tract of the special zone of problem areas. The rice variety Lekshmi has been specifically evolved for the second crop season. A hybrid derivative from the cross Kottarakkara I x Poduvi, Lekshmi is photosensitive and reaches maturity in 165-180 days. The performance of this variety in the Cheradi areas of the eastern lateritic belts of Kollam district of the state is very promising (Fmg situation: Onattukara). A photosensitive rice variety for the second crop season Dhanya has been released from the Rice Research Station, Kayamkulam. It is highly suitable for cultivation during the rabi season in the Onattukara tract (Fmg situation : Onattukara). For the 'thara lands' of Onattukara (nursery sites), an early maturing cassava has been evolved at Kayamkulam. It is a selection from the local koombuvella with a potential yield of 33 t/ha (180-200 days). It has been released as NIDHI (Fmg situation. Onattukara). For the Onattukara tract, cowpea varieties V 118 and CO 3 have been identified as promising for the coconut gardens and summer rice fallows, respectively.

The variety Vyttila-3 (Culture 4-4) was released from the Rice Research Station, Vyttila. This is a hybrid derivative from the cross Vyttila 1 and Taichung (Native)-1. The variety is specifically suited for cultivation in the Pokkali situations of Ernakulam and Aleppey districts where saline conditions prevail (Fmg situation: Pokkali). A high yielding rice variety tolerant salinity hazards Vyttila-4 has also been released.

Two medium duration high yielding rice varieties were released from Moncompu in 1982 (Pavizham) and 1985 (Karthika). These varietles are suitable for both the cropping seasons of Kuttanad and they are fairly tolerant to brown plant hopper. Kuttanad being an endemic area for brown plant hopper, these varieties are widely accepted by the farmers (Fmg situation: Kuttanad). 15,000 ha in Kuttanad is now under Pavizham and Karthika (Fmg situation: Kuttanad). For the Kuttanad tract, four high yielding varieties have been released from the Rice Research Station, Moncompu (Aruna ,Makom, Remya, Kanakom). These varieties posses multiple resistance to pests (BPH) and diseases (sheath blight, blast). The entire area of Kuttanad (56,000 ha) is now under high yielding dwarf varieties.

At Mannuthy, a very early duration (75-80 days) rice variety Hraswa has been evolved by hybridization (T 140 x IR 8). It is suited for the drought prone areas towards the fag end of the cropping season (Fmg situation: Kole)

Efforts to evolve high yielding, high sugar and red rot tolerant varieties of sugarcane resulted in the release of two varieties viz., Madhuri and Thirumadhuram from the Sugarcane Research Station, Thiruvalla. Madhuri (120 t/ha) is late maturing and is suitable for the central Travancore area where the fields get inundated during the South West monsoon. Thirumadhuram (134 t/ha) is suitable for cultivation in the semi arid tracts (Chittoor) as well as garden lands (Fmg situation:Sugarcane tracts-Thiruvalla, Chittoor). The high yielding snake gourd accession (2009) has been identified at Thiruvalla for cultivation in the acidic alluvial soils of central Travancore.

An early harvestable (180 days) shade tolerant variety of cassava KMC-1 has been identified for intercropping in coconut gardens at Kumarakom. It has a potential yield of 28 t/ha. Two varieties of dioscorea have also been evolved for cultivation in shaded situation. They are Dak 10/86 (*D. alata*) and Dak 4/86 (*D. esculenta*) (Fmg situation: Kuttanad). A number of elite types of *Garcinia gambogia* has been identified at Kumarakom. Technology for multiplication of garcinia by soft wood grafting has also been perfected (Fmg. situation: All situations).

Crop management

The results of permanent manurial trial on rice conducted at the RRS, Kayamkulam representing the Onattukara situation revealed that application of NPK & 80:40:45 kg/ha where 60 kg N was supplied in the form of inorganic fertilizers and 20 kg N as organic manures raised the grain yield to a significant level. It was also found that continuous application of nitrogenous fertilizers without P and K was deleterious to rice crop in that situation (Fmg situation : Onattukara). In an experiment conducted at Moncompu with the objective of developing a suitable schedule for nitrogen management for direct sown medium duration rice during the additional crop season, it was found that (1) application of 90 kg nitrogen per ha in three splits at 15, 35 and 55 DAS resulted in a significantly higher grain yield (Fmg situation : Kuttanad). In a field trial conducted at Moncompu to study the effect of calcium peroxide coating of rice seeds, it was found that this practice controlled wild rice as well as grassy weeds effectively (Fmg situation: Kuttanad). Studies conducted on the combined application of urea and carbofuran as basal dose in BPH endemic areas indicated that application of 90 kg N/ha gave significantly higher yield of grain when applied in combination with 0.75 kg/ha of carbofuran (Fmg situation: Kuttanad). Studies conducted at Moncompu over a period of two years (three seasons) on the effect of soaking rice seeds in nutrient solutions prior to seeding revealed that a net profit of Rs. 604/- per ha could be obtained by treating the seeds in a solution of $ZnSO_4$ (1%) and $CuSO_4$ (0.25%). In an investigation on the availability of phosphorus to rice from water soluble and insoluble sources, it was found that addition of Pyrite (1:1 W/W) improved the availability of P from rock phosphate. This practice also resulted in a higher grain yield (Fmg situation: All situations). At Moncompu it was found that spraying validamycin 3% liquid @2 ml/litre of water was most effective in controlling sheath blight disease when compared to other fungicides (Fmg situation: Kuttanad). Epidemiological studies conducted at Moncompu to asses the influence of weather factors on important rice diseases suggested that sheath blight was inversely correlated with rainfall while high humidity and temperature significantly aggravated the incidence of the disease. In the case of sheath rot, incidence of the disease was heavy during periods of high temperature (Fmg situation: All). It has been found that transplanting seedlings dipped in chlorpyriphos solution 0.02% for 12 hrs. effectively checked the incidence of gall midge, stem borer and brown plant hopper during the early stages of crop growth (Fmg situation: Kuttanad)

The fertilizer management trials for rice in kole lands indicated the need for increasing the dose of N for early (Annapurna) and medium duration (Jaya) rice varieties, the present recommended doses of N being 70 kg and 90 kg, respectively, for the two duration groups. For higher grain yields and better economic returns, these doses have to be increased to 90 kg and 110 kg per ha, respectively, under the conditions prevailing in kole lands (Fmg situation: Kole). Application of Benthiocarb @ 1 kg ai/ha 6 DAS followed by hand weeding 30 DAS has been found to be the most effective weed control practice in kole lands (Fmg situation: Kole). Application of Benthiocarb @ 1 kg a.i/ha 6 DAS followed by hand weeding 30 DAS has been found to be the most effective weed control practice in the kole lands. (Fmg. situation: Kole).

The fertilizer management trials on rice grown in Pokkali lands indicated that application of 20 kg N and 40 kg P_2O_5 per hectare at the time of dismantling and distribution of seedlings registered a 30 per cent increase in grain yield (Fmg situation: Pokkali). Result of trial on 'Koottumundakan' system revealed that the seeds of virippu and mundakan varieties can be mixed in the ratio of 70:30 (W/W) for obtaining maximum grain yield.

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Studies conducted at Karumadi indicated that sub-surface drainage through tile drains increased the rice yield by one ton per ha. This practice reduced the salt load in the root zone of rice. Action is in progress to adopt this technology in large padasekharams (Fmg situation: Kuttanad-Kole). A fertilizer recommendation of 45:15:30 was evolved for sesamum by improving the general recommendations of 30:15:30 NPK kg/ha (Fmg situation:Onattukara). Weed control studies on sesamum indicated that Alachlor @0.75 kg ai/ha can effectively control the weed *Cleome viscosa* (Fmg situation: Onattukara).

Crop protection

Biological control of *African Payal*

The people of Kuttanad witnessed an outstanding biological suppression of 'African Payal' (*Salvinia molesta Mitchell*) since 1985, by the use of a tiny weevil namely *Cyrtobagus salviniae*. The weevil has suppressed the weed menace over about 1,000 sq. kilometres in Kuttanad within a short period of two years.

Management of root (wilt) affected palms

Studies conducted at Kumarakom on the management of root (wilt) affected palms indicated a general decrease in disease intensity due to the incorporation of green manure crops in the basins of palms. The green manure crops found ideal for sandy and laterite soils were cowpea and sesbania, respectively. The role of nematodes in root (wilt) disease expression has been studied in depth. These studies indicated that (i) no single species of plant parasitic nematode is constantly associated with coconut palm, (ii) there is no relationship between the total population of parasitic nematodes and intensity of disease incidence and (iii) inoculation of parasitic nematodes does not result in root injury or lesions. Root excavation studies in alluvial and sandy soils indicated that decay was more in the root (wilt) infected coconut palms than in the apparently healthy ones in both the soil types. The total number of roots in diseased palms was only one fourth of that in apparently healthy palms. Tissue isolation and inoculation studies indicated that a species of *Cephalosporium* possibly *C sacchari* was associated with the leaf rot disease of coconut. ***In vitro*** and ***in vivo*** screening of fungicides against *B. haloes*, the leaf rot pathogen, showed that Bordeaux Mixture (1 per cent) was the best. The organophosphorus fungicides viz., Hinosan and Kitazin were next in the order of merit (Fmg situation: All situations)

Red palm weevil *Rhynchophorus ferruginous* is a very serious pest, especially of young coconut palms in Kerala. In an attempt to control the pest by insecticidal application, it was found that the root application of Monocrotophos (75 ml per palm in 75 ml water) did result in complete control of the pest (Fmg situation: All situations)

Intercrops in coconut gardens

Vegetable cowpea is traditionally grown as an intercrop in coconut gardens. The screening trials conducted over a period of three years have resulted in the identification of a superior type VS-4 with an yield potential of 13,500 kg/ha. This cultivar is tolerant to shade also (Fmg situation: Kuttanad). In a field experiment conducted during 1981 to 1984 to find out a variety of banana suitable for intercropping in the coconut gardens, Palayamkodan recorded significantly higher yield compared to the other varieties. A new fertilizer recommendation for vegetable cowpea has been evolved based on

Red Triveni, a high yielding short duration rice

Kairaly, a short duration rice released from RARS, Pattambi

Kerasoubhagya (WCT x SSA) — a promisiong coconut hybrid

V2-E5-2, a promising high yielding ginger variety for high range zone.

Sakthi, a bacterial wilt resistant tomato variety.

Ujwala, a chilli vartiety resistant to bacterial wilt, released from the College of Horticulture, Vallanikkara.

'MC-84', a high yielding bittergourd variety released from the College of Horticulture, Vellanikkara

Kanaka, a high yielding cashew hybrid

elaborate field trials conducted at Kumarakom. The new recommendation is 10:20:10 kg NPK per hectare (Fmg situation: Kuttanad). Studies on the fertilizer requirement of bhindi grown in the partial shade of coconut have revealed that the crop responds well to N application upto 75 kg per ha (Fmg situation: Kuttanad). In order to find out the NPK requirement of sweet potato grown as floor crop in the coconut gardens of Kuttanad, a field trial was conducted for three consecutive seasons with three levels each N (50,75,100 kg/ha), P (25, 50 and 75 kg P2O5/ha) and K (50, 75, 100 kg K2O/ha) in all possible combinations. The optimum dose for the crop was found to be 50 kg N, 25 kg P2O5 and 50 kg K20 per ha which recorded a tuber yield of 7.88 t/ha. This dose resulted in a net profit of Rs.4427 per ha over the absolute control (Fmg situation: Kuttanad)

Farming systems developed

Coconut is the pivotal crop in the reclaimed area of Kuttanad and is grown on bunds with intervening channels, 3-4 metres wide. These channels offer immense potential for growing fish and freshwater prawns. Fishes grown in these channels gave an average yield of 3980 kg/ha/year with supplementary feeding and 1389 kg/ha/year with only organic manuring (Fmg situation: Kuttanad).

Giant freshwater prawn has been found to be a suitable candidate for culture in channels of coconut gardens. Studies on prawn farming on scientific lines with supplementary feeding (clam and oil cake) has revealed that an average 805 kg/ha could be produced in 220 days fetching a profit of Rs.21,050/-per ha (Fmg situation: Kuttanad). Fish culture has been shown to be compatible with rice. Investigations taken up on the simultaneous farming of rice and fish has shown that paddy cum fish culture is a viable technology for Kuttanad (Fmg situation: Kuttanad).

Although with the commissioning of Thanneermukkom barrage, two crops are raised in many of the paddy field blocks in Kuttanad (Padasekharam), a sizable area remains single cropped. In order to evolve a technology for rearing fishes during the interphase period between two crops of paddy, investigations have been taken up at the Centre for rotational cropping of rice-fish in paddy fields. The trial indicated that fish production ranging from 539.00 to 1005.56 kg per ha could be possible during a period of six months. These studies highlighted that a cyclic crop of fish after paddy was more profitable than a second crop of paddy. The straw and stubble retained after the harvest of paddy were found to be the attributing factor for higher fish production. This practice has been popularised (Fmg situation : Kuttanad).

Tiger prawn, *Penaeus monodon*, has been successfully grown in the pokkali fields of Vyttila during the low saline phase with a survival rate of 30.5 per cent. The production was 768 kg per ha. The results revealed that it was highly profitable to raise tiger prawns in the pokkali area (Fmg situation : Pokkali). The trials conducted in cultivators' fields in the Pokkali tract of Ernakulam have conclusively show that fresh water fishes like grass carp, rohu, mrigal, catla and common carp could be successfully raised. The average yield was 3900 kg per ha per year. The optimum stocking density for these fishes was found to be 5000 per ha in the ratio 1:1:4:4:3:3: (Fmg situation: Pokkali).

In Kuttanad, duck raising is an allied activity in the homesteads. As water is abundantly available in ponds and channels, fish- cum- duck farming is a profitable proposition. A series of trials on mixed farming of ducks and fish taken up at Kumarakom, has revealed that this technology is economically feasible. The study has shown that expenses on supplementary feeding in fish culture could be saved in integrated duck-fish farming systems as duck dropping provided the necessary nutrients for fish

growth (Fmg situation: Kuttanad).

CENTRAL ZONE

Crop improvement

Three rice varieties viz. Suvarnamodan (PTB-42), Swarnaprabha (PTB-43) and Rasmi (PTB- 44) were released for general cultivation in Kerala State. Matta Triveni (PTB-45), Jayathi (PTB-46), Neeraja (PTB-47), Kairali, Kanchana and Nila were also released.

Cowpea variety Krishnamony (PTB-2) has been evolved and released for general cultivation in Kerala. Another cowpea variety Kanakamony (PTB-1) was found to be tolerant to drought. Sesamum varieties ACV-1 and C-14-3 were found to be promising for rabi uplands and summer rice fallows, respectively.

The water melon variety Sugarbaby was found suitable for the river beds of Bharathapuzha and the bhindi variety Arka Anamika, for the river banks. The water melon variety Arka Jyothi was recommended for cultivation in the zone. Bittergourd variety MC-84 has been recommended for general cultivation in the zone. Brinjal variety "Surya" has been recommended for general cultivation in the zone.

Two high yielding cashew varieties - Madakkathara-1 (Early to mid flowering) and Madakkathara-2 (Late flowering) have been released.

Crop management

Seed viability of rice can be maintained at 80% if stored in poly bags (700 gauge) in medium duration varieties for 12 months; and in short duration varieties, for eight months.

NPK @ 50:25:25 kg/ha is recommended for Mahsuri. N may be applied as 50%basal, 25% at active tillering and 25% one week before panicle initiation. In rice-rice (Medium) - fallow cropping system, the NPK in second crop can be reduced to 75% of the recommended level. In rice-rice (Medium) - green manure cropping system, reduction of fertilizer in the first and second crop seasons could be made by 25% of the recommended dose. Placement of N in the form of urea supergranules can be delayed upto 20 days after transplanting without yield loss the during first crop season. Nitrogen use efficiency was maximum when sulphur coated urea was used in the case of rice. Nitrogen loss through ammonia volatilization in submerged rice soils recorded 5.3% of applied N during the first crop season and 9.5% during the second crop season. Coated urea, urea supergranules and urea split application reduced the loss. Urea as supergranules increased rice yield. Nitrogen can be reduced if urea is used as supergranules. The fertilizer dose of 50:25:25 kg N, P_2O_5 and K_2O/ha was recommended for Jayathi. In laterite soils, a vulnerability to excess soil iron and resulting metabolic malfunctioning are primarily responsible for limiting the yield in HYV of rice. Exclusive use of fast releasing sources of nitrogen results in low rice productivity.

Phosphorus and potassium @ 25 kg P_2O_5/ha and 10 kg K_2O per ha, respectively gave higher grain yield in horsegram.

During second crop rice, 5 cm irrigation once in six days is adequate for areas where water is assured. For summer rice, 5 cm irrigation two days after disappearance of ponded water is sufficient. Benthiocarb and Butachlor were the best pre-emergence herbicides for dry sown rice. Pendimethalin was effective against weeds in first crop rice.

Cowpea seeds maintain 75% germination and low beetle damage (25%) for seven months in screw-capped bottles. Seed treatment with molybdenum @ 1 g/kg of seed increases the grain yield in pulses.

In the Koottumundakan system of rice cultivation, best yield was obtained at 20:10:10 and 30:15:15 kg NPK/ha during the first and second crop seasons, respectively.

In Palayankodan banana, one follower can be retained at any growth stage without affecting the yield of the mother plant. In banana var. Nendran, an economical yield can be obtained from first ratoon crop, provided wider spacing is given to ratoon crop.

A spacing of 4 m x 8 m and 4 m x 4 m in cashew clonal materials were found to be advantageous even in the 8th year of planting with respect to per hectare yield.

Results of response studies of colocasia to varying levels of irrigation and nitrogen on tuber yield revealed that effect of levels of nitrogen was significant.

Studies on rice based cropping pattern under constraints of irrigation water showed that higher annual net return can be obtained by adopting either rice-rice-bhindi sequence where bhindi is raised during third crop season with irrigation at 1W/CPE ratio of 1.2 or rice-rice-groundnut sequence where groundnut is raised during the third crop season with irrigation at 1W/CPE ratio of 0.9. Irrigating bittergourd at 15 mm CPE (approximately three days interval) is more economic than the farmers' practice of irrigating once in two days during the summer months from the point of irrigation water economy. In a sandy clayloam soil, irrigating coconut with 500 litres of water in the basins taken at 1.8 metre radius at CPE value of 50 mm (approximately 12 days) is most economical.

Crop protection

Resurgence of leaf folder was noted in plots treated with Carbofuran. Triazophos (Hostathion) @ 0.35 kg ai/ha was found very effective in controlling leaf folder. Dipping roots of rice seedlings in 0.02% suspension of Chlorpyriphos for 12 hours before transplanting was effective against gall midge. Spraying of fresh cowdung extract (20 g/l) was effective against bacterial leaf blight of rice. Topsin-M 70 WP was effective against blast and sheath blight of rice. Validacin-3 L @ 2 ml/l was effective against sheath blight of rice. Fongorene 50 WP was the best for seed dressing for checking seedling blast of rice. Joint application of Carbofuran @ 0.75 kg ai/ha and urea to supply 10 kg N/ha 20 days after transplanting of rice increased yield and pest control.

I.P.M. Schedule

The rice cultures BR51 and M2 were found to be moderately resistant to leaf blast. Fungicides Beam (75 WP) and Fongorene (50 WP) when used as seed dressing fungicides showed low incidence of seedling blast. The chemicals Validacin and Carbendazim were found to control sheath blight of

rice effectively. For effective control of rice blast, seed dressing with Fongorene 50 WP @0.2 g/kg seed followed by foliar application of 0.1 % Bavistin at tillering and panicle initiation stages were found to be optimum. Carbofuran application of 2 kg ai/ha in the nursery was effective in controlling the early stage pest damage in the main field. Seedling root dip in 0.02 per cent Chlorpyriphos 20 EC for 12 hours before transplanting was found to be the most effective and low cost control measure against gall midge in rice.

Growing plants such as marigold, sunhemp, sesamum, coriander and *Acorus calamus* in the inter space of banana var. Robusta can effectively control nematodes. Dipping banana suckers in neem oil, tobacco decoction and fish oil soap against burrowing nematodes resulted in significant increase in bunch weight compared to untreated check. Carbofuran @ 3 g ai/plant was found to be effective in controlling nematodes infecting banana var. Nendran.

Research on cropping systems

In rice-rice-green manure sequence the fertilizer application by 75% is recommended for the first and second crop of rice. In `Koottumundakan' system, the maximum yield was recorded in 20:10:10 and 30:15:15 kg of NPK/ha. Similarly, rice-rice-bhindi and rice-rice-groundnut sequences yielded maximum annual returns. Growing sesamum varieties ACV-1 and C-14-3 was promising for the summer rice fallows.

Tapioca as intercrop in banana variety Nendran gave the highest net returns. The cropping system involving tapioca as an intercrop in banana var. Nendran recorded the highest net returns.

Post harvest technology

Harvesting pineapple 130 days after flowering the best with respect to the keeping quality of slices in syrup.

NORTHERN ZONE

Crop improvement

Five coconut hybrids viz., Lakshaganga (LO x GB), Keraganga (WCT x GB), Anandaganga (AO x GB), Kerasowbaghya (WCT x SSA) and Kerasree (WCT x MYD) were released. They have been widely accepted for cultivation in Kerala. A good number of cultivars including exotic types added to the germplasm collection.

Four high yielding varieties of pepper viz., Panniyur 2,3,4 and 5 were released.

"Jayathi" (Cul-1727) was recommended for the northern region based on the results obtained at RARS, Pilicode. It is resistant to BPH, green leaf hopper, leaf folder and bacterial leaf streak. It is a non-lodging semitall rice variety suitable for all the three seasons and its grain colour is white.

Screening of cucurbitaceous vegetables suitable for summer rice fallows indicated that the lines PIL-MC-2 of bittergourd, PIL -TA-2 of snakegourd, PIL-CS-1 of cucumber and PIL-LA-1 of ridge gourd were superior and these lines have been put under farm trials in the northern districts of Kerala.

Rabbitry Unit (New Zealand White Giant), RARS, Ambalavayal

Conservation of ***Malabari*** goat at RARS, Pilicode.

Large White Yorkshire (crossbred) pig evolved at the College of Veterinary & Animal Sciences, Mannuthy

Fish being harvested by dragging.

Crop management

Twenty five percent K_2O can be substituted with Na_2O both in adult and young coconut palm.

Irrigating the palms with 600 litres of water once in four to five days and fertilizer application @0.5:0.5:2 kg N:P:K per palm per year recorded the maximum nut yield under sandy loam. Drip irrigation at IW/CPE ratio of 0.5 (24 litres of water once in five days along with fertilizer dose of 0.5:0.3: 1.5 kg N:P:K per palm per year recorded the maximum number of leaves in young WCT seedlings under sandy loam. Burying coconut husk in coconut gardens conserved soil moisture and alleviated the ill effects of drought. Tractor drawn paddy harrow and rotovator performed better in puddling than the common cage wheel.

Crop protection

I.P.M. Schedule

Neem cake @5 kg per palm per year plus soil drenching Calixin @ 25 ml/25 litres of water at four month-intervals checked the stem bleeding disease in coconut. For the control of foot rot (Quick wilt) disease of pepper, spraying, drenching and pasting with Bordeaux Mixture and spraying and drenching with Ridomil MZ (0.2%) were equally effective. Application of Phorate (3 g a i/vine) and copper oxychloride (0.3%) reduced slow wilt incidence.

Integrated farming system

Among the fodder grasses, *Panicum maximum* c.v Makueni, *P maximum* c.v. Riversdale and *P maximum* c.v. Hamil and among the legumes, *Stylosanthes guianensis*.C.V schofield and *Stylosanthes scabra* c.v. Seca were found to be suitable for cultivation in coconut gardens as intercrops under rained conditions of northern region of Kerala. Among the six medicinal plants tried as intercrops in coconut gardens, *Coleus vetiveroides* produced the highest economic yield, followed by *Maranta arundinacea* and *Kaempferia galanga*.

HIGH RANGE ZONE

Crop improvement

Performance evaluation of rice varieties showed that 'Edavaka' was superior to the other high yielding varieties with regard to grain and straw yields. This variety is exceptionally suitable for cultivation in the high ranges during the first and second crop seasons.

Studies with 27 mango varieties available in the station revealed that 'Prior' (Flowering in December-January and coming to harvest in May) and Dusheri (Flowering in January-February and coming to harvest in June) are high yielders (75 kg/tree/year).

Among the brinjal varieties, Arka Navaneeth recorded the highest yield. With regard to flowering, Surya and Pusa Purple Cluster were the earliest. Seventeen varieties of tomato were evaluated for growth and yield. Pusa Early Dwarf recorded the highest yield. The variety Naveen was the earliest. Among the cauliflower

types, 'Swathi' recorded the highest yield. 74-6-C and 234-9 were the early genotypes. Among the cabbage genotypes, 'September' recorded the highest yield. 'Golden Acre' and 'Sri Ganesh' were the early types.

Crop management

Standardisation of time of planting in "Edavaka" revealed that planting during the first week of August in the first crop season and planting during the first week of January in the second crop season is ideal.

Stone grafting was found to be the best method of vegetative propagation in mango. Neelam gave the highest percentage of success. Bennet Alphonso recorded the highest survival percentage of 56, followed by Bangalora.

Comparative evaluations banana cultivars under irrigated conditions showed that Bodles Altafort, Gros Michel, Chenkadali and Nendran were promising. Nendran had only a mean duration of 362 days as against 530-560 days in other varieties. Bodles Altafort was recommended as a table variety suited to High Range conditions, with good acceptance by the farmers in the locality.

Cultivation of cardamom under artificial shade has been found to increase yield by two fold.

Crop protection

Bacterial wilt of ginger could be effectively controlled by soil drenching and foliar spraying with 1% Bordeaux Mixture at monthly intervals, two months after planting. Studies on soft rot disease of ginger indicated that seed treatment with Captan 0.2% is effective in controlling pre-emergence rhizome rot. Control measures of azhukal disease of cardamom have been worked out and included in the package of practices recommendations of the Kerala Agricultural University.

Cropping pattern

Standardisation of rice based cropping pattern in single crop rice fields revealed that rice followed by ginger is highly remunerative.

VETERINARY & ANIMAL SCIENCES

Goat

A conservation programme for the Malabari goat, which is a prestigious home breed of Kerala, has been launched under NARP in the northern zone.

Rabbit

A rabbitry unit was established at Ambalavayal for training and demonstration for farmers in the high range zone.

Fodder

Two high yielding guinea grass varieties Haritha and Marathakam have been evolved in the southern zone which are suitable for cultivation all over the State.

FISHERIES

In a multifaculty, multidisciplinary approach involving veterinary pathologists, microbiologists, virologists and fisheries scientists, the etiology of the devastating fish disease which affected Kerala in general and Kuttanad area in particular was identified.

7. RESEARCH PUBLICATIONS

Discipline/Faculty	Total
Agronomy	122
Agrl. Botany	30
Soil Science	53
Plant Breeding	37
Horticulture	71
Agrl. Entomology	86
Plant Pathology	49
Agrl. Extension	37
Agrl. Statistics	21
Agrl. Engineering	6
Agrl. Economics	31
Home Science	6
Forestry	23
Co-operation & Banking	-
Veterinary Science	128
Fisheries	71
Total	771

The important publications are given separately.

8. ZONAL WORKSHOPS (ZREAC)

Frequency in the zone

The ZREAC meetings were convened twice every year, one for the kharif and the other for the rabi seasons, till 1986. The frequency was limited to once annually till 1992. After 1992, the meetings have been revived to twice a year. The latest workshop, the 16th, was held during May 1994.

Participation by development departments

Extension personnel of the State Department of Agriculture, viz. the JDAs/PAOs, the DDAs/ SDAOs/SMSs and the Assistant Directors of the T&V Sub-divisions, the Addl. Directors/ JDAs/ DDAs/ ADAs of the DOA headquarters and its Soil Survey/Soil Conservation wings, the representatives from the departments of Animal Husbandry, Fisheries, Social Forestry, Irrigation and Ground Water and the State Planning Board, the scientists of the KAU and those from the CPCRI, the CTCRI and the Regional Research Laboratory of the CSIR, Thiruvananthapuram actively participated in the workshops.

Quality of the workshops

The zonal workshops have been helpful in the efficient feedback of field problems and their prioritisation, meaningful discussions on the research results and their interpretation, approval of the newer technologies generated and transfer of such technologies to the farming community. Farm trials were recommended by the zonal workshops from 1985 onwards. From the data generated, production recommendations were identified which were later approved by the State level Package of Practices Workshop annually held by the University. The proceedings were covered by the AIR, Doordarshan, and newspapers. During the T & V days, till 1989, the extension specialists of the DOA were very enthusiastic with frequent lively discussions on controversial matters arising in the workshops. However, consequent on the termination of the T & V system and the abolition of posts under the Sub-divisions, the quality of the zonal workshops has been affected. Feedback is also feeble. The over-all conduct of the zonal workshops needs streamlining.

How far the ZREAC served the purpose of improving relevance of research and actions suggested for improvement

The interaction between the scientists and extension specialists during these workshops had been strong and efficient. The prioritised implementation of the research projects to solve the field constraints presented during the zonal workshops has yielded fruitful results. Several newer technologies could be generated and many of the existing ones could be modified to suit the zonal need. Farm trials were conducted to confirm, refine or modify the technology. The results of the farm trials were also examined by the ZREAC. Several such technologies have been generated and included in the POP during the Phase I, Phase II and post - NARP periods.

8.1. District level monthly workshops

The two-day monthly workshops earlier held during the T&V days were restricted to one day. The extension functionaries of the DOA at the levels of Joint Director, Deputy Director and Assistant

Director, the resource person from the University were the participants in the monthly workshops. The existing system of coordination between the researchers and agricultural officers at the field level used to be strong and effective during the T & V days. However, with the conversion of the two-day monthly workshop to one-day programme, the interaction has become nominal and less effective. The T & V system has been completely modified in the DOA and the effect is reflected in the Zonal Workshops also. The feedback from the department is feeble. The extension system has to be streamlined for better dissemination of the research findings to the departmental officers and to the farmers.

8.2. Joint field visits and their effectiveness

Joint field visits were made during the cropping seasons by the district level joint Diagnostic Teams consisting of SMS (Trg) or SMS (PP) and one or two specialists from the subdivision concerned of the DOA and scientists of the University, to study the field problems, to find out solutions to location-specific problems reported by the farmers and to analyse adoption pattern of the technologies. Such joint field visits helped in

the diagnosis of specific field problems and suggestion of appropriate remedial measures;
the inclusion of the problems in the research programmes of the University for detailed investigation to find out solutions on priority basis, if needed;
the selection of groups of farmers as Target Groups for a particular crop;
the study of the adoption of technology by farmers and to analyse the reasons for the low or non-adoption of improved technology advocated and to suggest improvements;
frequent visits to farm trial plots and observational trial plots to offer necessary guidance;
the feedback of new problems.

Interaction with farmers (both contact as well as other farmers) could be achieved. These visits were very useful and successful. The reports of the Diagnostic Team were conveyed to the Director of Agriculture and the Director of Research. By these visits, strong interaction between the farmers, the field officers and the research scientists of the University could be forged.

8.3. On-farm trials

The on-farm trials are quite relevant to the zonal concept and the technology generation process. The details of on-farm trials conducted in different zones are given below:

SOUTHERN ZONE

In the southern zone, 225 trials could be successfully completed. These trials were for testing new improved varieties of vegetables, sweet potato, cowpea etc. and for testing the new or modified technologies on crop management and crop protection in the farmers' fields in different locations.

Crop	Details of trial (varieties test)	No. conducted	Location	Outcome
Guinea grass	MC -2, FR-600 & local	3, 1983	TVM, QLN	MC.2 released as Haritha
Sesamum	ACV-1, ACV-2 & K-1	5, 1983 rabi	TVM	ACV.1, ACV.2 released as Soma, Surya
Sesamum	ACV-1, ACV-2 & K-1	4, 1984 summer	QLN	ACV.1, ACV.2 released as Soma, Surya
Chilli	Culs. 57, 47, 33 & Vellanotchi	9, 1986 summer	TVM, QLN	Cul.57, 47 released as Jwalamukhi, Jwalasakhi
Cowpea	V-26, C-152 & local	8, 1986 kharif	TVM	V.28 recommended as companion crop for tapioca
Bhindi	AE-1, Sel-2, P.S. & local	8, 1987 summer	QLN	
Bhindi	AE-1, Sel-2, P.S. & local	6, 1987 kharif	TVM	
Brinjal	H-1, H-2, SM1-10, PPC & local	9	TVM, QLN	H.1 & H.2 superior but not conclusive
Bhindi	AE-1, Sel-2, P.S. & local	7, 1987 rabi	QLN	
Amaranthus	S8, S1, K. local & local	10, 1988 summer	TVM, QLN	S.8 released as Arun
Bhindi	AE-1, PP, PS & local	9, 1988 kharif	TVM	A.E.1 released as Kiran
Veg. cowpea	S-7, S-16, K. payar & local	8, 1988 summer	TVM	S.7 released as Malika
Sweet potato	SPC-18, SPC-20, K.local & local	12, 1989 kharif	TVM	K.local released as Kanjangad
Grain cowpea	Chharodi-1, C-152 & local	10	TVM	Chharodi- 1 recommended for partial shade
Sesamum	Cul.41, 42, Surya & local	9, 1989 rabi	TVM	
Sesamum	S-8, ACV-1, K.1 & local	11, 1990 summer	QLN	
Rice	Cul.4, 126, 169 Jaya & local	11, 1990 kharif	TVM	Cul.4 released as Arathy, Cul.126 (Remya) recommended.
Guinea grass	MC.14, 16, FR.600, Mackuenii, Haritha & local	8,	TVM	
Blackgram	TAU-2, T09, local	14, 1990 rabi	TVM	TAU 2 recommended for partial shade
Sesamum	Cul.41, 42, Surya & Kayamkulam-1	9,	TVM	None superior, hence dropped
Blackgram	Pant., U.30, T.9 & local	10, 1991 summer	TVM	None superior, hence dropped
Sesamum	S.8, ACV.1, 2, K.1 & local	9,	QLN, PTA	S.8 released as Thilak
Veg. cowpea	Sel.108, 229, 7, K. payar, 61 B & local	12,	TVM	
Guinea grass	MC.14, 16, FR.600, Mackuenii, Haritha & local	6, 1991 kharif	TVM	MC.16 released as Marathakom
Veg. cowpea	Sel.108, 129, 7, K.payar, 61B & local	7, 1992 summer	TVM	S.108 released as Sharika
Veg. cowpea	Sel. 108, 129, 7, K.payar, 61B & local	11, 1992 kharif	TVM	S.108 released as Sharika

Crop	Details of trial (varieties test)	No. conducted	Location	Outcome
SPECIAL ZONE KUMARAKOM				
Cowpea	Farm trial with vegetable cowpea (VS 4 Vs local) for cultivation in the partial shade of coconut garden	12 1987-1991	Kottayam (2) Alappuzha (6) Mavelikkara (1) Koduthuruty (3)	VS 4 performed well constantly. Proposals have been submitted for its release to the University Variety Evaluation Committee
Cassava	Farm trial with early maturing cassava variety for cultivation in the partial shade of coconut garden	9 1989-90	Kottayam (4) Chengannur (3) Mavelikkara (2)	The variety KMC 1 has been recommended for release to the state sub committee by the KAU
Yams	Farm trials with greater yam (*D. alata*)	15 1991-94-95	Alappuzha Kottayam	
Lesser Yam	Farm trials with lesser yam (*D. esculenta*)	14	"	
Rice	Weed content in direct sown rice under wet conditions (2, 4-D in different doses for control of broad leaved weeds)	5. 1992-93	Kaduthuruthy	2, 4-D at 0.5 Kg ai/ha was equally effective as 1.0 Kg ai/ha. 0.5 Kg is more economical (submitted for inclusion in POP)
MONCOMPU Rice				
Puncha Additional crop Puncha	Trial with culture KAU 93 & Jyothi " "	1987-88 1988 1988-89	Kottayam and Chengannur Alappuzha Kaduthuruthy.	The culture KAU 93 was released as Mo8 (ARUNA) in 1990. This is a short duration HYV suited to the additional crop season
Puncha Additional crop	KAU 170 & Jyothi	1987-88 1988	Kottayam Chengannur Mavelikkara, Kottayam Alappuzha	The culture KAU 170 was released as Mo9 (MAKAM) in 1990. This is a short duration HYV suited to the additional crop and puncha seasons
Puncha	KAU 126 Jaya and Mo6	1983-84	Alappuzha	The culture KAU 126 was released as Mo10 (REMYA) in 1990. This is a medium duration, BPH resistant HYV suited to both seasons of Kuttanad

Crop	Details of trial (varieties test)	No. conducted	Location	Outcome
Puncha Puncha	KAU 153-1& Pavizham "	1987-88 1988-89	Alappuzha "	The culture KAU 153-1 was released as Mol1 (KANAKAM) in 1990. This is a semitall HYV suited to Kuttanad and Onattukara
Addtional crop Puncha	KAU M 28-1-1, KAU M 35-3-2 and Mo6 "	1993 1993-94	Alappuzha Kottayam	The culture KAU M28-1-1 is proposed for release as Mol2 (Ranjini). This is a medium duration, blast resistant HYV
Additional crop Puncha	KAU 168 and Jyothi "	1994 1994-95	Alappuzha Kottayam Alappuzha	
Additional crop Puncha	KAU 129 and Jyothi "	1994-95 1994	Kottayam Alappuzha	
Additional crop Additional crop	KAU 204 and Jyothi KAU Mo120 -19-4 and Jyothi	1994 1994	Kottayam Alappuzha Kottayam	
Additional crop	IET 6661 and Jaya	1994	Neyyattinkara, Kottarakkara Harippad	
Puncha	KAU 200 and Jyothi	1994-95	Alappuzha	
	Relative efficiency of fungicides against sheath blight	1986-87 1987-88	Alappuzha Chengannur	Kitazin and Ediphenphos were found to be equally good. Recommended in the POP recommend action
	Split application of water soluble P fertilizer		Alappuzha Mavelikkara Chengannur Kottayam Kuttanad	Split application 1/2 at basal, 1/2 at tillering was found to be better than single application recommended for Kuttanad
	Trial with new granular insecticides against rice pests		Kuttanad Alappuzha Mavelikkara	Cartap was to be more effective than carbofuran to control dead heart
RRS, KAYAMKULAM				

Crop	Details of trial (varieties test)	No. conducted	Location	Outcome
Rice Onattukara	Evolution of H.Y. photosensitive varieties of rice suited to different agroclimatic zones. Three cultures were evaluated with a local check	7 1989-90	Kollam (6) Mavelikkara (1)	Culture 1358-2 was adjudged as the best. It was released as Dhanya for the rabi season of Onattukara in 1992. (Sandy loam tract)
Rice	Genetic refinement of Orumundakan (OM-1 Vs local Orumundakan) for the salinity prone tract of Onattukara	3 1991-92	Mavelikkara (1) Kollam (2)	The culture was found to be adapted to the Orumundakan tract. It also outyielded the other culture and local check. Released as a variety - Sagara - in 1993
	Evolution of semitail short duration varities of rice suitable for kharif season. Six cultures were evaluated against the local check	5 1983	Mavelikkara (3) Kollam (2)	Culture 26-1-1 was released as Bhagya (95 - 100) and culture 52-3-6 as Onam (95 days in 1985
Cowpea	Identification of grain cowpea varieties suitable for summer rice fallows V-118, V2, V276 Vs Kanakamony	7 1989-90	Mavelikkara (2) Kollam (5)	V 118 was recommended for cultivation in the partial shade of coconut garden. The result is included in POP recommendations
Cowpea	Evaluation of grain cowpea varieties for summer rice fallows (CO Vu, 8456, CO-3 Vs local)	7 1991	Kollam (4) Mavelikkara (3)	Co-Vu-8456 was released as Poumami in 1993 with the permission of TNAU. CO-3 was included in the POP recommendations
Blackgram	Identification of blackgram varieties suitable for summer rice fallows	7 1991	Mavelikkara (4) Kollam (3)	Culture CO BG 307 was released as SYAMA in 1993 with the consent of TNAU
Blackgram	Blackgram varieties for coconut garden (CO BG 302, TMV 1, T 9 and KM 2 Vs local)	7 1991	Mavelikkara	The package of practices workshop held in Dec. 1992 has recommended the varieties TMV1 (tall) and KM 2 (medium) for cultivation in the partial shade of coconut garden
Cassava	Identification of short duration (6 months) cassava suitable for the Thara lands of Onattukara Koombuvella Vs Ariyan	6 1991-92	Mavelikkara (4) Kollam (2)	The local selection for Koombuvella was released as NIDHI in 1993 for cultivation in the nursery lands (Thara) of Onattukara

Crop	Details of trial (varieties test)	No. conducted	Location	Outcome
Cucumber	Standardization of spacing x fertilisation in var. Mudicode local	2	Mavelikkara	A fertilizer dose of 70:25:25 Kg/ha with a spacing of 2m x 2m has been recommended for the variety in the Onattukara tract included in the POP recommendation
RRS, VYTTILA				
Rice Pokkali tract	Field evaluation of rice cultivars tolerant to salinity and flood. Cultures 904, 905, 906 and local check	6 1990-91	Cherthala Ernakulam	The culture 906 outyielded the other varieties It was released as 'Vyttila 4' in the year 1993. Culture 906 is a hybrid derivative of Chettivirippu / IR 4630-22-2-17
"	Varietal evaluation of high yielding varieties of Pokkali areas (Salinity x floods) (Cul 655, 852, 905, 906, 869, 857, vyt 2, vyt 3)	8 1992-93 1991-93	Cherthala Ernakulam	Culture 655 was found superior to all the test entries including check varieties It has been proposed for release to the KAU variety Evaluation Committee
"	Farm trials with culture 852, 857 and 708 for salinity-prone Pokkali tract cultures Vs local check	8 1993-94	Cherthala Ernakulam	
SRS, THIRUVALLA				
Sugarcane	Field evaluation of sugarcane varieties for flood prone (Co TL 88321 Vs local var)	8 1987-88	Adoor Pathanamthitta	Co TL 88321 out yielded the local check in cane yield and sugar recovery. The culture was released in 1990 as madhuri for the flood- prone fields
Sugarcane	Varietal evaluation of sugarcane for semi arid and garden lands Culture 577/84 Vs local	5 1989-90	Adoor and Semiarid tract of Palghat (Menonpara Chittoor)	The culture was found highly adapted to the semi arid. Better than the local check in yield. Released as a variety - Thiruvananthapuram in 1991.

Crop	Details of trial (varieties test)	No. conducted	Location	Outcome
Sugarcane	Field evaluation of culture 527/85 culture 527/85 Vs local	5 1991-92	Adoor	Farm trials have been successfully completed. The KAU variety evaluation committee has recommended this variety for release. It is highly suited for jaggery making.
Snakegourd	Evaluation of snakegourd variety selection 2009 Vs local	5 1991-92	Pathanamthitta	Culture 2009 outyielded the local check in all the trials. The KAU variety evaluation committee has recommended this culture for release as "Kaumudi"
Bittergourd	Evaluation of bittergourd culture 1010 (cul 1010 Vs local)	4 1992-93	Pathanamthitta	Farm trials have been completed. The culture has been proposed for release to the KAU variety evaluation committee.

HIGH RANGE ZONE

Crop	Details	Outcome
Rice	Edavaka 8 trials (2nd crop 1990) ie. 3 in Wayanad & 5 in Idukki.	This is widely accepted by the farmers of Wayanad district.
Banana	Bodles Altafort 5 trials in Wayanad (1990)	Bodles Altafort has been included in the POP of KAU for High Range Zone
Dioscorea	Da No.30 5 trials in Wayanad (1990)	Da No.30 was found to be high yielding and widely accepted by farmers.
Ginger	V2E5 - 2; 5 trials each in Wayanad and Idukki (1993)	
Cabbage	September 5 trials in Wayanad (1993)	September was found to be high yielding under Wayanad conditions.

NORTHERN ZONE

Four on-farm trials (one each in rice, vegetables, stem bleeding disease of coconut and quickwilt of pepper) were conducted in different parts of the zone. Rice cul. 1727 has been released as "Jayathi" based on the On-farm trials. It is widely accepted by the farmers of this region. The lines identified viz. PIL-MC-2 of bittergourd, PIL-TA-2 of snakegourd, PIL-CS-1 of cucumber and PIL-LA-1 of ridgegourd have been widely accepted in the region. The check and control measures for stem bleeding of coconut are well accepted. In the case of quickwilt of pepper also, the recommended package is well accepted. In addition to the above, 50 demonstration plots have been taken up in cashew with the released varieties.

8.4. Farmer's influence on research

Since the inception of the NARP, the research programmes were formulated based on location-specific constraints presented by the farmers in the monthly and zonal workshops. Visits by Diagnostic Teams, Joint Field Visits and farmer group discussions provided additional fora for feedback. On-farm research was conducted only with the farmer's participation. The Information-cum-Sales Centres provided the farmers with planting materials and technical advice. Veterinary clinics and Agroclinics functioned to render service to farmers. Scientists visited the adopted villages and carried out demonstrations. Adopted villages played crucial role in technology transfer. Farmers visited the research stations in the zones frequently to acquire knowledge on newer technologies generated.

8.5. Interaction of zonal scientists with scientists of other organisations (ICAR, DST, CSIR etc) present stage and ways to strengthen linkages

The Regional Station of the southern zone maintained close linkage with the Central Research Institutes (ICAR) located in the zone, viz. the Regional Station of the CPCRI at Kayamkulam, the CPCRI Research Centre at Palode, the CTCRI at Sreekariyam, the RRII at Kottayam, the Regional Research Laboratory of the CSIR, the India Meteorological Department at Thiruvananthapuram, the research departments under the University of Kerala, the State Department of Economics and Statistics and the State Committee for Science, Technology and Environment. The Regional Station of the zone of problem areas had excellent linkage with the CMFRI, the CIFT and the M.G.University. The Regional Station of the central zone forged strong linkage with the KFRI & the Calicut University. The Regional Station at Pilicode worked very closely with the NRCS and the CPCRI. The Director or Senior Scientists of the ICAR/Central Institutes attended the zonal workshops and actively participated in the deliberations.

8.6. Interaction with special agencies working for agricultural development in the zone

Strong interaction existed between the zonal stations and the other organisations like the CPCRI, CTCRI, NRCS, Spices Board, Coconut Board etc. , the Tropical Botanical Garden and Research Institute at Palode, the State Committee on Science, Technology and Environment, the Centre for Earth Sciences Studies, the Kerala Horticultural Development Board, the State Khadi and Village Industries Board, the Agency for Non-Conventional Energy Resources, the Kerala Agro-Industries Corporation and the Krishi Vignan Kendras. Scientists from zonal station often contacted the above institutions for research support.

8.7. Integration of the research and extension activities of the University in the zone, to improve efficiency of man power

The research activities in each zone has been brought under the Regional Stations. All the Sub-Stations, the research schemes and projects are attached administrative to the Regional Stations. The extension activities in the zones were looked after by the field extension personnel of the Department of Agriculture and the Directorate of Extension including the Central Training Institute. The transfer of technology was effected by the University through field demonstrations in the adopted villages and periodical publications of small booklets and the monthly 'Kalpadhenu.' In addition, several training programmes on plant protection, apiculture, sericulture, mushroom culture, horticulture, tissue culture,

vermiculture etc. were handled by the Scientists. Farmers' seminars and training for farmers were also arranged in the zonal research stations. In addition, the KVKs ensured effective transfer of technology. The zonal workshops helped in the dissemination of recommended technology through the extension personnel of the DOA. The popularisation of research results was also carried out by Doordarsan, AIR and Newspapers.

8.8. Constraints

Shortage of funds in arranging more training programmes and seminars to benefit the farmers. Low extent of adoption of some of the recommended technology by farmers on grounds of high costs involved. Low cost technologies are now being attempted by the scientists. These include organic farming making use of biofertilisers, bio and organic pesticides and organic manures including vermicompost. Non-applicability of the transferred technology for reasons of natural constraints such as non-availability of sufficient water for irrigation to crops, high cost of labour, drought, soil erosion, soil salinity conditions, impeded drainage, flooding, marketing constraints, price instability, pollution hazards to crops, poor socio-economic background of the marginal farmers, etc. Many of these can be rectified only on community basis or at the government level taking policy decisions.

8.9. Quality and relevance of research

Many of the research projects were implemented with the objective of generating and popularising location-specific technologies. Zonal Packages of production recommendations were published for all the cultivated crops in the zones. Thus, the objective of the NARP to generate relevant, zone-specific technologies has been fulfilled to an appreciable extent. Each research station is maintaining a prioritised problem bank for the specific farming situation(s) it represents. The ZRS has priority-wise problems of the zone listed. Research programmes which are problem based, are implemented as far as possible with multi-disciplinary approach after clearance by the ZREAC, Project Co-ordinator (PC Group) and the Faculty Research Committee (FRC) of the faculty. The university has identified specific thrust areas of research under which all the related experiments are grouped. Each of these thrust areas and individual experiments have been assigned code numbers for identification.

Specific research projects formulated based on location-specific and need-based constraints, were fitted under the appropriate thrust areas of research identified by the University and priorities fixed for implementation. Many of these projects have been successfully concluded with the generation of suitable technology. Low cost technologies are being attempted to replace a few of the more costly ones already generated which are not within the reach of the marginal and poor farmers. Technologies of organic farming, vermiculture, biofertilizers, minimisation of input requirements, indigenous cheaper plant extracts as plant protection chemicals, controlled irrigation, biocontrol of pests and tissue culture, are being standardised and high yielding and drought resistant varieties are being identified. The monthly/zonal workshops and the joint field visits by Diagnostic Teams are the major fora at present for the TOT. Training programmes are also helpful. The KVKs help in the TOT. The zonal POP for all the zones have already been prepared. This contains details of all crops grown. However, POP for Animal Husbandry, Agroforestry, Fisheries etc. for the zones have not been prepared.

9. REVIEW BY IDA SUPERVISION MISSION

The IDA Mission and NARP Project Unit of the ICAR undertook midterm reviews of the progress made in the different zones. Kerala Agricultural University was ranked first among the Agricultural Universities where the NARP was implemented.

9.1. Suggestions for research

In the Kuttanad area there is considerable scope for bund cropping with pulses, vegetables and green manures. The rice straw is wasted in this area by ploughing *in-situ,* which is otherwise valuable for cattle feeding. Research on bio-conversion of crop residues and farm wastes in to compost may be given adequate emphasis. Coir pith composting technology suited to West coast conditions should be developed. Eventhough the area under sugarcane is limited in the state, there is considerable scope for raising it as an intercrop from November to February for increasing the income of the farmer. The Sugarcane Research Station, Thiruvalla should intensify Research on vegetables suited to the Region. Research in seed technology in many crops in different centres has to be strengthened. There should be much more important on farmers, field trials to fine tune the technology to suit the local conditions. Large number of first line and front line demonstrations should also be conducted by scientists of different disciplines.

The most burning problems of Kerala State agricultural research are root (wilt) of coconut, quick wilt of pepper, fruit borer of cocoa and wilt of solanaceous vegetables. These are being tackled since long both by the University and the ICAR institutes; but concrete solutions have not yet been achieved. Management practice of the above mentioned diseases were suggested to the University by Dr. Gangopadhyay for blanket application of neem cake (3 kg), lime (1 kg) heptachlore (100 gm), sodium chloride(100 gm) to reduce coconut root wilt and timely application of copper oxychloride for quick wilt of pepper. After conducting several years of experiment, KAU Regional station has found the above recommendation very effective for management of these diseases and immediate release to the farmers.

Pest surveillance and Integrated Pest Management

In the newer concept of sustainable Agriculture, the use of chemical pesticides has to be minimised through effective IPM programmes. The basis for IPM is pest surveillance. The fluctuations in the incidence and spread of pests in relation to changing weather parameters, after cultivation and cropping pattern have to be monitored through fixed plot and roving surveys covering the entire state. The crop phenology and ecology of the pests have to be continuously assessed and sound forewarning and forecasting systems developed. The various components of IPM for a given crop and cropping system should be identified and applied based on the pest surveillance data. The need for conserving natural enemies of pests and augmenting wherever necessary and judicious application of selective pesticides on the basis of Economic Threshold Levels (ETL) of the pests would reduce the cultivation costs and increase farmers' income besides protecting the environment.

This approach is very necessary in crops such as rice, vegetables and spices and plantation crops which consume large quantity of chemical pesticides in the Kerala State. It has been recommended to give adequate emphasis to this area of research and set up units to produce biological control agents for the management of certain pests and diseases of the above crops. The Scientists concerned

would need some training in this field who would organise the State level pests surveillance and IPM programmes in large number of points involving the plant protection staff of the State Department of Agriculture.

University Scientists were joining the Department of Agriculture in undertaking a large number of field diagnostic tours under farm advisory service to investigate and solve practical problems of farming, in different parts of the State. The extension education programmes undertaken by the Stations have been very successful . The literature brought out by the Scientists in Malayalam is noteworthy. As Kerala has the largest literacy rate, the extension education role of the University has been perceived very much. However, in this modern era of electronic media, the University should have a strong programme for video taping of the modern technologies in farming to send the video tapes regularly to the Doordarsan Kendra. The Communication Centre of the University should have the facilities including Eumatic TV Camera, recorder, editor etc. This should receive top priority. The on-farm trials and demonstrations conducted by the KAU and the DOA personnel also have been well received by the field functionaries and farmers.

9.2. Recommendation for additional requirements

Since the Kerala Agricultural University has effectively utilised the entire amount sanctioned for Phase I & II and implemented the NARP location specific research programmes successfully, additional funding for further strengthening of research capability of different zones with special reference to hybrid seed programmes of cereals, vegetables including nursery activities and milk, meat, fish and egg production at different centres should be provided to augment the overall agricultural development of the State.

10. IMPACT OF NARP

10.1. Agricultural production

The trend of crop production during the latter half of the eighties showed strong signs of recovery from stagnation trend in some of the important crops in Kerala. However, the performance of food crops continued to be disappointing in the State. Small holder commercial crops like coconut, pepper and cashew performed remarkably well and consequently the agricultural income which was stagnating around Rs. 1340 crores at 1980-81 prices has shown steady and continuous improvement during the last ten years.

Growth of agricultural income in Kerala (Rs. in crores)

Year	Agrl. income at 1980-81 prices	Rate of Growth	% Contribution
1885-86	1379.24	4.50	34.12
1988-89	1568.64	14.81	34.22
1991-92	2299.61	4.00	37.73

Despite marginal improvement in productivity, the production of major crops namely rice and tapioca could not be sustained because of the steep fall in their area under cultivation.

Rice

The production of rice which showed a declining trend during the last decade showed a sudden recovery in 1989-90 and it picked up from 10.12 lakh t. to 11.4 lakh t. in the year. The subsequent trend in rice production does not corroborate this view. The trend of productivity in rice showed that in autumn season it declined from 1961 kg to 1835 kg/ha during 1991-92. The productivity of summer season remained stagnant at 2205 kg/ha. The overall increase in productivity from 1942 kg/ha to 1959 kg/ha is contributed by "Mundakan" season, the productivity of which increased from 1960 kg/ha to 1968 Kg/ha.

Area, production & productivity of rice in Kerala

Year	Area (lakh/ha)	Production ('000 t)	Productivity (kg/ha)
1980-81	8.01	1271	1587
1985-86	6.78	1173	1729
1990-91	5.60	1086	1942
1991-92	5.41	1060	1959

Coconut

Coconut held its dominant position in coverage and contribution to agricultural income. The productivity of this crop continued to be low and unstable. The situation can be improved by launching a major rehabilitation programme combining replanting of palms in disease affected areas, irrigation and scientific management of existing palms.

Area, production & productivity of coconut in Kerala

Year	Area ('000 ha)	Production (Million nuts)	Productivity (nuts/ha)
1980-81	651.37	3008	4618
1985-86	704.68	3337	4792
1990-91	870.02	4232	5239
1991-92	840.28	4206	4969

Pepper

As in the case of coconut, pepper is also confronting problems like disease sensitivity and poor management. The rapid spread of quick wilt disease in an endemic form is a serious threat to the impressive performance in production achieved in the late eighties.

Area, production & productivity of pepper in Kerala

Year	Area ('000 ha)	Production (Mill.t)	Productivity (kg/ha)
1980-81	108.07	28.52	264
1985-86	121.56	33.12	272
1990-91	168.51	51.97	278
1991-92	169.66	54.70	224

Cashew

The area under this crop showed a declining trend in the late eighties. The productivity declined from 888 kg/ha in 1990-91 to 834 kg/ha in 1991-92. Tea mosquito is a serious menace to the crop.

Area, production & productivity of cashew in Kerala

Year	Area ('000 ha)	Production ('000 t)	Productivity (kg/ha)
1980-81	141.27	81.90	580
1985-86	137.74	80.20	582
1990-91	115.62	102.77	888
1991-92	117.39	97.91	834

10.2. Fertilizer consumption

The fertilizer consumption steadily increased till 1990-91 and decreased consequent to fertilizer policy.

Year	Consumption (t)
1990-91	244380 (peak)
1991-92	22473

10.3. P.P. chemicals

The need-based use of P.P. chemicals and biological control of important pests like coconut caterpillar reduced the consumption of P.P. chemicals.

10.4. Land use

	1989-90	1990-91
Net sown area	2232118 (57.4%)	224677 (57.82%)
Total cropped area	3019019 (77.6%)	3043044 (78.31%)
Cropping intensity	135.25%	135.44%

10.5. Extent of success made by the zonal Stations in achieving integrated multi disciplinary approach to resolve the prioritised problems of the zones and suggestions to improve it

Many of the prioritised research projects implemented in the zonal stations are multidisciplinary to the extent possible. Location-specific constraints are studied in the field by the Diagnostic Teams consisting of scientists drawn from different disciplines. Strong interaction between the disciplines has been ensured to the extent needed in handling the problem at all the stages of investigation. Although the multidisciplinary concept is very useful in remedying the adverse crop situation in the fields, all field constraints do not always necessitate research on multidiscipline concept. Multidisciplinary-cum-multi-institutional concept such as KAU/ICAR or KAU/CSIR collaborative research programmes will be helpful in avoiding duplication of work and in bringing out early solutions to the problems.

10.6. Implementation of cropping systems-based research (rather than crop-based) and initiation of farming systems research - Present stage and actions proposed and additional facilities required to strengthen the system

Eversince the inception of the NARP, the zonal stations have been implementing mainly the cropping system - based research. Accordingly, the following systems have been identified in the zones.

Rice-based farming system; coconut-based farming system; tapioca-based farming system; homestead farming system; integrated farming system.

Other cropping systems practised include banana-based farming system, pepper-based farming system, rubber-based farming system etc. The system-based research is emphasised in the zones mainly because the marginal and poor farmer does not always cultivate a single crop in his field. Instead, he utilises all the available partial by shaded inter spaces between coconuts or tapioca or banana for growing annuals or seasonals which could increase his net income.

10.7. Utilisation of training components under NARP

The scientists were trained on the use of the sophisticated items of equipment purchased under NARP and on computer application in agricultural research (data base build up & management, report preparation, project preparation, statistical analysis, etc.). These training programmes were organised at the Regional Stations. The Scientists were deputed for the different training programmes organised by the National Institutes under the auspices of the National Agricultural Research Project. Opportunities were given to the scientists to participate in National / International Seminars, Symposia etc. and to present their work.

11. FUTURE STRATEGY (Based on the experience gained in the implementation of NARP)

Making the best use of already developed facilities at the zonal stations

The Zonal Packages of production recommendations for most of the cultivated crops of the State have been formulated. Several location-specific technologies have also been developed from time to time. Details of the newly introduced crops such as mushroom, mulberry, orchids and other

export-oriented crops will have to be furnished to the farmers. Joint field visits and visits by Diagnostic Teams have to be strengthened. Agro clinics can also function on a regular basis in potential locations. The defunct T&V system needs revival or modification. This system is not effectively functioning at present to the extent expected. Consequent on the termination of the T&V system and the abolition of the posts therein, the farmer contact has become nominal and the transfer of technology weak. In the light of this, the monthly workshops meant mainly for the TOT and for the feed back has become routine. The monthly workshops need thorough streamlining to ensure effective TOT and feed back.

Media coverage plays a crucial role in the timely dissemination of technology. Popularisation of research results through newspapers, agricultural magazines, AIR and Doordarshan has to be ensured in the State where most farmers read newspapers and many subscribe to agricultural magazines in addition to getting enlightened through AIR and Television. Field demonstrations now confined to the adopted villages have to be widened to benefit the farmers of other villages also.

Major constraints in achieving the objectives of NARP including administrative, procedural, structural and policy issues

Regular farmer participation programmes are not operating, except seminars or field days. occasionally organised in the local stations and the ZREAC meetings. Even the ZREAC is not properly represented by the farmers. Many farmers, besides primary occupation of farming, are interested in the export-oriented subsidiary farming occupations also. These income generating avenues have to be identified and prioritised for research. There is ample scope for development of apiculture, aquaculture, sericulture, tissue culture, horticulture, mushroom culture etc. Vermiculture technology also needs attention. These aspects need to be studied in detail in the different agroclimatic situations, so that the technology generation can help the farmers in boosting their net income and at the same time sustain self-employment of the rural and urban youth.

Research areas of priority for future support

With the termination of Phase I and Phase II NARP, a review and re-prioritisation of the lead and verification functions of the zonal and local research stations have been made in accordance with the National and State Agricultural Development Policies so as to form a sound basis for microlevel research and development planning. This recasting was felt essential for the continuation of the on going programmes, for bridging the identified research gaps and for removing the adoption constraints. The focal theme of the National and State Agricultural Policies is decentralised planning and local area development with people's participation. The above policies also emphasize sustained production and productivity of each region through effective and integrated use of resources and skills. Provision of self employment opportunities to the educated rural unemployed and the promotion of export-oriented agricultural crops also require attention. Taking into consideration, the above aspects, the following research strategies are identified for the near future.

SOUTHERN ZONE

Export-oriented vegetables

With the migration of a good number of people from Kerala to Gulf/Arab and African countries, the demand for fresh vegetables from Kerala has picked up. The prospect of exporting superior quality

vegetables would be at an all time high during the years to come. Therefore, research on all aspects of export-oriented vegetables has to be intensified. Multi-disciplinary research efforts are required for developing high yielding and locally acceptable, insect/pest resistant varieties and formulation of suitable agronomic recommendations.

Export-oriented cut flower production

Kerala has been recognised as the zone for intensive development of orchid and anthurium cultivation. The establishment of a cut-flower industry in the State, must have strong R&D support. Genetic improvement, micropropagation to produce large number of planting materials, standardisation of management practices and packaging of cut flowers are some of the areas of priority research.

Micropropagation of export-oriented horticultural crops

There is immediate necessity to evolve protocols for mass *in vitro* clonal multiplication of leading export-oriented crops like cashew, orchids, anthuriums, rose and foliage plants. Appreciable progress has already been achieved in standardising techniques for the *in vitro* propagation of cashew (various hybrids), orchids (Red vanda, Phalaenopsis and Dendrobium), anthuriums (Pink and Red varieties), rose (various varieties) and foliage plants (*Alocasia* and *Syngonium*). Further research is essential to evolve viable and commercially feasible protocols within a short period.

Use of biofertilizer in Kerala

The extensive application of chemical fertilizers without the use of adequate quantity of organic manures has led to a situation where the soil has become almost inert loosing most of its physical, chemical and biological properties. A lot of attention is being paid recently to recover the lost soil properties by popularising the concept of organic farming. This also has an objective to reduce the consumption of costly chemical fertilizers. This can be achieved by the effective use of biofertilizers. In fact, if one has to achieve any success in the use of biofertilizers, it has to be coupled with the use of organic manures. This is of particular significance for a state like Kerala, where soil conditions due to its acidic nature and rather poor organic matter status are not congenial for the efficient use of different biofertilizers. Hence, in Kerala, the use of biofertilizers has to be popularised along with the practice of organic farming.

Vermi-technology

Vegetable garbage and biowastes of industries and agriculture pose serious environmental problems. Effort from the agriculture sector has not been made to evaluate the usefulness of these for crop production. In view of the escalating cost of inorganic fertilisers in the recent past, appropriate methods are to be for the efficient evolved recycling of organic wastes. The role of earthworms in the degradation of organic wastes and improving the physico-chemical properties of soil has been well recognised. Organic farming which includes vermitechnology is identified as one of the main thrust areas of research by the Kerala Agricultural University. The optimum quantity of vermicompost required for sustainable productivity of the major crops of Kerala and the comparative effects on different crops remain to be investigated.

Sericulture

The Kerala Agricultural University has been undertaking research in sericulture from 1980 onwards. Research results were helpful in developing a Package of Practices for sericulture in the state. However, a few constraints in the development of sericulture have been identified, which need early investigation and technology development for the promotion of the programme. These constraints are:

The weakness and breakage observed in the silk filament spun by the worm during rainy and highly humid seasons of June to November. The cocoons produced during the rainy days have only a low recovery of silk and not accepted by the reelers;

Identifying/breeding bivoltine silk worm races tolerant to high humidity and temperature conditions. Such breeds have been developed in China, leading to switch over from the multivoltine to bivoltine recently;

Identifying/breeding a high yielding variety of mulberry that can be grown as an intercrop in the partial shades in coconut gardens;

Evolving farming systems which can accommodate sericulture as a component for utilising family labour available under small and marginal holdings.

Analysis of the constraints in the socio-economic system in the zone for the development of sericulture, as it is an employment generating programme.

Value addition in horticultural products of Kerala

Kerala being a horticulturally potential State, much emphasis has been laid in enhancing the production of various tropical horticultural crops such as fruits, vegetables and plantation crops like cashew, coconut etc., in the past five year plans. Though coconut is the pivotal crop in Kerala, the major products coming to the market are confined to copra and oil. The importance of value addition to the coconut products by diversifying the processing technology to wet extraction methods so as to produce high value export potential products such as coconut cream, desiccated coconut, coconut honey, Nata-de-coco and ready to serve (RTS) coconut water beverages etc. can hardly be exaggerated. Much potential lies behind in collaboration with the Central Coconut Development Board and like bodies. In the field of tropical fruits and vegetables, fruits which are extensively produced such as Nendran banana, cashew, papaya and mango (seedling and pickling types) need value addition so as to make their cultivation highly remunerative to farmers. Vegetables which need value addition are mainly cucurbits which are seasonal confined to rabi seasons. Innovative products are to be developed out of pumpkin, ashgourd, snakegourd, bittergourd etc. and techniques standardised to preserve them in the dehydrated state and as intermediate moisture foods (IMF).

Watershed management

Kerala with a high annual rainfall coupled with undulating topography faces serious problems in soil and water conservation. Research on watershed basis will help develop suitable location - specific technologies.

Soil based agro-technology transfer

Data available from the various soil surveys and other soil studies so far made are insufficient to arrive at correct interpretations on crop suitability and for preparing the maps needed for formulating rational land use plans. Special surveys are needed on the priority areas with specific problems and potentials already identified by the zones. Reconnaissance soil surveys are necessary using aerial photographs, satellite imagery and topographic maps on 1 : 50,000 scale as base maps at the association or series level. Detailed soil surveys at scale 1:10,000 or even larger would be useful for planning at block, watershed and village level. Identification, characterisation and classification of bench mark soils are to be done for facilitating transfer of soil based agrotechnology. Soil series-wise collection of agronomic and socio-economic data for evolving Package of Practices for major crops are programmed in collaboration with the State Land Use Board & NBSS & LUP, Nagpur . Work would be done to create awareness and to train personnel for studying and monitoring land resources of the zones for micro level planning using Geographic Information System (GIS) and other allied packages available.

Soil and water management

During the monsoon seasons, the uneven topography of the land situation in the highland sub zone leads to heavy losses of the surface soil. Soil erosion, land degradation and landslips cause heavy destruction to the standing crops in hill slopes and valleys. The available soil conservation techniques suited to the different land situations in the zone need examination and popularisation to conserve the precious top soil. Lack of irrigation to crops grown in summer is a constraint in the zone. Efficient and low cost water conservation options like tillage, organic mulches, burial of coconut husk, contour trenches etc. suited to the zonal needs, have to be experimented, standardised and demonstrated to the farmers. Breeding for drought tolerant genotypes is also envisaged.

Crop water management research in coconut

Coconut is an essential component in the homesteads of Kerala. Experience has shown that irrigation alone to coconut palms can easily double the yield of nuts and fertilizer application can result in further increases. However, the crop is grown in the zone mainly as rainfed. Water deficit during the dry months of December to May is the main reason for the decline in yield. Irrigation scheduling based on canopy-temperature-based indices would be attempted.

Processing of fruits and vegetables

Research programmes to be taken up under Food Science and Nutrition will be centered around the problems of farm families. Simple technologies on post-harvest handling, storage and preservation would have to be developed. There is immense scope in developing a number of processed foods. Appropriate simple technologies on processing seasonal and under exploited fruits, vegetables and other food articles will be developed.

Imparting training to unemployed youth towards commercial agriculture

The Agricultural Development Policy announced by the State lays emphasis on restoring the social status and dignity of the farmers which has eroded over the years. The Policy has rightly realised that the future of Agriculture in Kerala lies on how best the literate youth could be attracted and retained

on the farm front. Training is proposed to be imparted to those for whom Agriculture is the main occupation and who possess aptitude and interest to Agriculture.

PROBLEM ZONE

Research is proposed to be intensified in respect of the following areas :

Integrated farming system (involving crops/livestock and fishery) models will be developed and field tested for varying agro-ecological environments in the zone;
Research efforts to manage the dreadful coconut root (wilt) disease will be intensified as 60 percent of the gardens in the zone are under the grip of the disease;
Fish diseases take a heavy toll in the production of fish in the water environments of the zone. Studies will be intensified to formulate control measures against the diseases;
Research on RTV/GSV complex of rice will be given more emphasis. Concerted efforts will be made to control the disease;
Breeding of rice varieties with high yield and multiple resistance to major pests and diseases will be continued;
Breeding of sugarcane varieties possessing disease resistance for varying agro-ecological environments will be intensified;
Cucurbitaceous vegetables like snakegourd and bittergourd are highly prone to virus diseases in the zone. Efforts will be continued vigorously to breed resistant varieties and to formulate management/control measures;
Economic and viable cropping systems for the *Onattukara* tract will be developed to suit the changing cropping pattern in the area consequent on the commissioning of Kallada Irrigation Project;
Testing and refining farm implements and machinery will be taken up on a priority basis as labour cost is soaring high in the zone;
Research will be intensified to monitor pesticide residues in water, crops, livestock and fish.

CENTRAL ZONE

Hybrid rice breeding

Efforts to develop a superior hybrid rice suitable for Kerala will be made during the next five years. For this, development of stable and adaptable cytoplasmic male sterile (CMS) lines through substitution back crossing, wide hybridization and induced mutagenesis; identification of maintainers and restorers for such CMS lines and developing superior hybrids having good agronomic characters and resistance to biotic and abiotic stresses, are programmed.

Breeding of varieties resistant to leaf roller, stem borer, gall midge etc., blast, sheath blight and Tungro virus, breeding of drought tolerant varieties suitable for dry sowing, breeding of high yielding medium duration rice, specially suited for rabi (Mundakan) season are also proposed.

Rice production

Many of our rice soils are becoming sick and unproductive primarily due to the unscientific nutrient management. Intense studies are needed to sustain the productivity of rice soils through an

integrated nutrient supply system involving the combined use of all possible sources of nutritior and their scientific management in specific agro-ecological situations. Effective utilization of rainfall and exploitation of other weather variables to the advantage of the rice crop can be largely achieved through temporal adjustments in crop establishment. This requires concerted studies on agro-meteorological situations in each zone and its influence on rice productivity. Considering the negative impact of rice mono-culture on soil health and economic viability of rice farming, newer systems of cropping are to be designed for specific agro-ecological situations.

Excess availability of iron and its continuous absorption have been found to be one of the yield limiting factors in rice in laterite soils. A multidisciplinary approach is needed to improve the productivity of iron toxic soils. Considering the increasing area under direct seeded rice in view of the acute labour scarcity and escalation in wage rates, it is imperative to develop management strategies for this system. Increasing trend in the use of herbicides is leading to problems such as herbicide residues in crops, herbicide resistance by weeds, environmental pollution, persistence in soil etc. It requires in-depth studies to solve these problems. The scope for integrating different complementary enterprises with rice farming is to be explored to improve the income of the rice farmer, to facilitate effective organic recycling and to generate additional employment. After collecting basic data on the prevailing farming system, testing can be undertaken on the possibility of integrating enterprises such as fish culture, duck/poultry rearing, mushroom production, biogas generation etc. with rice farming to ensure effective recycling of organic residues and to reduce the investment on purchased inputs. The future strategy for research and development to make the best use of available land water resources for the next five years in the division of soil science and Agricultural Chemistry is furnished below:

To obtain sustained maximum production and productivity of rice in each region/locality through effective and integrated use of resources, the research proposals will be streamlined in the following thrust areas viz. viable organic recycling package for rice to make the best use of available organic manures in the farm with bio-fertilizers, standardising management practices in stress situations particularly to iron toxic and acidic soils, integrated nutrient management techniques for dry and wet sown rice, improvement of fertilizer use efficiency for water logged rice cultivation.

Rice protection

Integrated Pest Management

The pest problems pose a threat to the farming community and the cost of cultivation increases due to the increased plant protection operations. Hence, the following lines of future research are suggested: developing cheaper methods of insect control like light traps, bio pesticides, pheromone traps, cultural methods and biological control, research on the non-toxic methods for control of pests in crops like vegetables, pulses and other crops in the Central Region and studies on the insecticide resistance in insects and residue in crops.

Integrated Disease Management

Disease management using cultural, biological and chemical methods, control measures on seed borne diseases and the storage methods for improving the seed viability, quality and health, developing moderately resistant varieties for important diseases like sheath blight, grain diseases and blast. are aimed at.

Starting of Plant Protection Clinics

There are multivarious problems in the field level and identification of problems based on the symptoms sometimes poses problem among the developmental agencies and farming community. Hence plant clinics with different disciplines like Entomology, Plant Pathology, Plant Physiology, Soil Science and Agronomy will be started for documenting and cataloguing the symptoms seen in farmers, fields, identifying the causal agents and feed back of the requirements to scientists for initiating research. The Techniques developed, newer pests and diseases identified will be explained to the farmers.

Pulses

Breeding cowpea varieties suitable for intercropping in coconut, tapioca and for fringe cropping in rice field bunds, collection and maintenance of germplasm of all major pulses crops like cowpea, greengram, blackgram, redgram etc., evolving superior genotypes of blackgram and greengram varieties suitable for summer rice fallows, breeding of photoinsensitive high yielding horsegram genotypes, introduction and popularisation of non-conventional pulse crops like soybeans, cluster beans, sword beans, winged beans etc.,introduction and screening of superior genotypes of sunflower, groundnut and sesamum for intercropping in coconut and tapioca are the future thrust. Establishment of a full fledged "Advanced Centre for Pulses Research" is envisaged.

Medicinal plants

Having built up the necessary infrastructure facilities, it is proposed to intensify basic and applied research on medicinal and aromatic plants in the following lines during the coming years. Survey, collection, conservation and evaluation of selected medicinal and aromatic plants of the Western Ghats, development of improved varieties for commercial cultivation, organic farming research and management of medicinal and aromatic plants for sustainable productivity, development of package of practices for the cultivation of important aromatic and medicinal plants, isolation and identification of active medicinal and aroma principles in selected species, post harvest processing and value addition of essential oils and raw drugs, development of botanical pesticides from medicinal and aromatic plants, establishment of a biotechnology laboratory and mass multiplication of planting materials of selected species of medicinal and aromatic plants, strengthening of herbal garden and nursery, revitalisation of local health tradition through popularisation of medicinal and aromatic plants in homesteads and for large scale cultivation are suggested.

Cashew

Effect of different growth regulators on inducing early maturity of shoots on cashew trees subjected to periodic pruning, effect of leader shoot pruning and training on cashew using grafts as planting material, root stock-scion interaction studies with different cashew varieties in softwood grafting, modelling a cashew based intercropping system by identifying suitable intercrops in new and old plantations, canopy manipulation for increasing production in cashew by optimum utilization of solar energy and land, evolution of dwarf cashew varieties by breeding, establishment of a large scion bank of improved varieties of cashew, developing technology for minimising casuality in graft production by improving the grafting technique, production of propagules through tissue culture technique, technique for enhancing scion production through manipulation of canopy are the future thrust.

Vegetables

Vegetables are commonly cultivated in summer rice fallows. Most of the solanaceous and cucurbitaceous vegetables are cultivated during this season. In each crop short duration varieties having multiple resistance to pests, diseases and abiotic stresses with high yielding potential are to be developed. Production of F1 hybrids are essential to tap the potential of available resources. The following projects are proposed viz. evaluation of varieties of bittergourd and snakegourd for summer rice fallows, water management and canopy management studies on vegetables, production of F1 hybrids in vegetables.

Fruits

The Zone has the mandate for producing quality planting materials in fruits such as mango, jack, sapota etc. The propagation techniques are to be refined in order to attain maximum efficiency in the production of planting material. Hence a full compliment of propagation including structures controlled growth chamber/green house is to be developed. The following projects are to be implemented: development of controlled mist house technique for producing maximum recovery of grafting of fruit plants, assessment of micro climatic requirement for achieving maximum recovery in layering and approach grafting in fruit plants, development of management techniques for potted plants/planting materials in nursery.

Mechanisation in nursery management

Development of top working technique for rejuvenation of old plantation having obsolete varieties with new improved varieties of fruit plants.

Banana

The current requirement in research is making the production technologies for fruits more eco-friendly and cost effective in the light of National policy change towards a sustainable development in Agriculture. Besides, reckoning the new economic trends of product diversification in Agriculture, R&D has to be strengthened in new frontiers of agricultural sectors viz., post harvest technology and marketing. The research programmes to be taken up along with the ongoing projects are selection, improvement and *in vitro* large scale multiplication of superior clones of banana and pineapple, breeding for leaf spot disease and nematode resistant, non lodging and dwarf statured plantain with all important fruit characters of Nendran, agrotechniques for mixed cropping of fruits, vegetables and tree crops under homestead conditions, technologies for integrated farming systems incorporating Horticulture, animal husbandry and aquaculture, development of crop simulation models for monitoring regionwise fruit production and constraints, development and standardisation of bio-fertilizers, bionematicides and botanical, development of pest and disease forecasting models for early surveillance and management of pests, formulation and standardisation of quick, reliable and sensitive diagnostic techniques for major diseases of banana for application in quarantine and eradication programmes, standardising post harvest handling techniques in banana: Pre-cooling, waxing, packaging and storage, product development in banana and pineapple using biomass and fibre.

Strengthening of research on integrated farming system

Research on integrated farm with poultry and piggery is proposed for studying the feasibility of recycling banana and pineapple biomass and animal wastes in the farming system.

Water conservation and management

Water management research has covered only the crops like rice,vegetables, banana pineapple, tuber crops, pulses and oil seeds. The same type of research will be extended to other economically important crops like coconut, arecanut, fruit plants (mango, sapota, guava) cashew, spices (nutmeg, pepper, cardamom, cinnamon, clove etc.).

Moisture conservation

Nearly 85% of the net area cultivated in the State is rainfed. Eventhough Kerala receives an average annual rainfall of 3000mm it covers a period of five to six months and hence a prolonged dry spell of about six months is being experienced. Drought damage is a common occurrence. It is therefore necessary to conduct research on rain water management in rainfed areas including water harvesting and storage and moisture conservation measures.

Study on irrigation methods

It is necessary to findout the most economic method of irrigation under different soil and varying agroclimatic conditions, and availability of irrigation water.

Water management for intensive cropping

The land : man ratio of the State is less than 14 cents and intensive cropping practices assume importance. The water management studies under intensive cropping practices like mixed cropping, intercropping, crop rotations etc. also have to be taken up in future programme of research.

Studies on soil-water-plant-atmosphere relationship

This is to evaluate, refine and develop water related methodology, concepts and relationships in the soil-water-plant atmospheric continuum system. Under this, one aspect is testing, modification and development of methodology used for studies relating to various aspects of water management in crops. Another is estimation of water production functions of crops under varied water, fertilizer, nutrients, other inputs etc.

HIGH RANGE ZONE

The high range region has the advantage of both tropical and subtropical climates. There is vast scope for carrying out research on an array of crops. Importance is to be given to identification of crops and cropping systems suited specifically to High Range conditions. Emphasis will be given to breeding for appropriate varieties and their management. Promising crops of particular relevance and the areas of research are given as follows:

Rice	: Hill paddy, including scented varieties
Spices	: Mainly pepper, ginger, turmeric, vanilla and cardamom.
Vegetables	: Mainly tomato, beans, tropical cabbage and cauliflower, carrot and raddish.
Tuber crops	: Tapioca and dioscorea.
Commercial floriculture	: Mainly anthurium, rose, gladiolus, dahlia, chrysanthemum.
Sericulture	: Commercial silk worm nursery.
Livestock	: Promotion of rabbit and pig rearing.

Major research areas

Evolving desirable hill paddy varieties for specific areas and development of scented rice varieties for export oriented cultivation, standardisation of techniques of management in spices with special relevance to pepper-based cropping system, development of appropriate technology for coffee-based mixed cropping in garden lands under rainfed conditions, development of water harvest and utilization technology and water management practices for major crops, pest and disease management practices for major crops, development of new varieties of tree spices and standardisation of crop protection techniques, post harvest handling and processing techniques of fruits and vegetables, efficient utilization of essential oil yielding plants of the region, identification of the economic crops and cropping systems in the High Range Zone based on economic analysis, demand - supply aspects in relation to price fluctuation of plantation crops produce, development of appropriate cultural/manurial management practices with special emphasis on organic farming, economic viability of livestock management under Wayanad conditions and feasibility of poultry and rabbitry development in the zone are suggested.

NORTHERN ZONE

By-product utilization of major crops like coconut and cashew, biological control of pests and diseases, formulation of pesticides of organic origin, intensification of research on organic farming, socio-economic status of farming community in the changing agricultural scenario, integrated farming systems in the zone are the major thrust areas.

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