AGRICULTURAL RESEARCH IN KERALA

STATUS PAPERS - 1978

DIRECTORATE OF RESEARCH
KERALA AGRICULTURAL UNIVERSITY
MAIN CAMPUS – VELLANIKKARA
TRICHUR, KERALA

FOREWORD

In an agricultural University the main task before the scientists is solving the problems of farmers so as to ensure them a higher net income from unit area, more employment and a better standard of living along with the over all increase in agricultural production of the state. In order to formulate a plan of action to achieve these objectives, the Scientists should have a thorough knowledge about the biophysical constraints and socio-economic problems acting as barriers in agricultural production. Mutual exchange of ideas from farmers, extension workers and research scientists through conventions, seminars, workshop and field demonstrations will expose these problems to a large extent. The problems and constraints so identified are yet to be subjected to a thorough scientific analysis in an inter-disciplinary group of scientists, for formulating need based research programmes. It is with this objective different inter-disciplinary co-ordination committees of Scientists have been formed in the Faculty of Agriculture and Faculty of Animal Science.

I am glad to note that the co-ordination groups so formed have made a serious analysis of the agricultural problems in the state and have generated a large fund of information as to what has been done in the past and what ought to be done in the future.

I am happy that these valuable informations are documented in a book and published by the University.

I am sure that this will be a useful document for the research workers in Agriculture.

Kerala Agricultural University,
Vellanikkara.

N. KALEESWARAN
Vice Chancellor.

PREFACE

The Kerala Agricultural University has enunciated a research policy to reorient the research programmes towards solving the problems of farmers, by enhancing agricultural production, employment in agricultural sector and ensuring a better standard of living. The programme also aims at reducing the cost of production by intensive utilisation of natural resources and efficient use of inputs in agriculture and animal husbandry.

A change over from the 'Institutional research' to the 'Project based research' was the first step introduced for achieving the above goal as envisaged in the research policy. These projects were implemented through various disciplines in three colleges and 23 research stations located in different parts of the state. The projects were further streamlined by discussing the problems in farmer's conventions, seminars and in the workshop of scientific workers. The number of crops, animals, birds and other groups covered by these projects were found to be large even in a single discipline. Therefore it was felt necessary that some sort of inter-disciplinary co-ordination in respect of crops, animals and other groups is necessary for making the project based research more purposeful. Accordingly, 14 Co-ordination groups in the Faculty of Agriculture and 7 co-ordination groups in the Faculty of Veterinary & Animal husbandry were formed as given in appendix-I. These Co-ordination groups have the responsibility to assess the present status of research work done in the respective area, identify the research gap and suggest future line of work, co-ordinate the inter-disciplinary research work in respect of each group and review the progress of work periodically.

In the 21 status papers compiled in this book, the project co-ordinators and their associates have given a critical account of the present position, a brief resume of work done and research gap and future line of work. This will form a valuable base material and guide to the research workers for selecting problems of practical importance as envisaged in the research policy of the University. I express my sincere thanks to all the Project Co- ordinators and their associates for undertaking this valuable work in addition to their normal duties and functions.

I am also thankful to Dr. A. Venugopalan Nambiar and Dr. N. Mohanakumaran and other scientists who helped in editing and scrutinising the final report. I have to gratefully acknowledge that Sri. K. M. George has spared considerable time and effort for arranging and supervising the printing work of the book. Sri K. Pushkaran, Sri. K. Rajmohan and Dr. G. Krishnan Nair have devoted considerable time for proof reading work. Thanks are expressed for their painstaking work.

I have to respectfully record that our Vice Chancellor Sri. N. Kaleeswaran is the guiding architect in the remodelling of organisational set-up in research and its functioning in every stage. I express my deep sense of gratitude to Sri. N. Kaleeswaran, Vice Chancellor for every guidance and facilities given for publishing this book.

The information documented in this book can be made concurrent with the time and needs by periodical revision. It is hoped that this will be a useful reference document for the agricultural research workers in Kerala.

Kerala Agrl. University,
Vellanikkara,
March, 1979.

U. P. BHASKARAN
Director of Research.

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PART – I FACULTY OF AGRICULTURE

PART – II FACULTY OF VETERINARY & ANIMAL SCIENCES

1. RICE

INTRODUCTION

Research on rice dates back to 1893. Early work in most countries of tropical Asia was aimed at improving popular local varieties mostly by pureline selection and in a few instances by hybridization. The maximum contribution in rice research has come from the Japanese workers. Their work has been mainly on the *japonica* rices. In India research work on rice was commenced at the beginning of this century. Considerable work has been done in Kerala on the various aspects of rice cultivation during the last half-a-century. In the eerlier years varietal improvement of tall *indica* rice received the highest priority. Cultural and manurial aspects also received attention. Studies on pests and diseases attacking rice were taken up much later.

The development through breeding of rice varteties with short stature has resulted in a substantial increase in yield potential of the rice. The establishment of the International Rice Research Institute in 1961 and the All India Co-ordinated Rice improvement Project are landmarks in rice improvement work. A number of high yielding dwarf *indica* rice varieties were evolved in India and abroad. With the introduction of these varieties in Kerala, there was a marked acceleration in rice production.

The total area under rice in Kerala is 8,54,374, ha. and the production is 12, 54, 003 tonnes; the average yield being 1468 kg/ha. The area put under high yielding rice varieties is 2, 63, 974 ha. The percentage of area under these varieties to toal area under rice is 32 in the first crop season, 20 in the second crop season and 67 in the third crop.

Research on rice in Kerala is being carried out at the rice research stations at Pattambi, Moncompu, Kayamkulam, Mannuthy and Vytilla, representing different situations under which rice is grown in Kerala.

RESUME OF WORK DONE

With the starting of the Rice Research Station at Pattambi in the year 1927, emphasis was on the improvement of the varieties which were widely cultivated in the different parts of the erstwhile Malabar and South Kanara districts of the then Madras State. In this part of the country rice is grown under a variety of situations and as such there was a very large number of varieties under cultivation, each suited to the particular set of environmental conditions. Under such conditions, it was but natural that varietal improvement had the highest priority. Pure line selection was the main line of approach and thirty four improved strains were evolved from the local tall *indica* cultivars. All these had their own merits. Of these, fifteen were photo –sensitive and suited to the 'Mundakan' (second crop) season while the rest were photoinsensitive mainly cultivated during the 'Virippu' (first crop) season. Three of these, viz; PTB. 28, 29 and 30 were drought tolerant and adapted to the upland (modan) areas. PTB 19, a short duration strain, was a cosmopolitan variety which could be grown in all the three seasons and a predominant variety for the 'Punja' (third crop) season. Apart from these, nine other strains were released for cultivation, two each from Ambalavayal, Moncompu aud Kayamkulam and one each from Mannuthy, Kottarakkara and Vytilla. UR.19 was a photosensitive variety popular in the sandy Onatukara region for the mundakan season. UR. 101 was evolved for the saline backwater areas of the same region. The two strains WND1 and WND2 were long duration varieties very much suited to the cool, high rainfall-area of Wynad. Kottarakkara I was a variety developed for the deep soils of Quilon and Trivandrum districts and Vyttila I was suited for the 'pokkali' area. Co.25, a long duration, blast resistant, photo-sensitive variety was an introduction which occupied a major area in the Palghat district during the Mundakan season. H4 was another introduction (from Ceylon) suitable for the deep areas.

Tainan 3, a 'poklai' variety introduced during 1964-65, inspite of its drawbacks, brought in an awareness among the cultivators on the possibilities of higher production by the use of fertilizer responsive varieties as against the popular tall ones. Mashoori, an *indica-japonica* hybrid introduced from Malaysia, became very popular in Kerala and was capable of giving very good yields.

With the introduction of the dwarf *indica* varieties like Taichung (Native) I and IR.8 there was a marked acceleration in the rice breeding programme in India. These dwarf varieties with very high yield potential were widely used for upgrading the most popular tall varieties by hybridization. IR. 8 and Jaya, the introduced high yielding varieties, became very popular with the farmers of Kerala. Kerala was also not behind in the development of high yielding dwarf varieties. Our workers came up with the first variety under this group viz., Annapoorna from a cross between PTB 10 and Taichung (Native) 1 in 1969. Being a red riced, short duration variety, this imme-

diatley became popular with the farmers of Kerala. This was followed by the release in 1971 of three strains, Aswathy (a product of a cross between Dee-geo-woo-gen and PTB. 10); Rohini (PTB. 10 × IR.8) and Triveni (Annapoorna × PTB. 15). Aswathy was intended for the dry sown areas. Rohini, a short duration variety with high protein content, performed exceedingly well in the Virippu and Punja seasons, taking only eighty five days for maturity during the latter season; Triveni was an improvement over Annapoorna in regard to sterility and adaptability. All of these are white riced. In 1974 three more varieties came out, two from PTB 10 × IR. 8, of which Jyothi is of 110 – 115 days duration and Bharathi, of 125 days' duration. The third one, Sabari, a progeny from IR.8/2 × Annapoorna, is of medium duration. All these three are red kernelled. Jyothi and Bharathi have resistance for blast disease and they are also found to be tolerant to brown plant-hopper. IR. 20 is an introduced variety which performs well under certain stress situations.

A semi-tall, nonlodging variety (ARC 11775) with high yield potential has been identified for the droughtprone uplands. This has been released under the name 'Suvarnamodan' (PTB.42) for trial cultivation in Palghat and Trichur Districts.

All these varieties rapidly spread in different parts of Kerala and were widely used in extensive areas in the Kuttanad and Kole areas. In spite of their high yield potential, their spread in Kerala taken as a whole has not been encouraging. It is estimated that even to-day the extent of area covered by these high yielding varieties is very low. This low spread is attributed to some of the weaknesses of these varieties, viz., their susceptibility to pests and diseases, requirement of higher inputs, more efficient management and non-adaptability to many of the situations under which rice is grown in Kerala. Hence the present breeding programme is oriented towards evolving varieties resistant to the more important pests like stemborer, gallmidge and brown planthopper and diseases like blast, brownspot, sheath blight, bacterial leaf blight and tungro and grassy stunt viruses. Work has been initiated in evolving varieties with high yielding abilities adapted to the cold conditions in the hills and saline conditions of the backwater areas.

Some of the traditional tall varieties released in earlier years have been proved to possess a high degree of resistance to certain stress situations. PTB. 18 and 21 are resistant to gallmidge, sheath blight, and tungro virus, while PTB 7 is resistant to footrot and gallmidge; varieties PTB 19 and 33 have a high level of resistance to brown planthopper, while PTB 12 is tolerant to bacterial leaf blight.

A large number of cultural, manurial and herbicidal trials also have been conducted in our state. Based on the findings of our manurial trials, we are in a position to recommend appropriate manurial schedules for different agroclimatic regions and for different types of varieties and cultivation methods.

There is universal response to applied nitrogen and it is the nutrient that limits production in the majority of the soils. The optimum levels of nitrogen have been observed to be 67 kg per hectare for tall varieties, 84 kg per hectare for early duration dwarf varieties and 122 kg per hectare for mid-duration dwarf varieties. Nitrogen use efficiency is about 14.7 kg of grain per kg of the nutrient now and it will be useful if investigations are made to increase the efficiency which has great economic implication.

Split application of nitrogen has been proved to be better than single application. Application of nitrogen at the reproductive phase has been proved to be highly beneficial both for tall and dwarf varieties. When fertilizer is in short supply the best time to apply the nitrogen has been found to be 7 days before panicle initiation. Smaller dressings of nitrogen at the panicle initiation, booting and heading stages have been found to be highly useful for increasing grain yield, protein content and recovery of head rice.

Placement of nitrogen in the reduced zone of soil has doubled the nitrogen use efficiency indicating that the dose of N can be reduced considerably by adopting placement technique.

Investigations on the manuring of upland rice has revealed that application of N at seeding increased the foraging capacity of roots and enhanced drought tolerance. Soil compaction is another method found useful for increasing nitrogen response of upland rice.

Among the nitrogen fertilizers, urea and ammonium sulphate have been observed to be on par in effectiveness. Shellack coated urea and sulphur coated urea have shown better effect compared to ordinary urea when N was applied entirely at planting. These coated ureas were not superior to ordinary

urea when nitrogen was applied in split doses. A recent study on nitrogen manuring has shown that urea super granules was highly effective in increasing fertilizer use efficiency in wet lands.

Investigations conducted on liming waterlogged soils yielded contradictory results in our research centres. Liming, however, has been found effective under conditions of iron toxicity. Top dressing lime at 1000 kg/ha at the tillering phase immediately after manifestation of toxic symptoms, has given excellent results for the control of iron toxicity.

Several trials have been conducted in the research stations on time of planting and method of planting. Planting first crop (Virippu) beyond the 15th of July and the second crop (Mundakan) beyond the third week of October definitely reduces yield under Pattambi condition. It is found that dibbling sprouted seeds in puddle has definite advantage over broadcasting. It also has shown higher productivity compared to transplanting.

The optimum density of planting for early and mid duration varieties has been worked out under different crop growing conditions. On an average of the research centres, spacings, 20 cm × 15 cm for the first crop and 20 cm × 10 cm for the second crop are ideal for mid duration rices. A closer spacing of 15 cm × 10 cm is the optimum for early duration varieties. Trials on age of seedlings have revealed that for maximum productivity the optimum chronological age of transplanting seedlings of medium duration rices is 35 days during the Virippu season and 28 days during the Mundakan season. The optimum chronological age for early duration rice is 20 days. Due to the failure of monsoons often it becomes necessary to transplant older seedlings. A recent study at Pattambi has shown that nitrogen plays a more important role than plant population density in mitigating the ill effects of old age of seedling. Studies on depth of planting has proved that shallow planting is good for rice (3 to 4.5 cm).

Studies on crop weed competition revealed that weed competition is more critical during the early vegetative phase and that weed-free condition upto 45 days from sowing favours higher grain production.

Chemical control of weeds has been found to be effective and economical in the uplands as well as wetlands.

Experiments on multiple cropping conducted at Karamana revealed that two rice crops followed by an early duration tapioca (H. 165) or Bhindi give higher net returns.

Some experiments are in progress at the Agronomic Research Station, Chalakudi on water management. Water requirement in different growth stages has been studied and their component analysis has been made. It is found that 50-70 percent of the water requirement of the crop is accounted for by percolation.

Studies have been made to assess the rainfall contribution, drainage requirement and net irrigation requirement of rice crop for different seasons and to find out a cropping method which can use the rainfall contribution to the maximum benefit. A semi-medium rice in Virippu followed by a medium duration rice in Mundakan has been found to take maximum advantage of the rainfall contribution.

In a study to find out an economic irrigation schedule for rice under high ground water table status, it has been found that intermittent irrigation is more advisable and also economical. This saves about 20 percent water without any significant reduction in yield. This system can be advantageously used in Mundakan season in areas where ground water table is high enough.

Economic irrigation schedule has been worked out for rice under limited water supply.

Some studies have been made in evolving agro-engineering measures for reducing percolation. Subsoil compaction can reduce the percolation loss to the tune of 25-40 percent. Soil dressing with laterite soil reduces the percolation loss to about 15 to 20 per cent.

We have a very large volume of data on chemical control of insect pests with sprays, dusts and granular forms. Almost all the chemicals in the market have been screened for their efficacy against different insects. We are in a position to recommend chemical control methods for major and minor pests of rice.

As the chemical control has become costly now-a-days due to the high cost of chemicals and labour, it is now the job of the researchers to evolve methods which are ecnomical. For this, investigations are in progress to find out now techniques for application and also to formulate economic schedules. Root zone application of carbofuran and seedling dip

treatment are such techniqnes to be mentioned. It has been found that seedling root soak treatment with 0.02 per cent solution of Dursban, Mipcin etc. are highly effective and economical. Placement of Carbofuran EC in the reduced zone of soil using a very simple locally fabricated applicator has given encouraging results.

The present day scientific opinion is in favour of less use of chemicals for the control of pests as this upsets the natural balance of the ecosystem. This aspect has to receive greater attention. Studies have been commenced for finding out the effect of the commonly used Insecticides on the beneficial insects.

At present utmost importance is given for breeding varieties for resistance to the major pests like stem borer, gallmidge and brown planthopper which are not easily amenable to chemical control. A lot of work has already been done on this and many donor varieties have been identified. For the control of brown planthopper which is capable of multiplying very rapidly under favourable conditions, resistant varieties are the answer. Resistant donor varieties have already been identified. PTB.19, PTB.33 and ARC.6650 have been proved to be varieties with high levels of resistance to this pest. These are now being widely used for the development of resistant high yielding varieties. Experience at the International Rice Research institute goes to show that the pests develop new biotypes as we produce resistant varieties. Studies so far conducted at the Rice Research Station, Pattambi and in the other Research Stations in the country have not given any indication of biotypic variation in brown planthopper in India.

Effect of pesticides on natural enemies of pests need a detailed study. In a recent study at Pattambi it was revelaed that crop protection with most of the pesticides reduced the population of insect pests as well as their parasites and predators. Among the chemicals tested there were none that could spare the parasites or predators in the field.

For controlling diseases we have developed chemical control methods for all the major and minor diseases. We have already evaluated the efficacy of almost all the fungicidal chemicals in the market, in controlling rice deseases. Except for sheath blight most of these fungal diseases of rice could be easily controlled with chemicals. But it is often beyond the means of our farmers as the cost of plant protection chemicals has soared very high in recent times. Edifonphos and IBP are good for blast, Zineb can be considered as a general purpose broad spectrum fungicide for the control of most of the fungal diseases of rice. Bacterial blight can be checked with streptomycin sulphate products.

Sporadic appearance of some type of yellowing disease is noted in some areas. Tungro and grassy stunt and yellow dwarf diseases have been identified from these areas. Some soil problems were also suspected. Work has been started at Moncompu for the thorough investigation of this yellowing complex.

For disease control in rice the widely accepted and the most economic method at the farmer's level is the use of resistant varieties. Search for resistant varieties for different diseases is progressing in all the research stations in collaboration with the All India Co-ordinated Rice Improvement Project and International Rice Testing programme. Local germplasm and varieties received from other sources have been screened for resistance to different diseases for fixing up suitable donors for resistance. At present the greatest stress is laid on breeding multiple disease resistant varieties which will enable the farmers to reduce or completely dispense with the use of chemicals.

For screening varieties for resistance to diseases foolproof methods to screen very large number of varieties in a very short period should be available. In this respect methods for screening large numbe rof varieties quickly for blast resistance have already been developed and are widely in use. The uniform blast nursery technique is a very efficient method in this regard. In the case of bacterial leafbiight also the clipping method has been found to be efficient. But in the case of sheath blight the methods now in use, viz., inoculation with stem bits or with the fungal culture on half filled grains are cumbersome and time consuming.

Only a few studies have been conducted on storage life of seeds. It has been observed that seeds could be stored after treatment with seed dressing fungicides upto a period of one year without impairing viability. Seeds stored in polythene bags have been found to retain viability for longer periods as compared to those stored in ordinary gunny bags.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

Although significant progress has been achieved in production, breeding, high yielding rice varieties

already released do not possess built-in resistance to various pests and diseases. Hereafter the accent has to be on evolving varieties with high level of resistance to the most important diseases; blast, sheath blight, brown spot, bacterial blight and tungro and grassy stunt virus, and pests; brown planthopper, stemborer, gallmidge and leaf roller.

The diverse ecological situations in Kerala also demand rice varieties possessing tolerance to adverse soil and climatic conditions. There is an area of 24 000 ha. under saline incursion for which we have to develop varieties capable of giving high yields. Varieties have also to be developed for cool areas of Wynad and Idukki.

The farmers have been clamouring for good varieties with slightly taller nature, photosensitiveness and high yield potential for the Mundakan season as the performance of the varieties which are being popularised now is quite erratic during this season.

Ill drained and flooded soils need varieties with high yielding ability and tolerance to flooding.

The Virippu crop is mostly drysown. The present dwarf high yielding varieties are not quite suitable for dry broadcasting as the traditional ones. High yielding varieties adapted for dry broadcast conditions during Virippu season are to be evolved.

Studies on slow release nitrogen sources are to be intensified to yield better methods to increase fertilizer use efficiency.

Though considerable work has been done on the phpsphorus and potash requirements of rice we are still not in a position to make recommendations with confidence. Response to phosphorus and potash has been observed to be erratic and inconsistent in most of our rice soils. However, experiments conducted in cultivators' fields in Trivandrum, Malappuram and Quilon districts, show a different trend. In these places response to N is limited in the absence of phosphate application. There is need to initiate extensive microlevel studies on the aspect of phosphate and potash manuring of rice.

Some stray works have been done on the Influence of micronutrients on rice. The results were often contradictory. The necessity of a micronutrient laboratory is highly felt in conducting micronutrient studies. Setting up of a central micronutrient laboratory will facilitate this type of studies, without which it is often difficult to interpret our results. A survey on the micronutrient status of soils may be conducted in Kerala before initiating field studies.

Only very few studies have been made on the fertilizer requirements of cropping systems. Some such studies a e in progress at Chalakudy on other crops. This can be extended to rice crop also with and without rotation. It is suggested that even in a pure rice crop area we can find out an economic manurial schedule if we consider the nutrients required for the whole year instead of taking each crop separately.

Fertilizer function on different varieties is another study which has great economic implication. Differences in fertilizer use efficiency have been observed in different varieties in our limited studies already conducted, If this line of work can be further extended it may be possible for us to locate some varieties with high efficiency of fertilizer use.

Screening rice varieties f r herbicide tolerence needs attention as some of our varieties are sensitive to herbicides and some others fully resistant. Studies on herbicide-cum-cultural method of weed control have to be initiated to formulate an effective and economic weed management practice for upland and wet land rices.

Little work has been done on rice-based multiple cropping systems in Kerala. This is a new area of research as far as our state is concerned. In some area of Malappuram district it is a regular practice to cultivate banana, vegetables or tapioca with rice in multiple cropping pattern. Studies on rice based-cropping systems have to be initiated in the different agroclimatic environments.

Post harvest technology is another avenue of research that should receive immediate attention.

Water management in rice crops needs a thorough study to make use of the available water of ayacut areas most efficiently. Water management studies are concentrated now in the Agronomic Research Station, Chalakudi where the soil is sandy loam and so the findings of that station cannot be utilized for other types of soil. Water management studies should therefore be taken up in all the agroclimatic regions of the state.

Varietal screening can be taken up to identify drought tolerant varieties that can survive better in delayed rain and under intermittant irrigation. Im-

portance of drainage should be evaluated in detail and attempts should be made to design some lowest drainage system of paddy lands of varying topography. Potentialities of reusing drainage water and tapping sub surface water are to be studied. Adverse effects of impended drainage and sub surface seepage on crop growth should be studied so as to suggest suitable measures to evercome the illeffects. Studies should also be initiated on water managament in problem soils.

As new insecticidal chemicals with high potency and at the same time not harmful to predators and parasites are being produced every year, screening trials are to be continued. It is also necessary to investigate whether the insects bulid up resistance towards the chemicals we recommend at present for controlling them. Whenever pesticides are screened, complementary data on their effect on the natural enemies of the pests should also be collected.

Detailed studies on the application of insecticidal chemicals in the root zone along with fertilizers are necessary before we start advocating it.

A joint effort is needed for screening rice cultures evolved for pest resistance, at different locations simultaneously to achieve quick results Further, screening methods for quick assessment of resistance have to be perfected. Study has to be continued to watch the emergence of new biotypes of brown plant hopper in India.

Our studies on terminal pesticide residues are very limited and so studies should be initiated on this line to save the wild life as well as human life,

Better methods for screening for sheath blight resistance have to be evolved since the present method of inoculating with stem bits or with fungal culture on half filled grains are cumbersome and time consuming.

Studies should also be initiated to build up an efficient forecasting service at least for the major diseases of rice so as to alert the cultivators to take proper control measures at the appropriate time to save their crop at minimum expenditure.

Effect of plant protection chemicals on the micro-organisms of the soils is another field to be investigated in detail as we are now using a large quantity of plant protection chemicals viz., Insecticides, fungicides and herdicides.

SUMMARY

At present we have enough number of general purpose high yielding varieties. Our need now is special purpose varieties suited to various stress situations, such as problem soils and disease and pest infected areas.

Methods should be found out to increase the fertilizer use efficiency to economise on the fertilizer use. The status of P and K in rice fertilization should be investigated thoroughly to make definite recommendations. Fertilization function on different varieties should be investigated to identify thrifty varieties. Some work is needed in locating the varieries which are thrifty in water requirement. Economic weed management practices should be evolved for different cropping patterns. Multiple cropping system for rice area has to be worked out for the economic utilization of available land by increasing the intensity of cropping leading to a high net return without adversely affecting rice production. Water management studies have to be conducted in all agro-climatic regions to utilize the available water for the maximum efficiency.

Low cost technology has to be developed by economising on fertilizers, chemicals and other inputs. Integrated pest control should be worked out to minimise the use of chemicals to avoid pollution and residue problems which may upset the natural balance. Intensive research has to be taken up to identify varieties with multiple pest and disease resistance and high yield potential.

Some more importance should be given to fundamental studies in all disciplinnes.

2. COCONUT AND ARECANUT

A. COCONUT

INTRODUCTION

Coconut is grown in an area of 0.695 million hectares in Kerala which represent a little over 25 percent of the net area sown in the state and about 70 percent of the total area under coconut in the country. The annual production is 3348 million nuts which accounts for nearly one third of the value of agricultural production in the state and about 65 percent of the total production of coconut in the country.

The district wise area, production and productivity of coconut for the year 1976-77 is given in the table below.

District	Area (Hect.)	Total production (million nuts)	Yield/ha.
Trivandrum	79335	402	5067
Quilon	93465	391	4183
Alleppey	64338	334	5191
Kottayam	56535	228	4033
Idukki	14594	50	3426
Ernakulam	53524	251	4689
Trichur	50030	342	6836
Palghat	18325	67	3711
Malappuram	67379	345	5105
Kozhikode	104885	575	5482
Cannanore	92575	363	3921
	694985	3348	4817

The district wise analysis of the distribution of coconut in the State shows that the area under coconut is highest in Kozhikode closely followed by Quilon and Cannanore. The contribution to production is highest in the case of Kozhikode. followed by Trivandrum, Quilon and Cannanore.

With regard to per hectare production Trichur tops the first followed by Kozhikode. Alleppey, Malappuram and Trivandrum. The lowest productivity is in Idukki followed by Palghat and Cannanore district.

During the last two decades or more integrated efforts were made both in the fields of development and research to modernise coconut culture and thereby increase coconut production. But it is surprising to note that inspite of our efforts productivity of the palms has not increased. In fact there is a steady decline in yield as will be evident from the year wise production and productivity given in the table below

Year	Total production (million nuts)	Yield/ha
1955-56	3099	6919
1960 61	3229	6430
1965-66	3293	5617
1968-69	3835	5589
1970-71	3981	5536
1972-73	3921	5260
1973-74	3703	4972
1974-75	3719	4971
1975-76	3439	4963
1976-77	3348	4817

The increase in total production of nuts from 1955-56 to 1976-77 was only about 249 million nuts (8,03 percent), while the increase in area was from 0.448 million hectares to 0.695 million hectares during the same period (55.6 percent). The per hectare yield went down from 6919 nuts to 4817 nuts.

Though Kerala is the major coconut producing state in India, the productivity of the crop in the State is low compared with that in other states.

Year	Kerala	Tamilnadu	Karnataka
1969-70	5589	8910	4767
1970-71	5536	9910	5616
1971-72	5551	8574	4838
1972-73	5260	8012	4791
1973-74	4972	8988	5210
1974-75	4971	8785	5408

Not only the per hectare productivity is low but the per palm productivity is the lowest in Kerala, According to the latest estimates the palm productivty in Kerala is only 33 nuts as against 41 nuts in Tamilnadu, 57 nuts in Karnataka and 44 nuts in Lakshadweep.

One of the causes attributed to low productivity of coconut in Kerala is the prevalence of root (wilt) disease in the southern districts of the State. But it is interesting to observe that despite the incidence of disease in the districts ot Quilon, Alleppey, Kottayam, Ernakulam and Idukki, the per palm productivity in these districts has been consistantly

on par or even bettern than that of the disease-free northen districts of Trichur, Malappuram, Calicut, Cannanore and Palghat.

District	1971-72	72-73	73-74	74-75
Trivandrum	43	43	43	43
Quilon	40	45	39	37
Alleppey	42	42	35	35
Ernakulam	41	41	37	31
Kottayam	30	30	31	32
Idukki	-	-	44	47
Trrchur	43	43	36	37
Malappuram	34	34	28	29
Calicut	39	39	34	33
Cannanore	25	25	21	22
Palghat	28	28	25	26

An analysis of yield data of 20 diseased (middle and advanced stage of infection) and 20 apparently healthy trees for 28 years made at coconut Research Station, Kumarakom has shown that while the mean yield of healthy palms was 45.0 nuts/palm the diseased palms gave an yield of 39.40 nuts. The yield difference was not statistically significant. The yield data from disease affected districts indicate that even in the presence of disease, the average productivity of palms could be maintained at satisfactory levels.

There is no denying the fact that the gap between the mean yield and potential yield or coconut is very wide where even genetically superior planting materials have been used and the palms have been well maintained by adequate manuring providing irrigation and adopting effective plant protection measures. the palms have given consistantly high yield. Gardens giving 100 to 200 nuts per palm are not uncommon. Super palms yielding 300 to 400 nuts per palm are also not rare. This shows the tremendous potentiality of coconut palms.

Considerable amount of research work on coconut has been done since the last more than half a century and valuable informations on various aspects of crop improvement have been obtained. The information yielded by research has been instrumental in evolving a systematic approach to the problems of coconut production in the country. However many useful research findings are often left unutilised or partly utilised which has resulted in the low productivity of the coconut palms.

Coconut Research in India was started in 1916 with the establishment of 4 research stations on the west cost of the erst-while Madras Presidency whlch now forms part of Kerala State. Of these, two stations were at Nileshwar, one at Pilicode and one at Kasaragod. With the establishment of the Indian Central Coconut Committee, the Kasaragod station was taken over by the Committee in 1947. In 1948 another research station was started at Kayamkulam to intensify research on pests and diseases. The committee also established nine regional coconut research stations in the different coconut growing states of the country. The Indian Central coconut Committee was abolished in 1966 and coconut research was brought under the Indian Council of Agricultural Research.

In 1970 the Central Plantation Crops Research Institute (CPCRI) was established by the I. C. A. R. with headquarters at the Central Coconut Research Station, Kasaragod. The other station at Kayamkulam was made a Regional station of C. P. C. R. I. In order to strengthen and co-ordinate the research on coconut in the country, the I. C. AR. sanctioned in 1971 in All India Co-ordinated Project for the improvement of the crop with headquarters at Kasaragode. Coordinated research in different disciplines has been taken up under this project in 13 coordinating centres located in 8 states, most of the centres being the old Research stations now attached with the Agricultural Universities.

Two of the oldest three research stations which were set up in 1916, one at Pilicode and the other at Nileshwar, were transferred to the Kerala Agricultural University when it came into being in 1972. Coconut Research Station at Balaramapuram in Trivandrum district and Kumarakom in Kottayam district are also now under the Agricultural University.

RESUME OF WORK DONE

Botany

Introduction and evaluation of indigenous and exotic cultivars was first started in 1924 at the Coconut Research Station, Pilicode. In 1940 the open pollinated progenies of these cultivars along with selfed progenies were planted at Kasaragod. Large scale introductions were resumed in 1955 and at present there is a collection of 65 exotic types and 32 indigenous types at Kasaragod and 29 exotic and 34 indigenous types at Pilicode. Studies made so far have shown that Laccadive ordinary,

Andaman, ordinary, Java, New Guina Cochin China, Philippines and Kappadam are high yielders. Compared to West Coast Tall the exotic types gave 30 to 100 percent more copra. The results of studies conducted at Nileshwar relating to six promising types are furnished in table below:

Cultivar	Mean No. of nuts/palm	Mean copra content in gm.	Mean copra out turn per palm per year in kg	Oil percentage
Laccadive ordinary	120	160.0	19.2	72.0
Philippines	84	249.7	20.9	69.0
Java	65	185.5	12.0	70.2
Cochin China	77	226.6	17.4	66.2
New Guinea	82	202.2	16.6	65.6
Laccadive micro	140	81.0	11.3	75.0
West Coast Tall	88	147.4	12.9	70.6

Copra output per unit area is low in India-mainly due to the fact that West Coast Tall, the major cultivar grown in this country produces comparatively small sized nut with correspondingly poor copra output. A slow but steady replacment of this type with the promising exotic and indigenous cultivars through the normal process of underplanting and replanting is definitely a sound approach for stabilising the domestic coconut industry.

We have already succeeded in evolving a few high yielding hybrids like T×D, D×T, . L.O×G and T×G. The earliest work on artificial crossing of the local West Coast Tall as female parent and Chowghat Dwart Orange as the male was done in India in 1932 and the first plantings of the hybrids was done at Nileshwar in 1934. Subsequently hybridization studies were further intensified since 1947. The results obtained from these studies have proved the superior performance of hybrids compared to local cultivars. Under ideal c nditions these start flowering and attain steady bearing early and give high yield. A number of other hybrids involving different parental combinations are under trial at different coconut Research stations.

The need for selection of dwarf male parents in the hybridization programme has been well established from various studies made on the performance of T × D hybrids. Tall × Dwarf green and Tall × Dwarf orange hybrids obtained from the same parents of Tall variety have shown that Tall × Dwarf orange hybrids are superior to Tall × Dwarf Green hybrids. Even among palms, hybrids with certain orange palms have given better performance. This shows the need for selection of male parents in the hybridization programme.

Another significant contribution of research is the establishment of selection/criteria of genetically superior mother palms for raising quality planting material. Detailed studies on the heritability of yield components of West Coast Tall Palms and the correlation between inflorescence characters and the consistency in high yield have produced results of tremendous practical utility. The identification of prepotent palms and their use for *inter se* crossing in the production of planting material has also resulted in great advancement in the development field. The recommendation to restrict mother palm selection to the best 10 percent of the palms in each field for characters such as higher nut production (80 to 100 nuts), higher weight of husked nuts (650 to 700 gm). higher percentage of flower set and large number ef spikes with one or two female flowers on each has contributed substantially to the genetic improvement of palms in the country.

Agronomy

Commendable achievements were accomplished in the field of agronomic research during the last few decades. More notable among these are the findings on the response of palms to fertilizer use and irrigation and also on the economic utilization of interspace in coconut gardens., Adequate and balanced fertilization have given significant yield increases under all soil conditions. The maximum yield increase was observed when efficiency of ferfilizer use was improved through split application. In a trial at Kasaragod, application of annual dose of

fertilizers in two splits resulted in increased nut production by 8.4 percent and copra output by 11.7 percent over single application. The beneficial influence of irrigation either with sweet or saline water, depending on soil conditions, on early flowering and high yield has also been established. The elaborate fertilizer trials conducted in the different states have given constant results and the yield increases reported were 7 to 15 nuts in Kerala, and upto 35 nuts in Tamil Nadu per palm per year. The response to irrigation alone and in combination with fertilizer use was more conspicuous in all centres. The finding that clean weeding by itself will improve the productivity of palms is definitely valuable. At Kasargod, clean weeding could maintain a mean annual yield of over 30 nuts per palm, as against 15 nuts in a neglected plot over a period of years. Regular weeding along with manuring could maintain a yield level of 62 nuts per palm under rainfed conditions.

The trials conducted at Kasargod on intensive cropping in the interspace in coconut gardens through parelled combinations of compatible crops have resulted in phenomenal increase in productivity per unit area of land and unit time. In a crop combination of coconut and cocoa, the additional net income realised from one hectare of coconut holding was Rs. 14,300/- and for a multistoried crop mix consisting of coconut, pepper cocoa and pineapple it was Rs. 17,430/-. The net in-come from coconut holdings could be increased to as much as 300 percent by the adoption of irrigation and by proper crop planning compared to a mono crop of coconut. The productivity of the coconut palm also improves under such a system and the increase recorded in the above experiment was 97 to 136 percent. Another finding of practical importance to the situation in Kerala was the additional employment potential that could be generated in coconut holdings. While one hectare of rainfed coconut under intercropping was necessary to sustain an average family, even half a hectare irrigated holding under high intensity intercropping is adequate for the same purpose.

A detailed trial to find out the effects of growing annual crops on the yield of coconuts and to workout the economics was laidout in the interspace of coconut hoding during 1967 to 1974 at Nileshwar. Intercropping had no deleterious effects on coconut on the other hand, the coconut palms were benefited by the cultural treatments given to intercrops and the nut production increased significantly. The increase ranged from 2.7 per cent to 30.3 per cent depending on the inter-crops grown.

Mixedfarming trials in coconut holdings have also produced useful results of practical value. Fodder grass and legumes grown in one hectare of coconut holding under irrigation can maintain 4 to 5 milch animals and provide full time employment to amedium sized grower family. In one of the trials conducted at Kasargod on mixed farming, it was observed that within a period of about 3 years, the yield of palms increased by 18 percent and the average net income from the experimental plot went up from Rs. 6023/- in pre-experimental period to Rs. 9715/- per year. The labour potential of the mixed faming system was 100 man days assuming full time employment to three adult members of a farmer family.

Plant Protection

The problem of root (wilt) disease has received top priority in the research programme since 1947. It is attached from two angles, evolving measures to control the disease and clearing agro-techniques to improve the productivity of coconut holdings in the disease affected area. Disease condtrol continues to be a baffling problem and has so far eluded all attempts of the research workers. Tolerance or resistance studies with different varieties and hybrids have not yielded any positive results.

Encouraging results have been obtained from various trials conducted to improve the productivity of coconut holdings by intensive utilisation of the disease affected holdings for mixed farming and intercropping. In a mixed farming trial at Kayamkulam where legume fodder is mix cropped with coconut along with the maintenance of milch cattle, the mean yield of palms increased from 31 nuts to 40 nuts with a conspicoues improvement in the general health of palms, particularly the colour of ponds Though symptoms of root wilt disease persisted, the improvement in the soil environment attributable to the recycling of animal wastes, summer irrigation and legume culture could result in sizeable productivity increases even in the presence of disease. The annual net income from one of the experimental area was Rs.1920/- per hectare.

Except in the case of diseases of unknown etiology like root wilt, research has yielded conclusive

results in respect of pests and diseases. The control measures formulated for the major pests and also for the increases caused by fungi and physiological disorders are popular among the coconut growers.

Technological aspects.

Research on the technological aspects of coconut industry, particularly product diversification, has not received adequate attention so far. Some of the research activities initiated in the sixties on mechanical drying of copra and wet processing have slackened subsequently with out adequate exploration. The Krauss - Maffei/CFTRI process which was developed in 1961 and researsh on other edible products from coconut conducted by the Central Food Technological Research Institute, Mysore have not been completed for drawing valid conclusions. Similarly, research on destructive distillation of shells, shell based activated carbon, shell based moulding prodens and mulches and production of coconut oil derivatives has not so far yielded convincing results for commerical exploitation.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

Botany

Selected high yielding cultivars have not been tested for their yield performance under varying agro-climatic conditions of Kerala. So also detailed studies on pest and disease resistance or tolerance have not been made so far except for a few experiments in progress at the Coconut Research Station, Kumarakom. The response of diverse genotypes to varying agro-climatic conditions as well as their resistance or tolerance to various pests and diseases should be studied in detail.

The occurence of very high yielding or super palms have been reported from various places. Some of these palms are reported to produce even upto 24 bunches a year. The genetic make up and the factors which contribute to extraordinary high production of these palms and their heritability as well as their resistance to pests and diseases should be studied. A survey to spot out such super palms should be conducted and they should be subjected to intensive studies.

We have already succeeded in evolving a few high yielding hybrids like T×D, D×T, L.O.×G and T×G. A number of other hybrids involving different parential combinations are under trial at the coconut Research Station, Pilicode. Hybridization programme involving all available cultivars based on definite groupings should be continued to evolve super-palms having resistance or tolerance to various pests and diseases.

We are now recommending certain criteria for selection of mother palms, seed nuts, seedlings etc based on morphological characters. How far these criteria are sound need invesigation since it has been found from the analysis of data of experiments at Coconut Research Station, Pilicode that at least some of the characters recommended for the mother palm and seedling selection are at variance with experimental results. Further intensive studies or criteria including biochemical criteria for selection of mother palms, seed nuts and seedlings should taken up. Selection criteria should be standardised for hybrid seedlings also.

With large scale plantings of hybrids there is every possibility for collection of seednuts from hybrid palms by cultivators for further propagation. Indiscriminate planting of hybrid progenies will result in wide variations in their performance. To obviate these variations to the extent possible, the hybrid progenies should be subjected to detailed studies and defenite guideliness issued regarding selection of seed nuts and seedlings. These progenies may also be studied critically to identify early maturing and disease resistant segregants.

Preliminary studies made on vegetative propagation of coconut have given encouraging results. For rapid multiplication of superior genetic material it is necessary to evolvs rapid propogation techniques. It is therefore suggested that experimental approaches towards vegetative propagation using both naturally occurring propagules such as bulbils and suckers as well as artificial methods like tissue culture should be initiated. Possibilities of using pollen and anther culture for haploid production should also be explored.

AGRONOMY

Providing shade in early growth period of 2 to 3 years and adequate moisture, fertilisers and sunlight have been recognised as critical mangement factors in pre-bearing period of coconut. These are not correctly adhered to by cultivators due to certain bio-physical constraints such as (a) lack of resources for irrigation and non-availability of shade materials; (b)

operational difficulties; and (c) lack of incentive for investments in the absence of immediate returns. Therefore studies should be undertaken on the following lines: (a) Complementary shade plants are to be developed for microclimatic regulation and fertility enrichment; (b) Tillage and other agro-engineering measures are to be evolved to increase the sub soil storage of moisture; (c) Methods of efficient use of irrigation water and mulching practice to be developed for increased water use efficiency; (d) Optimum fertilisers and growth promoting fertiliser supplements to be found out; and (e) Optimum drainage requirements and methods are to be worked out for ill drained areas.

Physiological age and yield status of old palms to take underplanting, spacing and distance from adult palms, optimum period of co-existance of adult palms and underplanted palms, manurial requirements and management practices etc. have not been worked out so far. These informations are very essential for Kerala where more than 50 per cent of gardens have past middle age and are in the senesence stage, Detailed studies on underplanting and their management practices are therefore, necessary.

The present fertiliser recommendations do not take into consideration the yield potential of individual trees in a garden, annual pattern of yield, age of palms, chemical and physical conditions of trees, availability of irrigation, nut number and copra content etc. This results in undermanuring or overmanuring of coconut palms. For fixing up a sound and scientific manurial schedule the following studies should be taken up. (1) Manurial requirements of palms of different yield groups-low, medium and high; (ii) Physiological age group-young, middle aged and old palms, (iii) Soil types and physical condition-major soil types including reclaimed back waters and low lying lands; (iv) Irrigated garden with emphasis on frequency of application ; (v) NPK requirements for "nut number types" and "high copra content types".

Fertiliser trials are mainly conducted in the Research stations at present. Due to high fertility status in the Research Stations no significant results are obtained from these trials. It is therefore, suggested that large scale fertiliser trials may be conducted in the cultivators fields in different agro-climatic regions.

Nutrient uptake and response are poor in diseased tracts. Pending curative treatments the crop is to be sustained and nourished to check the intensity of disease and make them reasonably productive. Proper forms of nutrients, freauency and method of application for better uptake are to be tried.

Prof. Davis has successfully demonstrated root injection and midrib feeding in coconut. Coconut crown where meristamatic growth is in progress and spadix primordia are initiated in succession, the scope of crown application and tissue feeding can be tried. Root injection can also be perfected. This will be of special advantage in problem soils and diseased tracts.

Irrigation responses at arbitary levels only have been assessed. Responses are found to vary with soil types and yield groups. Irrigation methods in small and large holdings as well as where there is ample water supply and limited water supply will have to be evolved. Better management practices including proper drainage in low lying, level and uphill regions will have to be worked out.

Button shedding is a serious problem in coconut. Though certain studies have been conducted previously the causes and remedial measures of this malady have not been fully understood. Detailed studies should be undertaken to understand fully the various factors contributing to abnormal shedding of button and methods to control it

Temporary yellowing in dry periods are observed in sandy soils of Cannanore District. Causes and remedial measures have not been found out. The role of micronutrients in correcting this malady should be studied.

There is need for developing methods of predicting coconut yield from the expected drought index for the year and for reducing by irrigation the possible losses in yield caused by immature nut fall.

Intercropping and multiple cropping in coconut garden have very good impact on coconut growers. But detailed informations on the best crop combinations in varying agro-climatic regions including reclaimed areas, the main crop-intercrop association and their cultural and manurial requirements in irrigated area etc. are lacking. Studies on these aspects should be undertaken.

Informations are available on maintainance of viable units of milch animals in garden having irrigation facilities only. Agrostology for rainfed

gardens and rearing milch animals are to be worked out for different regions. Systematic studies on recycling organic wastes for reducing inputs and cost of production of coconut and mixed crops should be undertaken.

Leaf dropping due to weak petiole is a serious problem in several coconut palms. This results in buckling of bunches and immature nut fall. The genetic and physiclogical causes of this malady require thorough investigation.

Plant Pathology

The most widely prevalent disease of coconut in Kerala is root (wilt) disease. Though research work is in progress on this disease for a pretty long time it still remains to be a disease of unknown etiology. Research efforts should therefore, be intensified to combat this disease by screening all available varieties for tolerance or resistance to the disease, evolving varieties tolerent or resistant to the disease, suitable cultural and manurial practices, mixed cropping and other management practices and also rejuvenation of diseased palms by suitable methods of inducing root development above the bole region.

Bud rot is another serious disease of coconut. The role of bacteria in the incidence of bud rot and its relationship with Phytophthora in causing the disease should be studied.

Stem bleeding is assuming serious proportion. Detailed investigations on this disease requires to be taken up urgenily.

Leaf rot is another disease assuming economic importance which requires to be taken up for detailed investigation.

Entomology

The damages caused by red palm weevil (*Rhynchophorus ferrugineus F)* to coconut palms are enormous and as such it is necessary to investigate control measures against this pest. The possibility of employing chemosterilants for the control of red palm weevil along with intensifying work on parasites and predators should be studied.

Work on using viruses, nematodes etc. for the control of rhinoceros *(Oryctes rhinoceros L)* should be intensified.

Work on biological control of *Nephantis serinopa* should be intensified. In the meanwhile, this pest may be controlled during summer months by using isecticides.

An integrated project should be developed for controlling rats in coconut gardens which is posing a serious problem.

Cock chafer beetle grubs *(Neucopholis concophora)* has become a severe problem in coconut garden. Studies on measures to control this disease should be intensified.

Prevelence of plant parasitic nematodes in the coconut gardens in Kerala has been reported by several workers. But we have no precise knowledge of plant parasitic nematodes associated with coccnut palms. With the popularisation of intercropping and multistoreyed cropping systems in coconut garden the influence of injurious nematodes may be aggrevated. Therefore, the following nemotolocial investigations require to be undertaken.

a) Survey of different coconut soil types for the plant parasitic nematodes and their role in the productivity of such palms.

b) Seasonal population fluctuations and their abundance in coconut gardens with and without intercrops, in differnt soil types.

c) Sruvey of coconut tracts where palms show seasonal yellowing for the presence of plant parasitic nematodes and their role in that matter.

Chemistry

The influence of different nutrient elements on the vegetative and yield attributes like leaf production, nut size, copra content, oil yield etc. have not been studied in detail. These studies should be taken up evolving a judicious manurial schedule for coconut.

The role of micronutrients in the nutrition of coconut palms especially in root (wilt) disease affected areas need further investigation.

The association and interrelationship of Physico-chemical and biological characteristrics of coconut soil intercropped with cocoa and other intercrops should be studied in detail.

Leaf analysis may be standardised as an index of fertiliser requirement.

Detailed studies are to be undertaken to evaluate the effect of hormones in influencing the yield attributes of coconut.

Technological aspects

Though India produces above 350,00 tons of copra annually, the common processing technology adopted is either sun drying or sun drying combined with smoke drying. The introduction of various types of indirect dryers has not produced useful results mainly on economic considerations. Suitable mechanical devices using cheap fuel will be of use for modernising the coconut industry at the grass root level. The processing of coconut is defenitely attractive if the unit operations could be brought to the minimum and diverse applications for the end products are developed. A comparative assessment of the technology now available Krauss-Maffei/CFTRI process, Texas A & M University process, TPI process and modified solvel process developed in India-could be made and research pursued for bringing in refinements and developing a suitable technology for commercial use. The economics of producing and marketing non-edible derivatives of coconut oil like fatty acids, fattyalcohols, fatty esters and glycerine has to be studied in view of the fact that more than thirty chemical intermediates made from coconut oil derivatives are currently in demand in the surfactant industry. The technological support for the manufacture of activated carbon from partially carbonised coconut shell and for the manufacture of shell flow is inadequate. Suitable technology for the preservation of coconut cream and for the use of skimmed milk and coconut water for various food uses can be of great advantage to the accelarated development of coconut industry in the country.

B. ARECANUT

INTRODUCTION

India is the biggest producer of arecanut with an area of about 1,74,200 hectares and an annual production of 14,700 tonnes. The important arecanut growing states in the country are Kerala, Karnataka, Assam, Meghalaya and Tamil Nadu. With an area of about 68,356 hectares and production of 11303.00 million nuts Kerala leads the rest of the states both in area and production.

The area and production of arecanut in 1976-77 in different districts of the state are given below.

District	Area (Ha.)	Production (million nuts)
Trivandrum	4056	481
Quilon	6866	753
Alleppy	3156	311
Kottayam	3258	289
Idikki	1236	113
Ernakulam	6444	994
Trichur	9668	1884
Palghat	1936	333
Malappuram	10934	2293
Kozhikode	7781	1677
Cannanore	12994	2176
	68456	11303

Cannanore leads in area closely followed by Malappuram and Trichur. In production Malappuram district stands first with Cannanore and Trichur coming next.

In recent years a declining trend is seen both in respect of area and production of arecanut largely due to the fall in prices and also due to the dreaded yellow leaf disease. The area and production of arecanut in Kerala from 1970-71 to 1976-77 are given below.

Year	Area(Ha.)	Production (million nuts)
1970-71	85S20	12738
1972-73	88630	13136
1673-74	90700	13459
1974-75	93040	13777
1975-76	76620	11387
1976-77	68360	11303

India has been traditionally an arecanut growing country. At the time of partition of the country in 1947, nearly 50 per cent of the total area under arecanut was in the East Bengal region (now Bangladesh). Since the production was insufficient to meet the local demand large quantities of arecanut were imported from other producing countries like Sri Lanka, Malayasia etc. Simultaneously, intensive efforts were made to increase production within the country. Due to the implementation of a number of developmental measures by the State and Central Governments, the production in almost all producing states increased stage by stage and imports were gradually reduced.

The restricted import policy followed by the country and subsequent stoppage of imports enabled the arecanut growers to get economic price for their produce for a number of years and this acted as an incentive for further increase in production. However, towards the end of 1971, there were indications of a fall in prices of arecanut. The situation became worse in 1972 and towards the end of the year, arecanut prices were reduced to nearly half of what they were during 1960-70. Though there is some improvement in the price situation in recent years it is not advisable to devote any additional area for arecanut mainly because the prospects for developing export markets and alternative uses of arecanut are very limited. It seems that the chewing habit is also tending to decrease with the people at large. The main accent therefore, is on increasing production by adopting improved cultural and manurial practices and also enhancing the income per unit area by adopting scientific intercropping in arecanut gardens.

Research work on arecanut in India was started only in 1956 with the establishment of the Central Arecanut Research Station, Vittal (now known as Central plantation Crops Rasarch Institute, Regional Station). Previous to that an Arecanut Research Station at Marthur in the Mysore State was started mainly to investigate disease problem of arecanut especially 'Koleroga' or 'Mahali'. But unfortunately before anything tangible could be done it was closed down. The Indian Central Arecanut Committee which was constituted in 1947 appointed an Agricultural officer for conducting an all India Arecanut survey. It was on the basis of the recommendations of the committee that the Arecanut Research Station at Vittal in South Kanara district was established. Subsequently sub-stations were started at Peechi and Palode in Kerala State. Under the All India Coordinated Coconut and Arecanut project arecanut research is in progress at Siorsi, Arsikere, Hirehalli, Dharwar and Thirthahalli all in Karnataka, Dapol (Maharshtra), Koothali (Kerala). Sakhigopal (Orissa).

RESUME OF WORK DONE

Botanical aspects

Improvements in the cultivars of *Areca* have been affected mainly through introductions, refinements in selection techniques for mother palms, seed nuts and seedlings. Hybridization has also been undertaken in recent years.

The Regional Station, Vittal has introduced 6 species and 34 cultivars of *Areca* begining from 1957 from Sri Lanka, the Philippines, Indonesia, Singapore, Malaya, Fiji, Solomon Islands, Mauritius etc. Based on comparative yield trial of 17 exotic cultivars introduced in 1961, one accession each from China (VTL-3) Indonesia (VTL-11) and Singapure (VTL–17) and two from Saigon (VTL-12 and 13) have been found; 15 yield 20 to 75 percent more than the local cultivar. Among them VTL-3 has been released for general cultivation under the name Mangala. It is semi tall, early bearing and yields about 75% more than the local type.

Among 17 cultivars of *A. catechu* collected from within the country, 'Thirthahalli' and Mohitnagar have given uniformly higher yield over the local cultivar during the previous 5 years and are in advanced stages of yield trial.

Regularity of yielding behaviour of the mother palm has no relation with the progeny performance. Heritability for yield in arecanut is very low (0.20) and hence no improvement in yield could be achieved by selection giving emphasis to this character. Among various characters analysed age at first bearing above was found to have high heritability and correlation with yields.

With respect to seedling section it was established that the number of leaves at the time of planting, girth at collar one year after planting and number of nodes two years after planting have high heritability and genotypic and phenotypic correlation with yield.

Hybridization work to combine various desirable characters in the hybrid progency has been undertaken. The hybrids obtained from the crossings are under observation at the Regional Station, Vittal.

A selection index based on two seedling characters ie. number of leaves and height have been worked out. Seedlings with higher value can be obtained by selecting seedlings with maximum number of leaves and minimum height as per formula. (No. of leaves $\times$ 40) — height).

Agronomical aspects

For the successful establishment of the seedlings and performance of young palms, two factors viz., drainage and protection from sun-scorch are very important besides proper and timely manuring and irrigation during dry weather period. Experimental evidence is that annual application of 100g nitrogen, 40g phosphoric acid and 140 g potash in the form of fertilizers and 12 kg each of green leaf and compost per bearing palm is necessary for the optimum yield. The fertilizers may be applied in two split doses during September-October and February and green leaf and compost in single dose in September-October.

For higher yields the palms are to be irrigated once in 3 to 6 years depending upon the soil type. In an experiment conducted at CPCRI, Sub-station, Kannara it is found that irrigation once in three and six days interval gives 229% and 168% more yield (Wt. of fruit) than on irrigation.

Intercropping in arecanut garden has been found to be very successful. The crops which can be grown successfully in arecanut gardens without detriment to arecanut yield are banana, ginger, elephant foot-yam, pepper, betel vine, guinea grass, pineapple and cocoa.

Plant Protection

Effective remedial measures have been found out for most of the pests and diseases of arecanut. 'Mahali' or fruit 'rot' (Koleroga) which causes heavy damage to nuts can be prevented by spraying 1% bordeaux mixture twice—one in May—June just before the onset of monsoon and second in July—August (40 days after the first).

The disease which of late has become very serious is the yellow leaf disease. This is a serious malady taking a slow but heavy toll of the palms in Southern Kerala and some parts of Karnataka. Palms of all ages are affected. The firt visible symptom is yellowing. The yellowing progresses along the leaf margin and is interspersed with green stripes. In advanced stages, necrosis of lamina takes place and crown size is reduced. The tips of feeding roots turn black. The kernel is often backened and yield gradually declines. The etiology of the disease is not well understood.

Technological aspects

Arecanut is mainly used for chewing purpose. It is consumed both in raw stage and after processing.

In different states different types are used for chewing. Fresh ripe arecanut, dried ripe nut, Kalipak, Scented supari etc. are some of the forms in which it is used. Even in these forms there are large number of variations which go by different names. Because of the increase in production and consequent fall in prices, efforts are being directed to find alternate uses for arecanut by separating various chemical constituants and putting them to specific uses, such as Polyphenols for fanning, alkaloid for medicinal purposes and fat for consumption or soap making. However, despite some fall in price of arecanut, it is still quite too high to utilise arecanut as a raw material for such technological purposes.

3. Research gaps identified and future line of work

A lot of research results are available for increasing the production of arecanut. The main problem of arecanut at present is the dreaded yellow leaf disease. The disease is causing serious damages in almost all the arecanut growing areas. Detailed investigations on this disease is of immediate importance.

Since income from arecanut crop has gone down in recent years, methods to maximise income per unit area of arecanut garden should be investigated. Intercropping and mixed cropping have been found to be very successful. The most remunerative companion crops in arecanut garden under different agro-climatic regions require to be evolved.

Arecanut is at present used only for chewing purpose. The chewing habit is showing a declining trend as a result of which demand for arecanut is also getting reduced. Therefore it is very necessary to find out alternative uses for arecanut. So also industrial uses for various other parts of arecanut should also be found out.

3. CASHEW

INTRODUCTION

Cashew growing and Cashewnut processing occupy a high place of importance in the economy of the State. The export earnings from the sale of cashew kernels and cashew shell liquid were over 100 crores of rupees in recent years. The cashewnut processing industry gives direct employment to about 1.5 lakhs of persons. These factories require about 4.5 lakh tonnes of rawnuts, if they are to work throughout the year. As against this, the indigenous production is only about 2 lakh tonnes; the rest being imported from African countries. With the establishment of mechanical processing factories in some of these producing countries, the import of raw nuts has become inadequate and difficult. Unless the indigenous production of rawnuts is stepped up by 2 to 2½ lakh tonnes in the next five years, this vital industry will not be able to surivive for long.

Accurate statistics on the above matters are not available. According to the Raj Committee report, the area, production and productivity of cashew in India during 1973-74 were as given below :-

Table 1. **Area, Production and mean yield of cashewnut in India, 1973-74.**

State	Area Hectares	Production MT	Mean yield/hect. (kg)
Kerala	1,03,000	1.16,000	1126
Karnataka	96,000	36,000	375
Tamil Nadu	93,000	13,000	140
Other states (AP, Orissa, Maharashtra and Goa)	1,28,000	28,000	219
Total	4,20,000	1 93,000	460

Eventhough the above level of productivity in Kerala is high as compared to that in the other cashew growing states in India, the present level of productivity is far below the yields obtained from some of the selections and hybrids in our research stations. A sample survey on the area and production of Cashewnut in Kerala, conducted by the Bureau of Economics and Statistics during the three year 1971-1974 showed that the average yield per bearing tree was 4.88 kg. 3.89 kg. and 3.9 kg. respectively. The district-wise area and production of cashew during 1975-76 are given in table 2.

Table 2. **District-wise area, production and productivity of cashewnut in Kerala 1975-76.**

	Area in hectares	Production in tonnes	Average yield kg/ hectare
Trivandrum	4468	5013	1122
Quilon	8692	9752	1212
Alleppey	3617	4058	1122
Kottayam	1334	1497	1122
Iddukki	1957	2196	1123
Ernakulam	3974	4459	1122
Trichur	6794	7623	1122
Palghat	9051	10155	1122
Malappuram	14391	16147	1122
Kozhikode	5847	6560	1122
Cannanore	45819	51409	1122

Export of cashew kernels and Cashew shell liquid from India and the import of raw-nuts to India during the period 1973-74 to 1977-78 are given in the Tables 3 and 4 below:

Table 3. **Export of Cashew kernels and Cahew shell liquid from India.**

Year	Cashew kernels		CNSL	
	Quantity in MT	Value in Rs.(000)	Quantity (MT)	Value Rs.(000)
1973–74	52293	744322	3846	4961
1974–75	65025	1181373	6696	16684
1975-76	50640	981328	not available	
1976–77	57565	1059660		
1977–78	39111	1476121		

Source: Directorate of Cashewnut Development, Ernakulam.

Table 4. **Import of raw cashewnut to India during 1974-75 to 1977-78**

Year	Quantity in M.T.	Value Rs.(000)
1973-74	180249	2,87,985
1974-75	160636	1,50 603
1975-76	137196	3,35,578
1976-77	74137	1,80,800
1977-78	60194	1,57,189

Source: Agricultural Statistics in Kerala. Directorate of Extension Education.

Resume of work done

Research on cashew in India was initiated in 1951 when the ICAR sanctioned a scheme for this, under which a central Cashew Research Station was established at Ullal in Karnataka State, with regional stations at Kottarakkara in Kerala, at Vengurla in Maharashtra and at Bapatla in Andhra Pradesh. When the ICAR withdrew its financial participation for the scheme at Kottarakara the State Government started a Cashew Research Station at Anakkayam in 1963. In 1972, a sub centre under the All India Co-ordinated Spices and Cashewnut Improvement Project was sanctioned at Anakkayam/Mannuthy. The research work done in these centres so far, and the work in progress are briefly summarised below:-

Survey, selection and testing of varieties formed important items of work from the very beginning of the projects. At present, there are 90 types in the germplasm collection at Anakkayam and 69 types at Mannuthy. Based on the performance of the types at Anakkayam during the past 14 years, 14 types which have given a mean yield of over 10 kg. nuts during the last five years, have been identified. Two of these types, BLA.139-1 and K-22-1 have been recommended for pre-release multiplication by the workshop held at Coimbatore in 1975. The 12 promising selections along with some hybrids are now put under comparative yield trials at Anakkayam and Mannuthy. Another yield trial with 4 best types from each of the research stations at Anakkayam, Vridhachalam, Baptla and Vengurla has been laid out at Mannuthy in 1973.

Detailed studies on the floral biology of the crop were undertaken at the Cashew Research Station, Kottarakara in 1961-62. Hybridization between selected types was started in 1963 and the first batch of 50 F1 were under evaluation during the past 14 years. Among these, H-3-17, H-1-4, H-4-7 and H-3-13 have been found to be promising and these are included in the comparative yield trials for further testing. Besides these, 191 hybrid progenies from 12 parental combinations and 114 hybrid progenies from 10 parental combinations have been planted at Anakkayam and Mannuthy respectively for evaluation and selection.

A trial conducted at the Cashew Research Station, Anakkayam, using selfed, crossed and open pollinated seedlings from the same mother tree showed that hybrid progenies are more vigourous than the other types of seedling progenies, followed by seedlings from open pollinated seedlings.

Studies on the best method of propagation of cashew were undertaken from the very inception of the research projects at different centres. The main findings of these trials are as follows:-

Dwarf-bush plant with intensive branching, giving an annual yield of not less than 10 kg of nuts per year, producing high percentage of perfect flowers and good fruit set, having a short flowering phase, medium nut size and high shelling percentage are important indices in the selection of mother trees.

In seed propagation, sowing the seeds 3-4 cm deep with the stalk end up has been found to be helpful in the development of the tap-root.

Under bin storage, the viability of seed was below 50% after 6 months storage.

92% of the water-sinking nuts germinated within 14-17 days while only 64% of the water floating nuts germinated within 14-22 days.

Only 8% of the transplanted seedling without cutting back survived, while 72% survived with 8" of the shoot and 4" of the root cut-back.

Among the vegetative methods of propagation, airlayering done during January to April gives 80-100% rooting.

Use of IAA at 250 ppm had a beneficial effect in increasing the number and length of roots in air-layers.

Age of parent tree had apparently no effect on the rooting percentage, but non-flowered shoots gave higher rooting as compared to flowered shoots.

There were no significant differences between the 4 rooting media tried-viz,. sand and saw dust, wood shavings and vermiculite, coarse and fine.

Layers from thick shoots were more vigorous in growth during the first year of planting.

Defoliation of air-layers, two weeks prior to separation had a beneficial effect on survival and establishment of the air-layer.

Study of the root-system of 6 month, 1 year, 2 year and 3 year old layers and seedlings showed that the layers had a better root system than seedlings of the same age group.

A comparative yield trial of seedlings, layers and grafts, laid out at Ullal in 1959 showed that the cumulative yield from 1960-71 was 17001 nuts from seedlings, 47667 from layers and 44908 from grafts.

Inarch grafting gave 80—100 per cent success at Kottarakara when it was done from July-October.

At Vengurla, budding was successful from July to October and Veneer grafting on two month old seedlings stock from July-September. Side grafting gave 72% success in August.

At Mannuthy 92% success in side grafting and 66% success in budding were recorded in July.

A spacing-cum-manurial-cum-mulching trial laid out at Vengurla showed that a spacing of 7.2×7.2m. gave the highest yield. For the levels of N applied (25 kg/ha and 50kg/ha), the response was linear.

A trial laid out at Vridhachalam indicated that application of 600g. N. along with 25 kg. of F. Y. M. significantly increased the yield, while there was no response without N.

Another trial laid out in bearing plants at Kasaragod indicated a linear response to N (100,300, 500 g/tree), while there was no difference among the levels of P (75, 150, 225 g/tree) and K (100, 300, 500 g/tree).

The economics of fertilizer application and plant protection measures as revealed by the results of Demonstration plots laid out under the Cashew Development Project are given in Table 5.

Table 5. **Economics of the respones of Cashew to Fertilizer and spraying carried out in demonstration plots from 1970—71 to 1973—74.**

	State/District	No. of years for which data are available	Increase in yield/acre (kg.) Rs.	Value at 75-76 prices Rs.	Incremental cost/acre Rs.	Incremental return per acre 4-5	Average incremental return per year 6/2
	Kerala						
1	Cannanore	4	527	1,318	1,160	+ 158	+ 40
2	Calicut	4	743	1,858	1,160	+ 698	+ 175
3	Malappuram	4	789	1,973	1,160	+ 813	+ 203
4	Trichur	3	408	1,020	870	+ 150	+ 50
5	Alleppey	4	729	1,823	1,160	+ 663	+ 166
6	Quilon	3	394	985	870	+ 115	− 38
7	Ernakulam	3	601	1,503	870	+ 633	+ 211
8	Trivandrum	2	477	1,193	580	+ 613	+ 307
9	Palghat	3	757	1,893	870	+ 1,023	+ 341
	Andhra Pradesh						
1	Visakhapatnam Anakappalli	2	279	698	580	118	+ 59
2	West Godavari Eluru	3	438	1,095	870	+ 225	+ 75
3	East Godavari Kakinada	3	464	1,160	870	+ 290	+ 97
	Goa						
1	Ponda	3	588	1,140	870	+ 600	+ 300

Note: Both the cost of fertiliser and value of oltput were worked out at 1975 prices.

Source: Report of the Committee on Cashew cultivation (1976) Page. 25 (ICAR).

Trials of foliar application of urea, conducted at Kasaragod, Vridhachalam and Bapatla did not show significant response.

Trials with NAA, IAA and 2,4-D sprayed twice during the fruitsetting period significantly increased the yield in treatments with IAA-50 ppm and NAA-10 ppm. Similar trials at Vridhachalm showed maximum response to IBA-70 ppm, followed by Planofix (NAA-30 ppm).

Trials at Vittal showed maximum fruit-set with 2 sprays of NAA-10 ppm, followed by single spray of 2,4 D-10 ppm and single spray of IBA-25 ppm.

Blossom Blight and 'Die-back' are the most serious maladies causing crop losses of 30 to 40 percent. Studies at Kottarakara clearly established that these maladies were caused by the attack of Tea mosquito *(Helopetis antonii)*. Trials at Anakkayam on the Insecticidal control revealed that spraying of DDT (0.2%) or Sevin (0.1%), two or three times, during the flowering season was effective. The recommendation from the CPCRI is to spray Endosulfan at 0.05%.

A detailed list of pests of cashew, their life history and control measures are contained in the Technical bulletin M. 7 published by the Andhra Pradesh Agricultural University. An exhaustive review of pests of Cashew and their control has been published by Pillai *et. al* (1978) (J. Plant. Crops *4* (2) : 37-50).

Research gaps identified and future line of work.

i The superior types isolated in Research Stations have not been tested in different locations. Their performance in sandy coastal area have to be studied. These should be simultaneously multiplied clonally so that sufficient planting materials of the selected types will be available for distribution to growers by the time the testing is completed.

ii. Breeding programme may be intensified to evolve varieties having the following attributes:- Drawf plant form, intensive branching, early and short flowering phase, high sex ratio, good setting percentage and medium nut size.

iii. The most offective method of vegetative propagation should be standardised for different locations.

iv. The performance of layers, veneer grafts or side grafts and budded plants should be compared.

v. Clonal progenies of the superior types and hybrids should be planted in seed orchards to produce clonal seed or elite seed.

vi. Studies on nutrition should be undertaken both in the Research Station and in cultivators gardens.

vii. Trials to determine the optimum spacing, including the economics of high density planting and subsequent thinning out should be taken up.

viii. A pilot study on the economics of replanting may be taken up immediately with a view to carrying out replanting programme to improve the genetic stock in the existing gardens.

ix. Trials to determine the optimum cultural practices should be initiated.

x. The intercropping possibilities in cashew gardens have to be investigated.

xi. Important pests and diseases of the crop have to be studied and control measures evolved.

xii Economic utilisation of cashew apple has to be investigated. Research projects on some of the above problems have been initiated and the remaining problems will also be taken up soon.

4. SPICES

A. CARDAMOM

INTRODUCTION

Cardamom (*Elettaria cardamomum* Maton) is an important and highly valued spice crop of India, ranking next to pepper in our export trade. Sri.Lanka, South and North Vietnam, Laos and Cambodia are other important Cardamom growing countries in the world. It is also grown to a limited extent in Thailand, Guatemala and El Salvador. In India, Kerala has the largest area under Cardamom, followed by Karnnataka, Tamilnadu and Sikkim. The crop is grown in higher elevations in the above states ranging from 600-1300 metres.

During the year 1977-78 a quantity of 2707 M. T. of cardamom valued at Rs. 46,47,11,000 were exported from India. According to the statistics available for the year 1975-76 the area under Cardamom in Kerala was 55,180 hectares and the production was 2048 tonnes. The yield per hectare is estimated at 44.7 kg only in Kerala as against 61.6 kg in Karnataka. However, there are estates in Idduki District, getting a yield as high as 200 kg. of cured Cardamom per hectare. Even-though, such high yields cannot be expected in the major parts of the Cardamom growing areas in the state, it is certainly possible to increase the present level of production substantially by adopting scientific methods of management of this important crop.

The main reasons for the low level of productivity in the existing cardomom plantions in the state are indicated below:-

i) Being a native of the hilly regions of South India, it grows very well in a wild state and until recent years, no attention was bestowed on its culture.

ii) The existing plantions were raised from un-selected wild plants and, therefore, the majority of the existing populations are of poor genetic stock.

iii) In many estates, the plant density is low. No recommendations based on research results are available on the optimum plant density.

iv) Definite recommendations on the nutritional requirements of the crop are not available.

v) The high yields obtained in some estates are from areas where the rainfall is well distributed or where sprinkler irrigation is possible.

vi) Incidence of serious diseases like 'Katte' and pests like 'thrips' are responsible for serious loss of the crop.

vii) The most effective and economical method of curing of the crop is to be standardised.

RESUME OF WORK DONE.

Eventhough some ad-hoc research schemes on Cardamom were undertaken from 1944, systematic work was undertaken only from 1956 when the Cardamom Research Stations were set up at Pampadumpara in Kerala and Mudigere in Karnatake state. The important research findings from the work at these stations are summarised below:-

i) Kanni Elam is suitable for lower elevations (600-900 M) 'Malabar' variety for intermediate elevations (900-1200 M) and 'Vazhukka, and 'Mysore' for elevations above 1200 M.

ii) Seed propagation is preferable to vegetative propagation for large scale production of planting materials and to eliminate the chance of transmitting serious diseases like 'Katte'.

iii) **Nursery practices;** Select fully ripe capsuls and sow the seeds as early as possible. Provide thatched sheds for shade and sow them shallow at about 900 seeds per sq.m etre. Keep the soil moist and transplant to the second nursery when the seedlings are oneyear old.

iv) There is positive correlation between the number of tillers and the available P and K in the soil.

v) Planting in July-August at 15-25 cm depth was best.

vi) Planting 20-21 months and 40 45 months old seedling in the main field gave the highest yields.

vii) Application of fertilizers at 15 and 25kg N, 15 & 30 kg of P and 20 and 30kg of K per hectare did not show any significanticant difference in yield.

viii) Liming at 0, 300 and 600g per plant did not give increased yields.

ix) An irrigation trial at Pampadumpara gava highest yield in the un-irriagated plots, even-though there was flowering all the year round in the irrigated plots.

x) Among the three spacings tried, (2m × 2m, 3m × 3m and 4m × 4m) the closest spacing gave the highest yields.

xi) Inter-cropping in Arecanut gardens up to 700m. elevations was found to be profitable and successful.

xii) Mulching was found to be the most important cultural operation in Cardamom plantations.

xiii) 'Katte' disease is the most serious one, against which none of the types or varieties available in the germplasm collection are resistant.

xiv) Thrips is the serious pest which can be controlled by different insecticides.

xv) At Mudigeve, a few high yielding selections have been identified and these are being evaluated in Comparative yield trials. At Pampadumpara type No. 17 alone has been selected as superior among the available collections. Beside, six promising lines from the poly-cross nursery are being evalueted.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK:-

i) Eventhough a few superior types have been identified in the research station, these have not been tested outside the research station in adequate measure.

ii) Simultaneously with varital testing, rapid methods of vegetative multiplication of the promising selections has to be standardised.

iii) The study on spacing showed that 2mx2m gave the highest yield. Closer spacing was not included in the trial.

iv) The nutritional requirements of the crop have to be studied in detail.

v) The shade required in different stages of growth has to be worked out.

vi) Varieties resistant to the serious pests and disease have to be developed by selection or breeding.

vii) Post harvest handling, curing and storage of the produce have to be standardised.

viii) Intensive studies on the pests and diseases of the crop and their control measures have to be determined.

ix) Eventhough the irrigation trial conducted at Pampadumpara did not give increased yields, it was reported that irrigated plants flowered all round the year. The possible reasons for not getting additional yields from the off-season flowering have to be found out.

Suitable projects to tackle the problems indicated above have to be drawn up and implemented for the development of this highly valued "Queen of Spices".

B. PEPPER

INTRODUCTION

Among the perennial spice crops grown in Kerala, Pepper ranks first in importance. The area under pepper in the state is estimated at 1,17,500 ha. and the total production, 27564 MT. (1975-76). The districtwise area, production and productivity during 1975-76 are given below:

District	Area (ha)	Production	Average yield/ha (kg)
Trivandrum	4050	863	213
Quilon	15353	5220	340
Alleppy	4393	619	119
Kottayam	16606	5048	304
Iddikki	5959	1299	219
Ernakulam	9778	1643	165
Trichur	4325	696	161
Palghat	629	108	172
Malappuram	5966	1080	181
Kozhikode	20487	4814	235
Cannanore	29970	6174	209
Total	117516	27564	

A major part of the pepper produced in India is exported. During the year 1976-77 and 1977-78, the following were the details of export of pepper from India.

Year	Quantity	Value
1976-77	20,206 M. T.	37.63 crores
1977-78	25,250 ,,	50.05 ,,

RESUME OF WORK DONE

A germplasm collection of 72 types have already been assembled at the Pepper Research Station, Panniyur and 76 types at Mannuthy. These are under evaluation for their economic characters. Work on describing these types and classification has been started at the Pepper Research Station, Panniyur in collaboration with the botany Department of the College of Agriculture, Vellayani.

The first high yielding variety of hybrid pepper was released and is now extensively grown in all the districts of the state. A large number of seedlings raised from open pollinated seedlings as well as hpbrids were raised and these are being tried. Comparative yield trials of promising varieties are in progress at Panniyur, Pilicode and Mannuthy.

A trial on dead and live-standards has been laid out at Mannuthy recently. A similar trial using concrete posts has been laid out at the CPCRI, Kasargod. Propagation from different types of shoots (basal runners, lateral shoots, hanging shoots) have been tried and the most effective nursery technique has been determined; but the productivity of the plants raised from these types of materials has not been studied. Cultural practices suited to Cannanore district have been studied, but these may not be suitable for other areas. Studies on shade regulation have been made. Not much information is available on the nutritional requirements of the crop. Trials on these aspects have been started recently. Spike-shedding is another serious problem in pepper, which needs detailed studies. Trials to find out whether spike-shedding can be controlled by Plant Regulator sprays have been started recently.

'Pollu' is the most serious pest, on pepper. The biology of this pest, mode of attack and control measures have been studied.

'Quick wilt' is a serious disease on which considerable amount of research has already been done, but effective control of the disease is yet to be achieved. From the trials conducted, it has been found that timely application of Bordeaux mixture can effectively control this disease. 'Pollu' caused by a fungus is a serious problem in certain years. Effective control measures are under study. The 'slow-wilt' of pepper is another disease, the cause of which is still not understood clearly. Nematodes are suspected to be the prime cause. This is being studied in greater detail.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

From the fore-going review, it may be seen that the more important aspects of growing this crop have either been studied or are under study in the trials in progress. However, the following problems need further investigations:

i) **Survey and collection:** All pepper growing regions in the country may be surveyed with a view to collect more types, (including wild forms) so as to evolve better yielding, resistant, varieties. Introdution of exotic varieties may also be undertaken.

ii) Description of the existing types in the germplasm collection with a view to identifying superior varieties suitable for cultivation.

iii) Varieties possesing resistance to major pests and disease are lacking. Varieties suitable for different agroclimatic zones in the state and for different soil types are yet to be identified.

iv) Nutritional studies for different varieties and varying soil conditions are to be taken up.

v) The best mixed cropping pettern, for this crop is yet to be derermined.

vi) The control of Pollu, Slow-wilt and quick wilt needs further investigation.

vii) The causes of spike shedding and its control are to be investigated.

viii) The post-harvest handling and processing need intensive study.

Suitable projects to tackle these problems are to be formulated and implemented in the next plan period.

C. GINGER

INTRODUCTION

Among the annual spice crops in Kerala ginger is the most important. It is used for flavouring of food products for medicinal purposes. India is the largest producer and exporter of ginger accounting for about 50% of the world trade in ginger. 9465 M. T. of ginger valued at 13.644 crores was exported from India. Apart from dry ginger, ginger oil and ginger oleoresin are also exported from India.

Ginger is cultivated over an area of 12.140 ha. in Kerala, the district-wise distribution being as given below:

Table

District	Area in ha.	Production (MT) (Dry)	Productivity kg/ha
Quilon	214	515	2397
Kottayam	3265	9988	5059
Idikki	1051	2262	2154
Ernakulam	822	1956	2380
Trichur	76	78	1027
Palghat	907	1461	1611
Malappuram	1855	2812	1516
Kozhikode	3519	8463	2448
Cannanore	431	989	2284
Total	12140	28524	

It may be seen from the above that the highest average yield obtained is only 3057 kg. of dry ginger per hectare. However, even this yield is far below the yields obtained in varietal trials conducted in our research stations (30,000 kg. green ginger/ha.)

RESUME OF WORK DONE

A germplasm collection of 30 types obtained from abroad have been built up and their performance evaluated. Varietal trials show that varieties Rio-de-janiero, Maran etc. give very high yields. Studies on seed rate, weight of seed bits, spacing, time of planting, cultural and manurial trials etc: have been conducted and useful results have been obtained.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

i) The varieties studied so far, though giving high yields, possess some undesirable characters like high fibre content, low oil content low recovery of dry ginger etc. Better varieties, possessing most of the desirable characters have to be evolved.

ii) In the major producing districts, ginger is grown as a pure crop. In perennial crop production, intercropping and multiple cropping are becoming more popular, as it is more paying. Ginger is adaptive to the above cropping systems. Technology of ginger growing under these systems needs detailed studies in all aspects of crop production.

iii) Green leaf mulching is essential for getting good yield from ginger. Since green leaf for mulching is becomming very scarce, alternate mulching materials have to be found out.

iv) The effect of nutrients (NPK) on quality of ginger has to be studied to determine the optimum manurial levels.

v) Ginger is now grown as a rainfed crop. Some studies have indicated better crop in ginger under irrigated conditions. The agronomic practices to be adopted for an irrigated crop of ginger are worth studying.

vi) Soft rot is the most serious of ginger. Effective control measures against this disease have to be found out.

vii) *Aspidiotus hertu* infesting ginger rhizomes, *Dichocrocis punctiferalis* and rhizome maggot *(Calobata sp)* are serious pests of ginger. Effective control measures against these pests have to be evolved.

D. TURMERIC

INTRODUCTION

Eventhough turmeric is considered as a minor spice, it is an important one, which is used daily in our dietary preparations. It has medicinal value. In foreign countries, it is used as a food colouring material, for which the curcumin content is important Apart from *C. longer*, another species, *C. aromatic* which has a lower curcumin content is also grown to a limited area in India. During 1977-78,9319 M. T of turmeric valued at 1.81 crores of rupees were exported from India.

This is a minor spice crop grown in Kerala-the area under cultivation being 4270 ha. and the production,4260 MT. The average yield is about 996 kg. perhectare.

RESUME OF WORK DONE

Excepting for the collection of some varieties and testing for yield, practically no research work on this crop has been done so far in our state.

RESEARCH GAP IDENTIFIED AND FUTURE LINE OF WORK

Almost all aspects of production and processing of this crop need investigation. The following studies are proposed.

1) Germplasm collection and evaluation.
2) Nutritional studies to determine the optimum level of fertilisation.
3) Mixed cropping with other root crops with a view to studying the effect of turmeric on the control of rodents.
4) Determination of effective and economic methods of processing turmeric.
5) Determination of the 'curcumin' conten in different varieties.

INTRODUCTION

Tree spices such as nutmeg, clove and cinnamon are crops quite suitable to be grown under Kerala conditions, especially as an intercrop in coconut gardens. The demand for spice products is increasing, both for internal consumption and for export.

Considering the importance of these crops, the ICAR had sanctioned certain research schemes on these crops. The former Madras State initiated some research work at Kallar and Burliar Fruit Research Stations in 1955. Research work was also initiated later at the Regional Spices Research Station, Chethalli (Karanataka State) Recently a few research programmes have been initiated at the Kerala Agricultural University Campus, Vellanikkara and at the Spices Research Station at Koothali (Peruvannamuzhi) under the CPCRI.

RESUME OF WORK DONE

Nutmeg

At the Kallar and Burliar Research Stations, propagation studies were conducted using 8 rootstocks. The root stocks used were:-

1) *Myristica malbarica*
2) *M. bedoneii*
3) *M. attenuata*
4) *M. contorta*
5) *M. magnifica*
6) *M. kanarica*
7) *M fragrans*
8) *M. laurifolia*

Out of these *M. bedoneii* was found to be the best rootstock. But it is found to develop bottle-neck union. The fruits with this rootstock were found to be comparatively small but more in number. This was closely followed by *M. fragrans* which produces smooth union. Hence *M. fragrans* is generally used as rootstock. The method adopted for grafting is inarching. Plants are grafted when the seedlings are 1½ years old and the best season for grafting was found to be from July to September, giving about 90-95% success.

The trials laid out at Kallar with these rootstoocks indicated much variability in yield. some of the grafts floweredr 56 months after planting. Generallay the plants were having drooping branches and were of spreading types. Fifteen year old grafted plants gave lower yield than the seedling trees of that of the same age. Now we can raise grafted plants or budded plants similar to that of seedlings by proper selection of scion shoots.

The yield studies on Nutmeg at kallar had shown that the cropping in Nutmeg is infuenced by anumb er of factors such as sex of the tree, age, availability of male and female flowers at the same time for pollination, nearness ot male tree fo female tree and vigour. Being highly heterozygous there are much variations in the performance of the seedlings raised from the same selected tree.

Clove

Nine-rootstocks were tried at Kallar. The rootstocks used were,

1) *Eugenia Jambos*
2) *E. maleccensir*
3) E. *calophyllifolis*
4) *E. uniflora*
5) *E. caryophyllata*
6) *E. smithii*
7) *E. calcadensis*
8) *Syzygium jambolanum*
9) *Eugenia arnottiana*

Among these, only *Eugenia carpophyllata* proved to be compatible for clove scion. The current season shoots arising from old shoots appeared to be more promising as scions. Grafting was found to be possible throughout the year except during February to April.

27 selections were made from Nilgiris, Courtallum Kannayakumari and Kottayam and their performance is being studied.

Cinnamon

As regards cinnamon, practically no work has been done on this crop except the standarization of seed germination.

RESEARCH GAP IDENTIFIED AND FUTURE LINE OF WORK

NUTMEG

1. Survey, collection and isolation of superior verieties

Nutmeg being a heterozygous plant and propagated mainly from seed, there is immense possibility of identifying superior types in the existing gardens. These superior types can be propagated as clones.

2. Propagation studies

Though inarching was found to be successful, it is admittedly cumbersome and expensive. Hence more suitable vegetative climente propagation methods have to be found out both for propagating the selected clones and also for topworking on xisting uneconomical female plants and excess male plants.

3. Nutritional st'dies

a. To find out the optimum requiremets of major nutrients using both seedlings and grafted plants.

b. *Foliar diagnosis:* Leaf analysis technique will be standardised for large scale adoption of fertilizer recommendation similar to the standards fixed for citrus in California.

c. *Micronutrient studies:* The effects of micronutrients on the yield, disease incidence and fruit drop have to be studied for providing suitable recommendations.

4. Studies on the Optimum Shade Requirements;

It is well known that nutmeg requires shade. However, the quantum of shade required for maximum growth and production is yet to be known. The effect of shade on RH, air and soil temperatures, growth of shoot and root, moisture level etc. will also have to be studied in detail.

5. Distinguishing male and female plants in the Nursery stage:

The possibility of distinguishing the sex of the seedling in the nursery stage will be studied by morphological, anatomical and chromatographic studies.

6. Optimum cultural requirements:

Detailed experiments have to be laid out to ascertain the optimum cultural requirements and irrigation.

7. Economics of inter cropping:

Nutmeg cultivation in coconut gardens is quite popular. The economics of inter cropping in coconut gardens with and without seasonal crops have to be worked out.

8. Studies on the floral biology, fruit-set and fruit-drop:

The floral biology of nutmeg has not been studied. The extent of fruit-set and fruit-drop under different conditions have to be worked out so as to suggest control measures.

9. Studies on pests and diseases

The borers are often found on nutmeg shoots. This causes drying of young twings. Therefore the etiology of different pests infecting nutmeg and control measures have to be worked out.

Certain fungi are found to be associated with fruit drop. Similarly the pink disease has become quite common. The etiology of these diseases has to be worked out in detail and control measures are to be found out.

10. Studies on the diversified uses of nutmeg

Although we are having sufficient demand for nutmeg at present, marketing may become a problem when large scale cultivation is taken up. It is therefore absolutely necessary to find out diversified use-of nutmeg. This can be undertaken by detailed studies on the important chemical constituents presents in various parts of nutmeg and their possible uses in spices and aromatic and medicinal industries.

Clove

The trials on the following lines are to be conducted. The nature of work will be almost similar to that of nutmeg.

1. Survey and germplasm collection to isolate superior plant types and to develop clonal progenies of the same.
2. Standardization of the best propagation method.
3. Manurial trials for
   a) Assessing the optimum requirements of the major nutrients.
   b) Standardization of foliar diagnosis for large scale adoption of manurial recommendations.
   c) Studies on the influence of micronutrients on the growth, yield, disease resistance and quality of the produce.
4. Studies on the optimum cultural requirements.
5. Determination of the optimum water requirements.
6. Studies on the optimum shade and the effect of shade on the quantity and quality of produce.
7. Studies on the floral biology, fruit-set and fruit drop.

8) Studies on alternate bearing so as to find out remedial measures.

9) Studies on the etiology of pests and diseases and for finding out control measures.

10) Technological studies to find out the diversified use of clove and Eugenol.

Cinnamon

1. Introduction of different species and types of cinnamon with a view to select the best economic type.

Species proposed are:

1. *Cinnamomum zeylanicum*
2. *C. cassia*
3. *C. tamala*

2. Standardization of different systems of cultivation—ie. planting single plants, 3 plants or 4 plants in a pit.

3. Standardization of training and pruning for maximum yield of quality quills and leaf oil.

4. Studies on the manurial requirements and their effect on the quality and quantity of quills and leaf oil.

5. Cultural trial to find out the optimum cultural practices.

6. Studies on the pests and diseases so far recorded to evolve suitable control measures.

7. Technological studies to find out the diversified uses of cinnamon and cinnamon oil.

5. FRUIT CROPS

Growing of fruit crops mixed with other perennial crops in the homesteads is a unique system of fruit growing practised in Kerala, which is perhaps unparellelled in the country. There is no organised system of orcharding in the state, yet fruits are no less important crop to the Kerala homesteads. Kerala ranks first in banana growing in the country with an area of 47,000 hectares. There are no large scale mango orchards in the State, yet mango is grown in an area of 62,000 hectares placing the State fifth in position in the country. Jack, which is grown in almost every house may also occupy an area more or less similar to mango on which figures are not available. The miscellany of fruits in the homesteads includes pineapple, papaya, sapota, citrus, guava, pomegranate and Annonas. The two fruits which are grown as pure crop in addition to homestead growing to any appreciable extent are pineapple and Banana. Even these crops are grown mixed with other crops to a considerable extent. On a perspective analysis it will be seen that the future of fruit growing in Kerala depends solely on its adaptability as a homestead crop. The Kerala homesteads form a veritable collection of variety of crops and it can be safely concluded that fruits will continue to grow in the home compounds. Inspite of several other cash crops, the fact that a fruit like mango continues to occupy an area around 62,000 hectares during the last ten years rightly points out that selection of crops in the home compunds in Kerala is based on personal need rather than for pure profits. In a State like Kerala which is not self-sufficient in food production, all possible efforts should be made to utilize every food crop grown in the State. The fruits like jack, mango, papaya and banana are no less important than any other food crops in the State, although the quantum of food supplied by these fruits has not received any serious consideration. These fruits apart from being nutritious are the only fruits available to the masses of Kerala.

Although the extent of cultivation of fruit crops like banana or mango may be impressive, the production status of these crops is far from satisfactory. The average yield of an important fruit like Banana is only 7,500 kg/ha which is much lower than that of Tamilnadu or Maharashtra. It may be surprising to note that an averge Kerala Banana bunch may weigh only around 6 *kg*.

The details relating to the knowledge and current research as individual fruits are discussed below.

A. BANANA

INTRODUCTION

The most delicious thing in the world is a banana; in history Disraeli mentioned banana like this. There is evidences to show that banana has been a staple food for thousands of people for thousands of years. Now it is an important commercial fruit of the tropical area of the world.

In India also, this is one of the most important crop. India occupies about 494,000 acres of area under banana cultivation. But the production is not comparable to the production vigours of other countries. Kerala's area is about 47.16 thousands hectare and production 356.71 thousand tone.

Year wise area, production and average yield of banana in Kerala is summarised below.

Year.	Area (000 Ha)	Production (000 tonnes).	Average yield
1965-66	47.78	361.12	7558
1966-67	45.59	344.90	7665
1967-68	49.42	374.28	7573
1968-69	51.59	390.48	7569
1969-70	53.50	404.94	7570
1970-71	48.76	368.98	7565
1971-72	47.89	362.27	7565
1972-73	47.29	357.88	7568
1973-74	46.72	353.62	7569
1974-75	47.14	356.57	7564
1975-76	47.16	356.71	7458

District wise area and production of Banana in Kerala (1977).

District	Area (ha)	Production (tonnes)
Trivandrum	710	5173
Quilon	1553	11315
Alleppey	827	6026
Kottayam	1546	11264
Idikki	106	772
Ernakulam	1149	8372
Trichur	1175	8561
Palghat	585	4262
Malappuram	1162	8466
Kozhikode	738	5377
Cannanore	1611	11738
Total	11162	81326

Source: 1. Kerala in Agrl. Statistics, KAU Publication 1977.

2. Farm guide-1979.

RESUME OF WORK DONE

Kannara

Research work on banana in the past was mainly done on irrigated bananas. In Kerala also practically no work has been done on rainfed bananas, although the major area under banana is under rainfed conditions. Most of the work has been done in Nendran and Robusta varieties under irrigated conditions. A resume of the research work done in the past on banana is given below.

i) The best season of planting for banana varieties under irrigated conditions has been found to be September-October. Earlier planting of Robusta in the middle of August is found to reduce the leaf spot incidence.

ii) Planting in ground level with rhizome alone underground followed by planting in trenches, 2 feet wide, was found to be the best method of planting for plant-crop.

iii) A spacing of 2 m between plants and rows leaving two followers for ratoon crop and application of 228 g. N. 228 g P_2O_5 and 456 g K_2O per clump lead to increased productivity in ratoon in Nendran although the average bunch weight was lower. when compared to plant crop or when only one sucker was left as ratoon.

iv) Spacing of 2.5 m x 2 m with one sucker per pit accounted for maximum mean bunch weight in Nendran.

v) Planting of banana at a depth of 1 foot was found to be superior in plant crop.

vi) In the trials to find out the optimum dose of NPK in Nendran Banana, it was found that the optimum combination of NPK was 191 g N, 335 g P_2O_5 and 301 g K_2O per plant per year over and above the basal dressing of 5 kg each of F.Y.M. and green leaf per plant. In subsequent trials it was found that application of lime as burnt lime (CaO) supplementary to manuring helped to increase production and the suggested dose was 1 lb. lime and NPK at 228 g, 228 g, 456 g per plant, the recomended dose as per package of practices being 225, 225, 450 g per plant per year for Nendran.

The results of Nutritional studies on Robusta banana have indicated that there was decline in bunch weight with increasing level of N, but there was progessive increase in bunch weight with increasing levels of P and K. The optimum levels of N.P.K. for Robusta banana were found to be 100g. N, 166 g P_2O_5 and 1266 g K_2O per plant, in recent trials.

vii) The micronutrient trial on Robusta banana did not give any conclusive results.

viii) The storage life of Nendran banana fruit could be increased by treating with 4% Waxol (Fungicidal wax emulsion).

ix) Trials with suckers of different sizes revealed that large sized dried suckers (35-45 cm) are superior in productivity.

x) Storing of sun dried suckers of Nendran for more than 15 days was not desirable as productivity of suckers stored for 30 days was found to be poor.

xi) Weedicide trials on Robusta yielded the following results:-

a) A total number of 36 varieties of weed exists in the banana plantation at Kannara of which 13 are of major importance.

b) A post emergent application of a combination of gramaxone 1.5 l. per hectare and Diuron 2 kg. per Hectare at 6 monthly intervals was found to be superior. At these doses the herbicides were not deleterious to the plants.

The varietal collection of banana consists of 144 varieties at the Banana Research Station, Kannara.

The observations made so far have revealed that Monthan Group (ABB) is comparatively more drought resistant. The following varieties were found promising for popularisation.

a) **Dessert types**

I) Dwarf
- i) Monsmari.
- ii) Gaint Governor
- iii) Robusta.
- iv) Dwarf Cavendish.

II) Tall
- i) Gros Michel.
- ii) Chenkadali.
- iii) Poovan.
- iv) Palayankodan.
- v) Njalippovan.
- vi) Amritsagar.
- vii) Karpooravalli.
- viii) Poonkalli.

III) Nendran
- i) Nedunendran.
- ii) Zanzibar.

b) **Culinary types**
- i) Monthan
- ii) Batheesa
- iii) Kanchikela
- iv) Nendra Padathi.

Among the various available mutants of Cavendish banana, Mons-mari was found to be more productive, producing larger sized fruits with higher sugar content and lesser acidity. In the discipline of Plant Pathology trials were conducted to survey of incidence of diseases, screen varieties for disease resistance and to control of vectors of diseases. Results are summarised below:

i) a) The survey revealed that bunchy top disease is prevalent in all the districts on all the varieties grown.

b) Kokkan disease is seen restricted to Trichur district especially on two varieties of banana viz., Nendran and palaymkodan.

ii) Screening trials against bunchy top disease indicated that Boodles Alta Fort, Pisang Awak, Booditha Bontha Batheesa and Karpuravally exhibited some degree of tolerance, whereas variety Kanchi Kela did not take up any infection in one seasons trial.

iii) Control of aphids by insecticidal application was found to reduce the incidence of bunchy top disease. Of the granular insecticides tried, Thimet was found to be the most effective.

iv) The etiology of Kokkan disease is yet to be found out and hence no tangible results have so far been obtained from the various trials conducted.

v) Two species of fungi namely *Cercospora musae* and *Cordana musae* were found associated with leaf spot diseases. Bordeaux mixture (1%) was found to be most effective in controlling the disease.

Most of the trials on entomological aspects were recently started and conclusive results are yet to be obtained. However, it was found that the data collected on the incidence of nematodes indicate that the incidence is not alarming at Kannara as it is below the normal pathogenic level.

Horticultural Research Station, Ambalavayal.

Results of trials conducted at Horticultural Research Station, Ambalavayal are summarised below.

i) The manurial trials conducted on Gros Michel, Nedran and Cavendish did not give significant difference due to treatments tried.

ii) The desuckering trial on Gros Michel banana did not give any significant results although the treatment retaining the first and fourth produced suckers recorded the maximum yield.

iii) The mulching trial with polythene film, though indicated that the mulched plants were vigorous in vegetative growth, they did not give significant improvement in yield.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

If the total area and production is taken into account, the average per hectare production in banana in Kerala is only to a tune of 7,500 kg. If average bunch weight is computed this will work out only around 6.5 kg. While even the moderate potential bunch weight is much higher, ie. about 20 kg or even more the poor performance of banana in Kerala needs immediate consideration. In the light of the knowledge on the crop obtained so far, as well as the method of cultivation adopted by the farmers, the following appears to be the main factors affecting production.

1) The majority of banana (over 80%) cultivated in Kerala is rainfed grown mainly in the homesteads, where no systematic crop management is

adopted. In one type of a semi-perennial system of banana growing, once the suckers are planted, they are in the field continuously over a period of several years, and harvests are made from the successive generations ofplants.

Some of the major defects noticed in homestead banana growing are given below:

i) There are a large number of varieties grown, ranging widely in yield, quality, tolerance to disease and pests which make uniform management difficult.

ii) Since the area is cultivated continuously without manuring the soil has become highly depleted of nutrients resulting in very low production. (bunches weighing even less than 2 to 3 kg.)

iii) Continuous cropping has resulted in the increased incidence of pests and diseases. The homesteads act as a perennial source of bunchy top disease and stem weevil in addition to other pests and diseases.

iv) All the suckers produced in a clump are retained and desuckering is practised only when fresh suckers are required for planting. Due to non-regulation of suckers, the bunch weight and size of mother and daughters are considerably affected.

v) Shade is a problem in the homesteads. The varietal reaction to different intensities of light have not been studied, as a result of which varietal recommendations to the homesteads are not possible. (The indications are that certain varieties such as Palayamkodan are more shade tolerant than Nendran) Knowledge in crop management or manuring under shade conditions is totally lacking in bananas. There are indications that there is a nutrient sparing action when bananas are grown under shade.

vi) The bananas grown in the home compounds are practically unirrigated. Wherever application of water has been possible, at least during dry summer months, an yield increase has been noticed. The most economic methods of water application in homesteads using the little source of available water in the homes have not been worked out.

vii) The experiments conducted on bananas in India and even in our State have been under irrigated pure crop conditions, the results of which have little practical utility in the homestead rainfed conditions.

The foregoing account on the constraints of production in bananas clearly indicates, that research on bananas should clearly fall under two categories:

i) For irrigated pure crop bananas.

ii) For rainfed bananas grown under partial shade conditions.

The research projects in progress under the All India Co-ordinated Banana Research Scheme, envisage studies only on irrigated bananas. Even in this, varieties selected for studies have been ressricted to a few, leaving some of the commercially cultivated varieties of Kerala like Poovan and Palayamkodan. Trials will have to be conducted on varieties important to Kerala on all aspects of crop management, which have not been included under the All India Co-ordinated Scheme. This is necessary because recent work has clearly shown that there is considerable variation in nutrient uptake between varieties. Coimbatore experiment shave shown that a variety like Poovan utilizes nutrients to advantage even at later stage than at 4 to 5 months of planting. These aspects clearly indicate that in order to have a complete understanding of the different varieties and their reaction to manuring, irrigation, etc. in addition to mere field experiments basic aspects of study have also to be taken up. Immediate attention may be devoted for organising research work on rainfed bananas on all aspects of crop management.

The majority of the bananas grown in Kerala being rainfed, research work has to be intensified on rainfed bananas on all aspects of cultivation. To start with, a few varieties like palayamkodan, poovan and kadali may be taken up for the study. Simultaneous trials may be carried out on these varieties under irrigated conditions also. Some of the more important aspects to be taken up immediately are briefly outlined.

i) Nutritional trials

Recent studies at Coimbatore and elsewhere have shown that the nutrient uptake is closely related to the different phases of growth in bananas. In this respect varieties differ considerably. Therefore nutrient uptake studies with reference to varieties and agronomic conditions (irrigated, rainfed, under shade etc.) are necessary. It has also been observed (Simmonds) that there is some nutrient saving action in bananas when grown under shade. If this is so,

the nutrient requirement under shade will be lower than for irrigated grown crop.

ii) **De suckering trials** (rainfed)

iii) **Flower bud differentiation studies in different varieties**

This is more a basic type of study but the flower bud initiation in bananas has a close relationship with banana nutrition. This aspect of study may be taken up as a part of the work of the post graduate students.

iv) **Ratooning trials** (irrigated and rainfed).

v) **Kokkan disease**

Although kokkan disease was reported as early as 1961, the etiology of the disease is yet unknown. In order to understand the disease condition it is necessary to conduct studies on basic aspects like nutrient uptake and biochemical make up of the affected plants. Field trials with more micronutrients may also be conducted.

B. PINEAPPLE

INTRODUCTION

The crop thrives well in tropical climate such as is found in the tropics near the sea or at sono elevotion above it. Total area under pineapple in India during the year 1975-76 is estimated to be 36,000 hectares with a production of 2,00,000 tonnes while in Kerala the total area was 8,971 hectares and production 63,000 tonnes.

The district-wise area and production of pineapple in Kerala is narrated below:

District wise area and production of pineapple in Kerala (1975-76)

District	Area (Ha.)	Production (MT)
Trivandrum	614	
Quilon	1050	
Alleppey	524	
Kottayam	658	
Idikki	778	
Ernakulam	583	
Trichur	1475	
Palaghat	393	
Malappuram	510	
Kozhikode	1067	
Cannanore	1319	
Total	8971	63,000

Source: 1. Kerala in Agricultural Statistics, K. A. U. Publication, 1977.
2. Farm guide, 1979.

RESUME OF WORK DONE

Except for certain isolated trials conducted at Kannara, Taliparamba and Ambalavayal no systematic study is seen conducted till the implementation of the All India Co-ordinated Fruit Improvement Project in 1974 at Vellanikkara.

Experiments in progress in K. A. U. are:

i) Population density trial (2 trials)
ii) Nutritional studies (2 „)
iii) Growth regulator studies (5 „)
iv) Weedicide trials
v) Survey of diseases and their assessment
vi) Optimum sucker size trial (2 trials)
vii) Shade trial

The significant results obtined are summarised below:

i) Planting of higher population of suckers per unit area help in increasing yield of pineapple considerably. Spacing of suckers at 30 cm between plants, 60 cm between rows and 90 cm between trenches (43,086 plants per hectare) accounted for the production of 50 to 60 tonnes per hectare in the plant crop season as against the yield of 25-30 tonnes now obtained by the cultivators adopting a spacing of 45 cm × 60cm × 180 cm (15,000 suckers per hectare).

ii) The cultural trial on the planting of suckers at different depths indicated no significance due to treatments.

iii) Soil application of N fertilizers as urea was found to be better than foliar + soil application under Trichur conditions.

iv) The survey on weed flora of pineapple plantation the presence of 41 types and varieties of weeds of which 20 types were major ones. Application of herbicide Diuron at the rate of 3 kg per hectare as pre emergent and repeated application of a $\frac{1}{2}$ dose 4—5 months after the first application as post emergence, control all the dicot weeds and 80% of the monocots. The herbicide application was more economical than hand weeding besides helping increased production by 15per cent.

v) Trials conducted with growth regulators on the induction of flowering showed that Ethrel at 500 ppm and 1,000 ppm is most effective in inducing maximum flowering in suckers of 14 to 16 months age in plant crop season. In ratoon crop Ethrel at 100 ppm was found to be sufficient. Maximum flowering could be induced in crowns of 17 and 18 months with Ethrel at 500 ppm. The combination treatment, 25 ppm Ethret + 2% urea + 0.04% Calcium carbonate was found to be very effective both for plant crop as well as ratoon crop.

The results of earlier trials conducted at Ambalavayal & Taliparamba in pineapple are given below:

i) Cultural and manurial trial.

This was laid out in 1955 with 8 treatments in a replicated randomised block design to find out the best cultural and manurial treatments for pineapple under wynad conditions. No conclusive result could be obtained from this trial as most of the plants were damaged by wild animals.

ii) Trial on the effect of mulching in pineapple with polythene film.

Laid out in 1963, this trial was to find out the beneficial effects that can be derived by mulching

the pineapple with polythene film. Data indicated that the average weight of fruits produced by treatment 'Mulching' and control were 2.707 kg and 1.857 kg respectively. The yield data also gave indication in favour of mulching.

iii) Trial on the application of Gibbrellic acid on halfmatured fruits.

This was laid out in 1962 with the object of inducing early maturity and to increase the size of the fruits with 4 different concentrations (250, 500, 1,000 and 1,500 ppm) of the hormone with appropriate control. Data indicated that there was an increase in the girth of fruits under treatments 500 ppm, and 1,000 ppm, 1,500 ppm over that of control. The weight of the fruits was also found to be more in all the treatments except 250 ppm as compared to the control. Maximum fruit size and weight were recorded under the treatment 1,500 ppm.

iv) Trial to find out the effect of Gibbrellic acid on flowering of pineapple

This was laid out in 1961 to find out the effect of GA in inducing early flowering in pineapple. Four different concentrations (250, 500, 1,000 and 1,500 ppm) were employed along with appropriate control. The observations recorded revealed that the plants treated with 1,500 ppm G. A. flowered earlier than the plants in the other treatments. The lower concentrations of the hormones were not found to be effective in inducing early flowering in pineapple.

v) Ice-carbide trial in pineapple

This was laid out in 1955 with the object of staggering the production of pineapple by treatment with ice water and granulated calcium carbide for regulating supply to the market. Treatments consisted of 20 plants treated with ice water and calcium carbide and 20 plants as control at four different periods viz., 8, 9, 10 and 11 month old plants. The trial was discontinued in 1957 as most of the plants were destroyed by wild animals.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

The main factor restricting the per hectare yield in pineapple in Kerala appear to be the following.

i) Planting of lesser number of suckers per hectare

Experiments else-where and those conducted in the University have clearly shown that yield could be considerably increased by increasing the number of suckers per hectare (45,000).

ii) Erratic nature of flowering

The annual yield from a unit area is unpredictable due to high variations in the time of flowering between the suckers. In a planted crop, it has been observed that under natural conditions only 20-30% suckers come to flowering during the first year inspite of best attention received.

iii) Continued ratooning for 6-10 years

The fruit size gradually dedreases of the ratooning is extended rssulting in low unit area produciion.

In view of the large number of field trials in progress under the All India Co-ordinated Project, further field trials may not be necessary for the present. The following areas need immediate attention on intensification of studies.

i) Hybridisation experiments

ii) Fruit development in relation to growth regulator application.

It has been found that variation in fruit size occurs when the fruits are induced by the application of growth regulatiors with in suckers of almost any size and age. The causes for this variation have to be studied.

iii) Performance of pineapple under different intensities of shade.

C. MANGO

INTRODUCTION

The choicest fruit of 'Hindustan' is still the mango, as it was in the days of the poet Amir Khusrau; who song its praises in the 14th century. Indeed, the mango has been a favourite fruit in India throughout recorded history, and is frequently mentioned in sanskrit literature. The total area under mangoes during the year 1975-76 in India was estimated to be 9,77,000 hectares with a production of 89,30,000 metric tonnes. The year wise area production and average yield of mangoes in Kerala is given below.

Year wise area, production and average yield of mangoes in Kerala

Year	Area ('000 ha.)	Production ('000 tonnes)
1965-66	63.22	
1966-67	61.98	
1967-68	64.48	
1968-69	62.22	
1969-70	60.26	
1970-71	58.10	
1971-72	56.16	
1972-73	57.12	
1973-74	57.49	
1974-75	62.53	
1975-76	62.53	

District wise area of mango in Kerala during the year 1975-76 is given below.

District-wise area of mango in Kerala (1975-76)

District	Area (Ha.)	Production MT.
Trivandrum	7050	
Quilon	9331	
Alleppey	4183	
Kottayam	10220	
Idukki	1235	
Ernakulam	4608	
Trichur	4638	
Palghat	7381	
Malappuram	3972	
Kozhikode	4940	
Cannanore	4974	
Total	62532	739000

Source : 1. Kerala in Agricultural Statistics K. A. U. Publication, 1977.
2. Farm guide, 1979.

RESUME OF WORK DONE

Most of the works on mango were done in the Agricultural Research Station, Taliparamba. Some of the earlier works included studies on propagation, poleyembroyonic root stocks and hybridisation. These studies were not carried out an systematic iines with the result that conclusive result are lacking in most of the experiments. Although a large number of hybrids were produced in Taliparamba during 1957-58, proper evaluation of all the hybrids has not been made. So also while other mango growing states in India are conducting large number of studies on the exploitation of poleyembryonic seedlings as root stocks have not made much progress in the direction. Information on manuring and other operations like pruning, regulation of crop production etc. is completely lacking in our state.

The trials now being carried out in the Kerala Agricultural University includes survey and collection of pickle varieties and table varieties of mango, root stock studies nutrition trials and trials as pruning.

Since mango is a major fruit crop of the state, it would be worth while to plan detailed experiments in the different aspects of mango growing.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

There are no reliable figures available on the annual production of mango in Kerala. It is also not possible to draw conclusions from the past work in the state as these aspects have not been studied. The following are the main factors affecting production.

i) Stocking of a large number of seedling types, highly variable in yield and other characters.

ii) Erratic flowering and alternate bearing

iii) Incidence of pests and diseases especially at the time of flowering leading to vary high percentage of shedding of fruits.

iv) Improper nutrition of the trees

v) Non standardisation of root stocks.

D. CITRUS

INTRODUCTION

Although, authorities may disagree violently as to the history, classification, nomenclature and best cultural methods of citrus fruits, none can dispute their importance, both from the point of view of size of the industry and as delicious and wholesome fruits. In acreage, the citrus fruits probably rank third among the sub tropical fruits of the world. The correct statistics about the production and average yield of citrus in our state is not available. The area under citrus in Kerala is 19600 ha. from 1965–66.

RESUME OF WORK DONE

Mandarin orange (Citrus reticulata)

Mandarin orange is the main species of Citrus cultivated in Kerala especially in Wynad and Nelliampathy. The work done in the past consisted mainly of trials on mandarin oranges at the Agricultural Research Station, Ambalavayal. A resume of the work done in given below:

i) Introductidn and trial of Citrus species and varieties:

The object of this trial was to find out the best variety suited to Wynad conditions. Selections of Mandarin orange from different parts of India and from foreign countries were included. The trial was started in 1956. In all, 14 indigenous types and 5 exotic types were compared. The results indicated that Nagpur Santra, followed by Chitragiri selection iii among the indigenous types and 'Cleopatra' and 'Valentine' among the exotic types perform well under Wynad conditions.

ii) Root stock trial on Mandarin orange

This was started in June 1952 with 6 root stocks in a randomised replicated trial. Results indicated that the trees budded on Rough lemon (*Citrus jamberi)* have recorded maximum growth and yield consistently. The trial was abandoned in 1973 as almost all trees under this trial were affected with various pests and diseases and also because a fresh trial with more root stocks was to be laid out.

A new trial with 16 different root stocks was laid out in 1964 in a randomised replicated design. No conclusive results could be drawn from this trial as the entire plantation has declined showing symptoms of die-back.

iii) Cultural trial on Mandarin oranges.

The trial was started in 1951 with 6 different rteatments viz., digging, mulching, covercrop, manuring and digging, manuring and mulching and control. Statistical analysis of the data indicated that the treatment 'Manuring and mulching' has surpassed all other treatments in both height and growth aspects. This treatment has given the highest yield consistently. The trial was abandoned in 1963.

iv) Trial of budlings and seedlings of Mandarin orange.

This was commenced in 1952. The budded plants of Mandarin orange on rought lemon and seedlings of the same scion were compared in a randomised replicated trial. A better free height in the case of seedlings and a better spread in the case of budlings were observed 3 years after and it was also seen that budlings came to bearing stage during this period. The trial was, however, abandoned due to the differential age of the plants planted under this trial.

v) Trial on the micronutrients spray individually on Mandarin orange budlings.

The trial was laid out in 1963 in a replicated randomised block design with 6 different treatments. The results indicated that treatment with Mn was superior to all other treatments in respect of yield and growth. The minimum yield was obtained from plants treated with 'Cu'. The trial was abandoned in 1971.

vi) Micronutrient trial on Mandarin orange seedlings individually and in combination.

This was laid out in 1964 in replicated randomised block design to study the effects of micronutrients individually and in combination to combat decline. Eight different treatments were compared. No conclusive results were obtained and the trial was abandoned in 1972.

vii) Scheme for trials on improved cultural and manurial practices in Mandarin oranges in Wynad.

The object was to evolve optimum cultural and manurial schedules and suitable pest and disease control measures by utilization of all available information from research findings and local practices for upgrading commercial orchard practies for Mandarin orange. The scheme was sanctioned by the I. C. A. R. for 5 years from 1-4-1964 and the actual working of the scheme started on 12-10-1964. Under this scheme 200 plots in cultivation field of 0.5 acres each 40 plots in each of the 5 cents of North and South Wynad Taluks were selected and

the different treatments as per technical programme were conducted. The data collected during the period had indicated that, manuring the bearing trees 50 kg. FYM, 2.5 kg. CAN, 1.5 kg. of superphosphate and 0.5 kg. of MOP twice a year and micronutrient sprays with Zn, Cu. and Mn and plant protection measures against stem borers and fungal diseases help at least to double the present yield of Mandarin orange in Wynad.

viii) Planofix trial on Mandarin orange

The object was to study the response of Madarin orange to planofix in respect of fruit drop, yield and quality of fruits. The trial was started in 1961 with 3 different concentrations viz., 2.5 ppm, 5 ppm and 10 ppm and control. The results indicated that there was appreciable reduction in the fruit drop in the treated plants. The treatment 5 ppm was found to be the most effective in preventing the fruit drop througout. In respect of weight and other qualities on fruit there was appreciable difference between treated and untreated plants.

ix) Fungicidal wax trial

This trial was taken up in 1962 to study the effect of fungicidal wax in improving the keeping quality of fruits. The 12% wax solution supplied by C. F. T. R. I., Mysore, was used for the trial. This was diluted to 4% strength and fully matured uniform sized fruits were dipped in the solution for one minute. The fruits were kept in dealwood boxes along with the untreated fruits as control. The results indicated that while treated fruits could be stored without rotting upto 41 days as a gainst 32 days in the case of untreated ones. It was further found that Mandarin oranges could be stored upto 20 days without deterioration of quality or spoilage by treating with fungicidal wax.

x) Fertilizer trial on Mandarin orange

This trial was started in 1962 to study the effect of fertilizer application on the sweetness of fruits. Data indicated that the manured plants have given higher yields than the untreated plants. The sugar/acid ratio was 9.7:1, in the control, it was 12:1 in the treated plants.

Acid lime (*Citrus aurantifolia*)
Trial on the application of lime in Acid lime

This trial was laid out in 1962 with the object of finding out the effect of lime on the growth of yield of acid lime plants. Lime @ ½ lb, 1 lb, and 1½ lb per plant with suitable control was employed. The growth measurements recorded for the subsequent 2 years revealed that the maximum height and girth of plants were noticed in plants applied with 1½ lb lime. The trial was terminated in 1965 as the most of the plants were effected by drought and die-back symptoms.

Malta lemon (*Citrus limon*)
Trial on the application of lime in Malta lemon plants.

This trial was laid out in 1962. The objective was to find out the effect of applicalion of slaked lime on the growth and productivity of Malta lemon plants. Three levels of lime as above were tried, The data revealed that the treatment 1½ lbs lime has produced the maximum yield (216 Nos·18,800 kgs) followed by treatment ½ lb lime (1973 Nos. 14.900 kgs). The least yield was obtained from plants under control.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

The major citrus species grown in Kerala is Mandarin oranges. The citrus decline is a wide spread malady found in the mandarin growing tracts which has been the root cause of decline in production.

Under the All India Co-ordinated Citrus Research Scheme, trials have been laid out at Ambalavayal. The results of trials may be awaited. The following are areas of future research.

i) Germplasm coiiection of citrus at Ambalavayal.

ii) Trials on acid lime cultivations.

INTRODUCTION

Jack (*Artecerfue hetero phyllus L*) is extensively cultivated in tropical and subtropical regions of India especially on the west coast. The tree bears profusely and fruits are available in plenty during summer. Jack fruit is valued mostly for its cultinory table and processing attributes. Fully ripe fruits were sweet in taste and flavour. The district wise area and production of jack fruit during 1975–76 is furnished below.

District	Area (Ha.)	Production (MT)
Cannanore	9431	
Trichur	2495	
Quilon	5585	
Kottayam	4054	
Ernakulam	2784	
Malappuram	4596	
Kozhikode	8540	
Palghat	3988	
Trivandrum	5463	
Alleppey	1877	
Idukki	1361	
Total	50174	723000

Source : Farm guide, 1979

RESUME OF WORK DONE

In Jack the few trials conducted were on propagation aspects. Isolated studies on grafting have been done at Taliparamba and at Vellayani. Successful grafting and layering of seedlings to some extent have been reported from Vellayani and Taliparamba. Work in progress in the College of Horticulture has indicated for the first time the possibility of successful airlayering in old jack trees.

At Ambalavayal, the observational trial was started in 1963-64 to find out the viability of Jack seeds. The germination counts recorded of ten different periods of interval revealed the following.

i) The maximum and minimum period taken by jack seeds to start germination after sowing were 22 and 39 days respectively.

ii) Cent per cent germination can be obtained by sowing freshly extracted seeds.

iii) Seeds stored up to 22 days gave good germination up to 80-90% and there after the viability was reduced.

iv) No germination was observed in seeds sown after storing for 42 days.

v Under Wynad conditions, it is advisable to sow jack seeds immediatley after collection. Sowing should not however be delayed beyond 20 days after extraction.

Research gaps identified and future lines of work

Although there is considerable area under jack in Kerala, no high yielding quality varieties are available for cultivation mainly because of lack of widespread vegetative propagation. There exists considerable scope for selection of varieties based on yield and quality. No work has been carried out to provide suitable methods for adapting scientific cultivation.

The following research projects are now planned under the Adhoc Scheme on survey collection and evaluation of germplasm of jack fruit functioning in the Department of Pomology in the college of Horticulture.

i) Germplasm collection and description of types.

ii) Standardisation of propagation techniques in Jack.

iii) Training and Pruning trial in Jack.

iv) Tillage operations in Jack.

v) Manurial trials on Jack.

vi) Comparative performance of seedlings, grafts and layers.

F. OTHER FRUIT CROPS (Avacoda, Papaya, Sapota, Geeava, Pomegranate)

INTRODUCTION

These are several minor crops as grown in Kerala. The actual statistics on area and production of these crops are lacking.

RESUME OF WORK DONE

The research work done on these crops are practically nil. Except for a few root stock trials conducted in Taliparamba on Sapota and some holeyembryonic studies on Avacoda, the work done in other crops was isolated and sporadic in nature and no results are available on them. Out of the several minor fruit crops, it appears necessary that fruits like papaya and sapota require more serious consideration of the research workers.

Few studies were conducted on the extent of holeyembryoney in Avacado seeds in 1963. The results revealed the following.

i) Avacoda seeds require 20 days to commence germination and 42 days to complete the same irrespective of the variety.

ii) Variety Fuerte has recorded the maximum percentage of germinetion (96) followed by P. Purple hybrid (70) and Pullocks (68).

iii) Monoembryoney was dominant in all the varieties and holeyembryony existed in varying degrees.

iv) The extent of holeyembryony was from 2.5 seedlings/seed.

v) Maximum percentage of holeyembryony was recorded by variety Pullock (47%) P. Purple hybird and Fuerte recorded 15.8% and 12.3% respectively.

vi) In respect of distribution status of holyembryony Fuerte ranked first having produced one, two, three, four and five seedlings per seed.

Research gaps identified and future line of work

In the case of fruits like Papaya, Sapota, Pomegranate, Guava and Avacoda, even suitable varietiee have not been identified for cultivation in our state. Among the minor fruit crop, papaya is a fruit grown largely in every homestead. Selection of suitable varieties, adaption of scientific management etc. will have to be followed to make the growing of these fruits profitable.

6. BEVERAGE CROPS

A. COCOA

INTRODUCTION

Though cocoa was introduced to India about 50 years back, the importance of cocoa has been felt in India only during the last 10 years. The cultivation of this crop has been gaining ground only during the last 5 years. The low price obtained till two years back (about Rs. 6/kg) was responsible for its slow development. Because of the keen competition in the internal market and the heavy demand and increased price in the world market, the price shot upto Rs. 40.50 per kg. during the last year. The price shot upto a record high during the early part of this year (above Rs. 55/- kg).

During 1850, the world production of cocoa was only around 18,000 tons; which increased to 15 lakhs tons by 1975. Even this quantity is sufficient to meet the demand by 50 per cent only. The world demand is also increasing at least at 3.9 per cent per annum and the consumption is likely to be increased to 2.2 to 2.4 million tons by 1985.

The estimated area production and demand for cocoa in India are as follows:

	Area in ha. (1976—77)
Kerala	5548
Karnataka	2240
Tamil Nadu	193
	7981
Production	200 tons
Demand	10,000 tons
Estimated demand by 1985	20,000 tons

***World production of Cocoa**

Year	Production in tons
1960-61	11,73,000
1965-66	12,05,000
1970-71	14,81,000
1972-73	13,99,000
1973-74	14,35,000
1974-75	15,36,000
1975-76	14,83,000
1976-77	13,73,000

* Source : Directorate of Arecanut & Spices.

Export of cocoa and its products from India

	1672-73		1973-74		1974-75		1975-76	
	Qnty. tons	Value lakhs	Qnty.	Value	Qnty.	Value	Qnty.	Value.
Cocoa powder (unsweetened)	15.4	9.2	53.6	3.2	23.2	2.4	22.6	2·4
Cocoa butter and paste	15.3	1.7	—	—	—	—	—	—
Chocolate & other products	806.1	46.9	1646.2	95.3	558.9	43.1	572.8	49.1
Total	1005.4	57.8	1699.8	98.5	582.1	45.5	595.4	51.5

Import of cocoa and its products to India (Quantity in tonnes, Value in lakhs of rupees)

	1972-73		1973-74		1974-75		1975-76	
	Quty.	Value	Qnty.	Value	Qnty.	Value	Qnty.	Value
Cocoa, Roasted Beans	893.4	44.3	1080.1	189.2	434.3	56.1	647.7	78.6
Cocoa power (unsweetened)	90.2	6.7	51.2	51.1	30.1	4.0	7.1	1.1
Cocoa paste	35.0	1.96	—	—	—	—	7.5	1.8
Cocoa butter	11.2	1.04	—	—	—	—	7.35	3.1
Chocolate and other products	2.6	0.25	3.0	0.3	3.7	0.5	7.0	1.3
	1032.4	54.25	1134.3	240.6	468.1	60.6	676.65	85.9

Source: Directorate General of Commercial Intelligence & Statistics, Calcutta.

The above stated statistics clearly indicate that the internal and external demand of cocoa is likely to be increased.

The climate of Kerala and a good portion of the soil are congenial for the large scale planting of this crop. The estimated demand of 20,000 tons can be produced from 40,000 ha. of which we have already covered 5548 ha. Experiments done so far have alredy indicated that cocoa is a good intercrop under coconuts. Therefore it is quite easy to find the requried 35,500 ha. of suitable land in the existing coconut gardens for interplanting with cocoa.

RESUME OF WORK DONE

Practically no reserch work has been done on this crop in Kerala except finding out its suitability as an inter crop in coconut gardens. Recently under the Kerala Agricultural Development Projects several research projects have been initiated at the Kerala Agricultural University and at C. P. C. R. I., Kasaragod including its regional station at Vittal. However research work on several aspects of cocoa cultivation, processing and utilisation was undertaken at the Imperial College of Tropical Agriculture, Trinidad and in Ghana, Nigeria and Malaya.

The main varieties under cultivation are Criollo, Forastero and Amelonado. Amelonado which is a Forastero type is mainly cultivated in African countries and the bulk of the produce (nearly 80%) comes from these areas. Several selections have been made at the Imperial College of Tropical Agriculture and five of these selections were tried at the Arecanut Research Station, Kannara and the Arecanut Research Station, Vittal. The data at Vittal show that ICS6 and ICS51 clones are promising; although final conclusions are yet to be drawn.

The shade requirements and the nutritional requirements are interrelated in cocoa. Experiments conducted by Evans and Murray (1953) at Trinidad with different intensities of shade have indicated that the greatest growth in the first year has been at a light intensity of 30 and 60 percent full day light. At this stage, fertilizers produced little effect on growth, the light intensity being the over-riding factor. As the plants grew the effect of fertilizer applications became increasingly evident depending upon the intensity of shade. Murray (1954) found that under high intensity of shade (15 and 25% light) yields were low irrespective of fertilizer application. The yield increased upto 50% light intensity even when no fertilizer was applied and thereafter the yield declined. But in case of NPK fertilization, the yield increased upto 75% and continued at that level with only light decrease. The difference in yield was 100% (500 lbs and 1000 lbs/acre/year).

Experiments couducted at Trinidad have shown that (i) nitrogen is most needed in the absence of shade. This is particularly applicable to young cocoa plants before overhead shade is established. (ii) the need for nitrogen diminished as the plants developed overhead canopy. (iii) phosphorus balances nitrogen uptake and stimulates bacterial multiplication and favourable root development. (iv) potassium is necessary in shade. The resistance against diseases increased with increase in potassium levels.

The trial conducted at Tafo, Ghana is quite interesting. A ten year old Amelonado cocoa planted at 2.4 × 2.4m under uniform shade of glyricidia was divided into blocks. The shade was completely removed from half of the plot and fertilizers were applied both for shaded and unshaded plots at the following rates:

	N	P_2O_5	K_2O	MgO
First year	126	134	101	52
Subsequent years	112	112	84	56

Thus there were 4 treatments: Shaded with no fertilization, shaded with fertilization, unshaded with no fertilization and unshaded with fertilization.

The absence of shade gave a substantial increase in yield. The yield was further increased by fertilization. However, it was concluded that increasing the yield without shade and withour fertilization may lead to early senescence of trees.

The following has been found to be the nutrients removed from the soil by cocoa crop of 560 kg/ha.

	N	P	K
In beans	13	3.4	11
In husks	11	1.1	25
	24	4.5	36

Attempts have been made to standardize leaf analysis technique for cocoa. Murray (1967) found that in the fully expanded leaf, the level of N, P and K were high and they decreased with increase in age. On the other hand the Ca and Mg content increased with age. The light intensity also affects

nutrient content on the leaves. Higher nutrient level was noticed in the leaves grown under high shade compared to those in light or no shade. In other words, the nutrient content of the trees will be increased either by application of these nutrients or by removing or reducing the light. Murray (1966) found the following level of nutrients on the leaves of cocoa grown in Trinidad.

	Percentage of dry matter		
Nutrient	Deficient	Low	Normal
N	1.80	1.80-2.00	2.00
P	0.13	0.13-0.20	0.20
K	1.20	1.20-2.00	2.00
Ca	0.30	0.30-0.40	0.40
Mg	0.20	0.20-0.45	0.45

In Trinidad, 450 g. of a 20:20:0 mixture pev plant per year is recommended in soils rich in potash. In soil which contains high level of P and deficient in K, 10:5:15 mixture is recommended. Cunningham (1963) recommends the following to maintain a yield of 2240 kg/ha.

Urea	125 kg/ha/year
Triple phosphate	125 kg/ha/year
Pot. sulphate	500 kg/ha/year

Two split applications have been found to be better than single application.

Wood (1976) recommends, 6:5:6 or 10:5:10 ratio tor the fertilizers. According to him, during the first year, 100-200 g, depending upon the soil type, may be applied per plant. The dose can be gradually increased to 600 g or 1000 g depending upon the soil and shade.

Experiments conducted at Trinidad have shown a low yield in case of shallow ploughing and forking. Based on these experiments, it has been suggested that no form of soil cultivation should be practiced for cocoa for tropical soils under high rainfall.

Experiments conducted at River Estate, Trinidad have shown higher yield (1273 kg/ha as against 900 kg for control) in case of green leaf mulching. Trenching (60 × 60 × 45 cm) between lines and filling with organic manures was also found to give better yield (145 kg more/ha).

RESEARCH GAPS IDENTIFIED AND FUTURE LINES OF WORK

Not much work has been done on cocoa in India and as such research data available is very limited. Therefore, for suggesting the "Package of Practices" for scientific production of cocoa based on research data and also to cope up with the problems that may arise in due course, detailed studies on different aspects of crop production, processing and utilisation are essential.

1. Germplasm Collection of Varieties and Types

Criollo, Forastero and Trinitarios are the three types avaiiable at present. In addition, several ICS (Imperial College Selection) clones are also avaiiable. It is worthwhile to have a collection of these varieties and types with a view to selecting high yielding, disease resistant oi tolerant varieties or types.

2. Standardization of Propagation Teehniques

a. Standardization of Mother Plant Selection

It is absolutely necessary to standardize the criteria for selecting a mother plant for producing high yielding, quality seedlings. Early bearing habit, high yield, drought resistance, resistance or tolerance to pests and diseases, large bean size, low proportion of shell high fat content, uniformity in fermentation and good flavour are some of the important characters which are to be taken into account for fixing the criteria.

b. Fixing the Criteria for Selection of Seeds and Seedlings

Whether the size of the beans and the eariy germination have any bearing on the performance of the seedlings is yet to be studied. Criteria are to be developed for selecting the seedlings in the nursery for getting comparatively uniform plants and to avoid casualities in the early phase of their growth.

c. Standardisation of vegetative propagation

Cocoa being highly heterozygous and being grown mainly through seeds, wide variation in plant population is often met with. The variation in the size of the beans are often detrimental to the uniform fermentation and quality of products. These defects can be eliminated by adopting cheap vegetative propagation methods and such methods have to be standardized for our conditions.

Certain clones are found to be self incompatible Therefore while propagating vegetatively, self compatible clones have to be selected.

3. Optimum shade repuirements

The optimum requirement of shade under various ecological conditions has to be worked out. The functions of shade under varying conditions of sunshine, humidity and soil are also to be studied. The best shade trees to be planted at different growth periods of cocoa are to be identified.

4. Determination of optimum shade vis-a-vis nutrient requirement under Kerala conditions

The nutrient requirements of cocoa is found to be related to the amount of light intensity. Therefore it is necessary to find out the optimum requirements of N, P, K, Ca and Mg under different intercropping conditions prevailing in Kerala.

The optimum requirements of the micronutrients such as zinc, copper, boron, molybdenum and manganese for production of high quality produce needs investigation.

5. Optimum training and prunning

Standardization of training and prunning must be done to suit the agroclimatic conditions of Kerala so as to obtain higher yield and quality produce which in turn will fetch higher returns to the grower.

6. Studies on the optimum agronomic practices

The optimum requirements of water, cultivation methods and the effect of mulching, trenching, etc. are to be worked out.

7. Economics of Interplanting

Cocoa is being advocated as an intercrop in coconut, arecanut and coffee plantations. The economics of such interplanting has to be worked out.

8. Important Plant Protection Methods

Research work must be undertaken to standardise the plant protection methods against various pests and diseases affecting cocoa.

9. Study on the Etiology of Diseases

The etiology of the various diseases affecting cocoa (pink disease, die-back, etc.) has to be studied in order to help standardise the control methods.

10. Methods of Curing Small Quantities

The conventional methods of curing are more suited for larger growers. It would be worthwhile to standardise a method of curing small quantities to suit the small growers.

11. Post Harvest Technological Studies

Methods of storage by which the beans can be kept without pest or fungus attack for long periods have to be investigated and standardised.

12. Technological Studies to Find Out the Possible Diversified Uses of Cocoa in Future

Diversified uses of cocoa are to be standardized (like home preparation and consumption, use in cold beverage, etc.). More co-operation and co-ordination among the production, industrial utilization and research agencies are required for these studies.

13. Production of Better and Small Units of Extraction of Cocoa Butter

If small units of extraction are made available it will be possible to start cocoa processing industry in the main producing area itself. Growers can then expect better price for their produce.

14. Studies on the Economic Utilisation of Fruit Waste and Fermentation Liquor

Large quantities of fruit waste (about 85-88%) are available. The possibilities of utilizing the same for the production of cattle feed need study. The economic utilization of the fermented liquor also requires investigation.

15. Microbiological studies under interplanting conditions

Preliminary studies have shown that the activities of certain microbes are found to be more when cocoa is interplanted in coconut gardens. The symbiotic activities of these microbes, their effect on coconut palm, etc. need detailed study. When interplanting is done, the quantity of light that is falling on the soil is reduced considerably. It is important to know how the low incidence of light under such a situation will affect the life and activities of the beneficial soil organisms.

INTRODUCTION.

Coffee is an important plantation crop of Kerala. During 1976-77, Kerala produced 15030 T of coffee from an area of 52644 ha. Our state accounted for 27.94% area and 14.69% production of coffee during that year. Karnatake, Tamil Nadu and Kerala are the three Princial coffee producing states of India, together accounting 98.59% of the total coffee area in the country. The estimated area of coffee in India during 1976-77 was 1,88;447 ha.

The total holdings in Kerala numbered 47760 during 1976-77 out of which 98.44% were holdings below four ha. each. Arabica and robusta are the two species cultivated in the state, robusta being the most predominant one.

The world production of coffee declined during 1975 mainly because of frost attack in Brazil and earthquake in Guatemala. The decreases in world production subsequently led to a substantial increase in the world prize.

The export of coffee from India during 1976-77 was 50,558 tonnes valued at Rs. 125. 75 cr. The export rose to 55,827 tonnes valued at Rs. 230. 46 cr. du ing 1977-78.

The relevant figures are presented in following tables.

Area Under Coffee in India During 1976-77 (ha)

State	Arabica	Robusta	Total
Karnataka	68,369	32,557	1,00 926
Tamil Nadu	26,705	5,520	32,225
Kerala	2,926	49.718	52.644
Non-Traditional area	2,571	81	2.652
	1,00,571	87,876	1,88,447

Area Under Coffee and Production of Coffee in Kerala During 1976-77

District	Area (ha.) Arabica	Robusta	Total	Production (T
Palghat	846	797	1,643	788
Cannannore	523	16.646	17,169	3547
Calicut	600	27,071	27,671	9651
Kottayam	7	1,233	1,240	559
Alleppey	—	19	19	1
Quilon	—	107	107	16
Trivandrum	29	19	48	3
Ernakulam	—	172	172	55
Idukki	888	3,654	4,542	705
Trichur	33	—	33	5
Total	2,926	49,718	52,644	15030

Home consumption and export of coffee

Home consumption		Exports		
Year	Quautity (T)	Year	Quantity (T)	Value (cr.)
1968	35,822	1968-69	28,741	17.96
1969	39,052	1969-70	32,383	19.62
1970	33,582	1970-71	32,189	25.11
1971	37,904	1971-72	35,695	22.07
1972	37,452	1972-73	50,855	32.93
1973	39,381	1973-74	52,688	46.01
1974	37,562	1974-75	49,467	51.36
1975	36,680	1975-76	59 386	66.65
1976	37,702	1976-77	50,558	125.75
1977	44,088	1977-78	55,827	230.46

Source:- "Indian Coffee", December 1978. Vol.XLII, No. 12.

Resume of work done.

Regular and systematic work on coffee research is being undertaken since 1930 at the Central Coffee Research Institute, Balehonnur (Karnataka).

At present 233 varieties and selections of *Coffea arabica* including exotic varieties are being maintained at the CCRI. Eighteen exotic and three subvarieties of *Coffea canephora* are also being maintained. In addition, 17 other species and Hybride De. Timor (*Coffea canephora* × *Coffea arabica*), *Coffea liberica* × *C. arabica* hybrid from Congo and some interspecific hybrids from Indonesia are also being maintained. *Coffea racemosa* received from Mozambique has been found to possess better aroma aud hardiness. Indian species, *Coffea wightiana*, has been found to be drought resistant. *Coffea racemosa* berries ripen in three months, the shortest period noted so far. Nematode resistance has been noted in hybrids. The hybrid *Coffea canephora* × *C. arabica* has been found to be tolerant to *Fusarium* wilt. But none of the types or species is found to have complete resistance or tolerance to all races of leaf rust.

Some of the promissing selections made at the Central Coffee Research Institute are as follows:

Coffea arabica S 288, S 947, S 33, S 795 and S 1934'
Coffea canephora S 274

Several other hybrids and cultures are under trial at CCRI.

The CCRI has standardised cultural practices for the different agroclimatic conditions.

Providing renovation trenches between lines along the contour during August-October has been found to be beneficial. Digging has been recommended at the end of monsoon in November upto a depth of 35–40 cm. for 2–3 years. When canopies are closed digging is not recommended. In grown up plantations, scuffling to control weed growth and conserve moisture, is recommended at the beginning of the dry period. Mulching is found to be useful. Weed growth can be effectively controlled using gramaxone as a post emergence spray or Simazine and Carmex as preemergence spray. Gramaxone has been found to be effective at the rate of 1.25 litres in 450 litres of water/ha.

Sprinkler irrigation has been found to be quite useful as an insurance against failure of blossom and supporting rains. Experiments have shown that sprinkler irrigation increased the number of nodes per branch, hastened ripening and gave higher yield of coffee. Irrigation once in 20-25 days from November to April has been found to be satisfactory. To maintain continuous growth, an irrigation of 40 mm was found adequate. 10-20 numbers of sprinkler heads or rainers can cover two to three acres per day in two shifts. However, there may be height variation depending upon the capacity of the pump and height to which it is to be lifted, etc. The installation cost will vary from Rs. 3000 to 6000/ha. depending upon the water source, availbility of electricity, etc. The operational cost may range from Rs. 150 to 300/ha. and the entire installation cost can be made good from the extra crop produced in three years.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. **Dwarf characters-** Dwarf & smaller plant type will be preferred and this may be exploited by hybridization.

2. **Photosynthetic efficiency and nutrient uptake.**

Coffee variety *arabica* is sensitive to intense light and high temperature. Under such conditions, stomatal functioning is impaired. Therefore it is necessary to produce plant types which have better photosynthetic efficiency and can be grown at higher temperatures and under low shade conditions.

3. **Improvement of quality.**

The important characters of quality of the coffee powder are body aroma and acidity. It is desirable that a correlation between these characters and physical as well as chemical characteristics of the beans is worked out for a proper evaluation of the quality ot the produce.

4. **Drought resistance.**

Under Indian conditions wet and dry conditions alternate and in certain years the dry period will be for four to six months. Therefore there is necessity to evolve specific varieties with drought resistance.

5. **Resistance to leaf rust.**

Coffee rust is caused by the fungus *Hemileia vastatrix* and about 26 races are recorded of which 13 races are prevalent in South India. None of the existing cultivated varieties is found to be resistant to all the races of coffee rust. Therefore, multiple line breeding is likely to contribute resistance or tolerance and therefore this line of work should have priority.

6. **Pest and disease resistance**

In addition to leaf rust, infestation of white stem borer on *arabica* and shoot borer on *robusta* are serious. Therefore, it is necessary to evolve varieties which are tolerant or resistant to these pests. Suitable control measures should also be standardised.

7. **Nutritional studies**

The effect of micronutrients, especially zinc, in die-back should be assessed and suitable recommendations may be made.

8 **Uniform ripening**

Harvesting at frequent intervals is quite expensive. The cost on this item can be reduced if ripening can be made more uniform. Recent studies havshown that ethrel application is of same use. Therefore the possibility of using plant growth substances for uniform ripening and for recommending large scale adoption need exploration.

9 **Technological studies**

Better processing methods are to be developed. Methods of packing to avoid 'staleness' also require experimentation and standardization.

C. TEA

INTRODUCTION

Tea is an important beverage crop which earns valuable foreign exchange to our country. Out of the Rs. 1455.65 crores earned by export during 1975-76, tea alone contributed 236.81 crores (ie. 18. 1%). Kerala ranks third in hectarage and fourth in production among the Indian states. The state accounts for 10 percent or the area under tea in India.

Area, production and yield (per hectare) of tea in different states of India

States	Area (ha.)			Production (T)			Average Yield/ha (kg.)		
	1973	1974	1975	1973	1974	1975	1973	1974	1975
1. Assam	185113	187408	188792	251825	265281	263055	1360	1416	1393
2. West Bengal	89025	88224	88785	110489	118028	111860	1241	1388	1260
3. Tripura	5461	5421	5467	3857	4166	3674	706	768	672
4. Bihar	459	459	459	23	37	18	50	81	39
5. U.P.	1810	1817	1817	840	908	980	460	560	319
6. Himachal Pradesh	4183	4183	4183	1127	1388	1391	269	332	333
7. Tamil Nadu	35044	35370	35481	56020	54676	60452	1599	1546	1704
8. Karnataka	1865	1874	1774	2873	2830	2892	1540	1510	1630
9. Kerala	37146	36907	36347	44898	42161	43215	1209	1142	1189
Total	360108	361663	363105	471952	489475	487137	1311	1353	1342

Area, and production of tea in Kerala during 1976-77

Districts	Area (ha.)	Production (T)
Trivandrum	1070	804
Quilon	2021	851
Kottayam	2333	664
Idukki	24063	34340
Ernakulam	30	—
Trichur	438	913
Palghat	662	1275
Malappuram	174	133
Kozhikode	3885	1214
Cannanore	1485	1450
Total	36161	41644

The average yield of tea in Kerala is below the national mark. The average yield is maximum in the case of Tamil Nadu, closely followed by Karnataka. There is immediate need to increase the productivity of tea in Kerala to keep our product competitive in the market, because the labour charges and the cost of production is more in Kerala.

The world consumption of tea is increasing at the rate of 5% per annum. The internal consumption in India went up by 75.7% during the period from 1964 to 1973. The increase was due to the population increase and faster urbanisation. However, the per capita consumption of tea in India is only 0.4 kg. per annum, while it is 3.81 kg. in England. 2.08 kg. in Australia and 2.66 kg. in New Zealand. These factors indicate that the demand for tea will increase both for the internal consumption and for export. The estimate is that the production has to be doubled by 2000 A.D.

Among the tea producing countries of the world India continues to be the largest producer contributing to about 48% in 1975. Srilanka which stood second in the list contributed 22% of the world crop. In export also India dominates the world market.

Exports of tea from India during 1968-69 to1975-76

Year	Quantity (T)	Value(Rs. in Cr.)
1968-69	200824	156.51
1969-70	174112	124.50
1970-71	214317	160.92
1972-73	198229	150.99
1973-74	190268	144.85
1974-75	229500	228.06
1975-76	212300	236.81

Resume of work done.

Tea research is being carried out mainly at two centres- one at Tokalai Experiment Station, Jorhat (Assam) by the India Tea Association (started in 1911) and the other at Cinchona (Coimbatore Dt.) Tamil Nadu under the control of the United Planters Association of South India (UPASI) which was ori-

ginally started at Deversala in 1925 and shifted to Cinchona in 1964. Another small Reasearch Station is functioning at Palampur under the control of the Punjab Agricutural university. It was established in 1925 by the Government of Punjab.

At the UPASI Tea Research Station, 23 clones have been selected so far of which Sundaram, Pandian, Athrey, springfield and Singara Swarna are important. Clones suitable for different tracts have been obtained. These clones are found to yield 3600 kg. to 6000 kg. per hectare.

Selection criteria for high yield and quality have also been standardised. Growth habits and yield potential are found to influence the quantity of the produce, while the pubescence and colour of the flush are found to influence the quality of tea. Pubescent leaves generally give good quality tea with better strength, flavour and aroma. Light leaved plants give better colour and strength to the liquor in addition to providing the flavour. Therefore, light green leaves with pubescence give the best tea with good flavour, strength of the liquor and better aroma. Between pubescent and light green, pubescent types are better.

The seed propagation and vegetative propagation by rooted cuttings were standardised. Rooted cuttings are commonly used because the resultant plants are more uniform and true-to-type. Tea, being highly heterozygous is found to give wide variation in seedling populations.

The requirement of NPK for different situations and for the different stages of growth have been standardised by UPASI.

The 'CTC' method of manufacture of tea was standardised and is being followed in different estates, while the 'orthodox' method is still continued in other plantings. Tata Firm at Munnar, Tokla and at Wentworth Estate in Nilgiris is manufacturing instant tea.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK.

The main objective of future research programmes should be to increase the productivity and production so as to double the output by 2000 A. D.

1. Clonal selection.

Ninetynine percent of the existing population was raised from seedlings. Being highly heterozygous, a wide range of genetic diversity is generally available in the population. This gives ample oppertunity for selection of high yielding, better quality bushes and for their multiplication vegetatively. Hence, this line of work should be intensified.

2. Hybridisation.

Plant hybridisation and selecting the desirable plant type from the hybrid population should also be undertaken for obtaining plants with high cup qualities, high yield and disease resistance/tolerance. In addition, the drought resistance and production of leaves throughout the year are also important desirable characters for increasing the productivity under Kerala conditions.

3. Nutritional studies

The effect of micronutrients in combination with macronutrients for increasing the yield and quality of tea also requires experimentation.

4. Control of pests and diseases

The etiology of the main pests and diseases should be carefully studied and their control measures standardised.

5. Technological aspects

i. Studies should be conducted to increase the out-turn at low cost.

ii. Studies in the standardisation of the use of tea in cold drinks.

iii. Standardisation of better methods of instant tea manufacture at low cost and without deterioration in quality.

7. PULSES AND VEGETABLES.

A. PULSES

INTRODUCTION

It is now widely recognised that the only practical means of solving the protein malnutrition problem in the developing countries is to increase greatly the production of the pulse crops. The pulses contain in their grains nearly three times the amount of storage protein found in cereals. Although the value of pulses has long been recognised their method of functioning through root nodule bacteria remained unknown until revealed by scientific investigations made late in the 19 th century. Conclusive evidence has shown that pulses differ from other food plants in having the property of obtaining, through symbiotic root nodule bacteria, combined nitrogen as an available nutrient from the inexhaustible supplies of inert nitrogen in the atmosphere. Our farmers also seem to have realised the value of pulses as agents of restoring soil fertilily. Their contribution to enriching soil fertility can be further enhanced by new scientific procedures such as pelleted rhizobial cultures.

In Kerala pulses are grown to an extent of about 38,440 hectares with an average production of nearly 13'768 tonnes and an verage yield of 340 kg/ha. The main pulses grown are:

1. Cowpea (*Vigna sinensis Endl*)
2. Greengram - Mung *(Vigna radiata L.) Wilezek)*
3. Blackgram - Urd *(Vigna mungo L. Itopper)*
4. Horsegram - Kulthi *(Dolichos biflorus L)*
5. Red gram - Arhar *(Cajanus cajan L.)*

The average yield of pulses in Kerala is rather poor and is the lowest among the Indian States. High rainfall, low per capita availability of cultivated land and farmers' preference for the rice crop-the staple food-over pulses are a few of the main reasons limiting the area under pulses in this state. The continuous cultivation of traditional low yielding varieties of pulses and the neglect of manuring and timely plant protection measures are some of the reasons for such a low yield in pulses.

RESUME OF WORK DONE

No detailed investigation on the problems of successful cultivation of pulses has been done in Kerala till 1963. A scheme for pulses research with one Research Assistant as technical staff was commenced at Sasthamkotta in Quilon district in 1963, with ICAR grant and it was shifted to the Rice Research Station, Pattambi, in 1966. The ICAR scheme was terminated in 1968 and thereafter it was continued as one of the state schemes. The subcentre of the All India Co-ordinated Project for intensification of research on the improvement of pulses started functioning at the Rice Research Station, Pattambi from November, 1976.

Collection of germplasm, adaptation trials, pure line selection from among the promising varieties and hybridization were the main items of work done under varietal improvement. Types numbering 50 to 100 in cowpea, blackgram, greengram and redgram were collected, grown and their agronomic attributes and other yield parameters studied. In cowpea two collections from Kozhikode district were found to be good yielders. Pure line selection in these two types was made and two high yielding lines viz., Calicut-51, and Calicut-78, were identified. Both these varieties are vegetable types and flower in 45 days and bear pods continuosuly for about a month. Calicut-51 is a green podded variety while Calicut-78 is purple podded.

In the adaptation trials New Era, C-152, Pusa Phalguni, Pusa Dofasli, and Pusa Barsathi were found to be promising and well adapted to Kharif and rabi seasons.

In Blackgram, varieties T-9. Co.2, S1 and No.55 were found to be high yielders.

In Greengram varieties Philippines, S8, Madira and Pusa bisakhi were found to be superior over others tried

Trials with soybean varieties revealed that the variety Bragg, was quite suitable for cultivation under Kerala conditions.

An attempt to improve horsegram through single plant selection was made in 1930-31 and continued upto 1939-40 when no culture was found to be promising and hence the work was discontinued. Later it was tried as a mixture with wild indigo in single crop lands after the harvest of the Ist crop paddy. No superior varieties have yet been identified in horsegram so far.

With a view to evolving a high yielding cowpea variety with short flowering phase, hybridisation work was initiated during 1975-76 using Pusa-Dofasli, Kolinji payar, P-118, Kunnamkulam local, New Era and Pusa barsathi as parents. Two crosses, viz.,

Pusa Dofasli x Kunnamkulam local and P-118 x Kolingi payar were successful. Selections are being made for the desirable combinations in the segregating generations.

A project for evalution of cowpea varieties was initiated in 1974-75 in order to identify early duration varieties possessing high yield potential. Five short duration cowpea varieties (New era, Pusa dofasli, Pusa Phalguni, P-118 and Pusa barsathi) were tested for their yield potential along with two check varieties (Calicut-78 and Kunnamkulam local). This trial which continued till 1976-77 resulted in the isolation of a dual purpose moderately high yielding locally adapted cowpea variety viz., PTB. 1. in the year 1977. (Kanakamony).

The most significant accomplishment of the Co-ordinated Project on Pulses during 1977 was the release of dual purpose (Grain as well as vegetable) cowea variety. This variety, named as PTB.1, is the first released variety of cowpea in the state evolved by pureline selection from the local Kunnamkulam variety.

PTB. 1 is a medium duration, bushy, moderately high yielding dual purpose cowpea variety which will mature in 75-80 days during kharif season and 65-70 days during rabi season. This variety is excellent as a green vegetable and equally good as pulse (grain) type. The protein content of this variety is 22.41%.

Current Activities

Maintenance of germplasm collections: This project is aimed at maintaining different varieties of pulses as genetic stock to provide materials for future research programme.

The following are the different pulse germplasm collections maintained at the All India Co-ordinated Project at Rice Research Station, Pattambi.

Cowpea	181 types
Greengram	49 ,,
Blackgram	21 ,,
Redgram	8 ,,
Soybean	4 ,,

These collections will be subjected to screening for high yield and pest and disease resistance.

Breeding high yielding cowpea varieties with short flowering phase: To evolve high yielding cowpea varieties with short flowering phase which can be grown in rice fallows, a trial was laid out. The seeds collected from the F3 generation plants of the two crosses viz., Pusa Dofasli x Kunnamkulam local, and P-118 x Kolingi payar made during 1975-76 were advanced to the F4 generation.

To estimate the yield potential of different varieties of cowpea and to select varieties suitable for the locality the co-ordinated varietal trials on cowpea are being conducted as directed by the Project Co-ordinator. The results obtained from these trials will be of much use in spotting out the best locally adapted variety.

To assess the best suited variety of blackgram for the locatity, an yield trial was laid out. The results revealed that out of the twelve varieties tried during 1976-77 kharif season viz., No. 55, D6-7, Sind-khed, No. 4, Type 21 Nedumangad local, NP-14, NP-15, C-2, T9, Si and No 45, the variety Sind-khed recorded the maximum yield followed by type 21 and Si. During 1974-75, the variety T9 recorded the highest yield while in 1975-76 NP-14 recorded the highest yield followed by type-21.

To estimate the yield potential and adaptability of different blackgram varieties produced all over India as directed by the Project Co-ordinator (pulses) a co-ordinated varietal trial was laid out. During the kharif 1977 an experiment was conducted with 13 varieties, viz., T9, Pant U-19, Pant U-30, UG-117, UG. 157, UG-152, Pant U. 26, NP. 3, M3, 4 5-2, KMU3 (culture 2), Culture 1 and Co. 2 (local check).

For evolving a high yielding short duration drought resistant blackgram variety by single plant selection, seeds of 92 single plants were collected from cultivators' fields of EDAKKAD, AJANUR, PERALAM PUTHUR, VELLOOR, KANKOLE, PULLOR and KODIYERI villages af Cannanore district in April 1977. Seeds of these single plants were sown in progeny rows to assess the harvest index, tolerance to drought and resistance to insect attack and fungus diseases. The performance of these lines is being adjusted.

To evaluate the yield potential of different varieties of greengram an yield trial was started in 1974-75 kharif season. Out of 8 varieties tried in 1974-75, 4 varieties, viz., Philippines, NP-36, NP-40 and Madira recorded maximum yield.

During 1975-76, the variety NP-40 recorded the highest yield followed by NP-36.

In 1976-77 trials, variety Philippines recorded the highest yield followed by NP-40.

To assess the adaptability and yield performance of horsegram varieties produced all over India as directed by the Project Co-ordinator (pulses), a co-ordinated varietal trial was laid out. During this Rabi season (1977-78) an experiment was laid out with the following varieties in RBD with 4 replications. NPK 1; 2, 3, 4, 5, 6 and 7, Hebbal I and 2; BGM-I, Co. I, PDPI, VZM. I, and local Pattambi variety. The performance of these varieties is being studied.

2. RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK:-

The future programme will be formulated on the following lines.

1. Improvement in plant type for intensive cultivation. Efforts will be made to develop high yielding, drought tolerent varieties of grain legumes with a relatively short maturity duration, which can be filled in a series of multiple cropping patterrs. These varieties will be expected to show an improvement in their plant type in the direction of a much higher harvest index.

This can be achieved by collection, growing and screening of germplasm obtained from major pulse growing areas in India and abroad. Yet another way to achieve this objective is by Mutation breeding.

2. Breeding varieties resistant to pests and diseases.

3- Breeding varieties with higher protein content.

4. Breeding varieties with a greater response to phosphorus than the present low phosphorus responsive varieties.

5. Investigation on the biological control of pea aphid *Aphis, cooccivora* by predatory insects, *Coccinellidus* and *Syrphids* are to be taken up for the mass raring potentital and host regulatory efficiency.

6. Evaluation of aphicides against *Aphis crassivora* and the associated predatory insects.

7. Studies en resistance spectrum of cowpee varieties against *Lampides boaticus*.

8. Seed treatment with systemic insecticides for control of pests occurring in the early stage of growth.

Germplasm collections on a world-wide basis offers the greatest possibility for the genetic improvement of grain legumes in the shortest possible time.

To make a major production advance in pulses, a genetic reconstruction of the existing plant types is essential. This has to be achieved by adopting recent plant breeding methods like hybridization and selection, Mutation breeding, etc. Efforts will be made to produce pulse (crop) varieties, with short flowering duration which can be fitted in multiple cropping and inter-cropping patterns. High yielding varieties with good fertilizer response, multiple resistance (insect pests) and high protein content must also be produced as long term breeding programme

INTRODUCTION

In Kerala there is no large scale production of vegetables. Vegetable growing is mostly limited to homesteads and to some extent in rice fallows and river beds during summer season where irrigation facilities are available. At present vegetables are grown only in an area of about 3,170 hectares, with an annual production of 2,750 tonnes and average yield of 878 kg/ha. There is vast scope for developing large scale vegetable cultivation around major cities and towns in Kerala, provided adequate research support is made available. At present the cultivators are facing numerous problems, like lack of suitable varieties adapted to local conditions, to complete with the imports from the neighbouring states. The major risk involved in vegetable cultivation is the high susceptibility of many vegetable c ops to numerous diseases and pests.

RESUME OF WORK DONE :-

At present the research results on many of the problems associated with vegetable growing are scanty. A serious attempt in this line is yet to be started in our State. A short cropwise review of the previous work done and the lines on which future work is to be oriented in important vegetable crops of our state are given below :-

Brinjal

In Kerala no substantial work has been done for the improvement of brinjal. In other parts of India, good progress has been achieved for the selection of high yielding varieties from the existing strains which resulted in the release of varieties like Pusa purple long, Pusa purple round, Pusa purple cluster, Pusa Kranti etc. The studies conducted in the College of Agriculture, Vellayani indicated the possibility of exploiting hybrid vigour. One of the major problems facing brinjal cultivation in Kerala is the high incidence of bacterial wilt. Work done in Vellayani has shown that *Solanum melongena*, var *insanum* possesses a dominant gene for wilt resistance, which can be easily transferred to cultivars.

Research work carried out on the pests of vegetables has been reviewed by a few workers from time to time. Detailed studies on the best complex associated with vegetable crops have been initiated at he Indian Institute of Horticultural Research, Hasartghatta. Most of the studies conducted so far relate to insecticidal control of major crops and very little attention on management methods like the use of hormone and hormone analogues, antifeedants and repellents and attractants. Seasonal occurrance of pests of important vegetable crops in relation to the associated natural enemy complex has been investigated at the College of Agriculture, Vellayani and the College of Horticulture, Vellanikkara. Evaluation of the relative contact and systemic toxicity of insecticides against pests of vegetables has also been carried out.

At Vellayani, hybridisation between *Solanum melongena* var, *insanum* and promising cultivars and irradiation of the Fl to increase recommbination potential are being attempted for evolving a wilt resistant variety.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. Selection of high yielding varieties from the collections made from within and outside the State is the first step to be made for the improvement of the crop.

2. Incorporating pest and disease resistance to selected cultivars.

3. Biological control of insect pests.

4. Studies on relative systemic toxicity and persistance of granular insecticides.

5. Evolving proper fertilizer recommendations.

Bhindi

Inheritance of various economic characters has been studied. Interspecific crosses to the best advantage of useful characters especially as a source of resistance to diseases and pests were attempted. Singh *et al* (1962) evolved a variety, *Pusa savani* which was tolerant to the Yellow-vein mosaic virus. But now, it has become susceptible. Studies on the possibility of evolving mosaic resistant varieties are in progress in the College of Agriculture, Vellayani.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. Breeding for Yellow-vein mosaic virus resistance, using the wild species *Abelmoschus manihot* as a donor parent.

2. Evaluation of systemic aphicides and other insecticides.

3. Biological suppression of fruit and shoot borers.

4. Evaluation of newer acaricides against the red spider mite.

5. Evolving fertilizer recommendations.

6: Relative systemic toxicity and persistence of granular insecticides applied at sowing time against major pests.

Chillies

Good strains have been evolved in different parts of the country where they are itntensively grown for dry as well as green chillies. In the important chilli-growing states efforts were made by the breeders to evolve suitable strains. In some of these areas there has been a set back because of the serious Incidence of virus diseases especially the leaf curl complex diseases. Attempts have been made to breed high yielding varieties coupled with resistance to disease and high Vitamin C content. The probable source of resistance to virtue disease was reported by Jayarajan and Ramakrishnan (1969). Studies were conducted in Kerala to investigate the association between fruit yield and contributing characters. Interspecific hybridisation studies revealed that the promising economic combinations were *C. frutescens X C. buccatum and C. pendulum X C. microcarpum*. Exploitation of heterosis was also found to be feasible in some studies with inter-varietal hybrids. It has been observed that *C. frutescens* is tolerant to most of the virus diseases.

Exploitation of hybrid vigour and estimation of combining abilities with regard to important economic tracts are being studied. Hybridisation involving 29 genetically divergent varieties collected from different agroclimatic regions is in progress.

Research gaps identified and future line of work:-

1. Introduction of varieties and selection of varieties for the agroclimatic conditions of Kerala,
2. Screening of local and introduced varieties for diseases and pests.
3. Breeding varieties resistant to diseases and pests.
4. Evolving fertilizer recommendations.

CUCURBITS

Much genetic variations exist in curburbits, because of high degree of cross pollination. Some of the genetic materials have been profitably used within the last few decades and some excellent varieties have been evolved in Pumpkin, bittergourd and ash gourd. The new pumpkin variety *Arka Suryamukhi* is reported to be the first variety to be resistant to common fruit fly. In bottle gourd, *Pusa meghdut* and *Pusa majari* are reported to be heavy yielders. Information regarding breeding disease and insect resistant varieties of these cucurbits is also available.

Selection of suitable varieties in pumpkin, bitter gourd and snake gourd is in progress at Mannuthy. Collections of these vegetables were raised during the summer of 1977 and promising types have been identified.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. Collection of types of all cucurbitaceous vegetables and selection of superior varieties.
2. Breeding for disease and insect resistance.
3. Control of fruits flies with bait sprays.
4. Evaluation of attractants for fruit flies.
5. Insecticidal control of *Aulacophora* spp.
6. Evolving fertilizer recommendations.

TOMATO

Most of the outstanding varieties cultivated in India were introduced from the Western countries and some of them became popular among cousumers and growers in different agroclimatic regions depending upon their adaptability. The Division of Plant Introduction at IARI, New Delhi, has introduced till now almost all the important tomato varieties from all over the world which have been evaluated for various purposes. Some of the introduced American varieties like Sioux, Marglobe etc were recommended for commerical cultivation. An outstanding achievement was made at IARI, when the new tomato variety *Pusa rubi* was evolved by crossing Sioux with improved Meeruti, an indigenous hardy variety. Recently the new tomato Co_1 from Tamilnadu, Pusa Early dwarf, S_{120} and Pusa Lal Meeruti trom IARI, S_{21} from Punjab and Kalyanpur from Uttarpradesh have been reported to perform well in these states.

At present emphasis is to breed tomato varieties resistant to diseases and pests which have become a limiting factor in tomato cultivation in various regions. In Kerala, bacterial wilt disease is a very serious problem, the infection being as high as

100%. At Vellayani, attempts were made to evolve resistant variety by hybridisation of the local varieties with exotic resistant varieties.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK:-

1. Interspecific hybridisation with a view to evolving a variety resistant to both bacterial and fungal wilt.
2. Introduction and selection of varieties resistant to wilt and also having other economic characters.
3. Evolving fertilizer recommendations.

AMARANTHUS

Though rich in nutritive value, amaranthus has received little attention in the maintenance and improvement programmes. Co_1 is a variety of amaranthus released by Tamilnadu while IARI has recommended varieties *Badi Chowlai* and Chotti *Chowlai*

In Kerala no research work has so far been taken up on the improvement of Amaranthus.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK:-

1. Collection and maintenance of all the varieties available in the various tracts of Kerala and study of their performance in the different agro-climatic conditions.
2. Introduction and selection of high yielding varieties.
3. Evolving fertilizer and other cultural recommendations.
4. Control of *Lepidopterous* pests of amaranthus with the bacterium *Bacillus thuringiensis*
5. Evaluation of J. H. Analogues against *Hymenia recurvalis* and *Psara Bipunctalis* infesting Amaranthus.

8 TUBER CROPS

The following crops are of great importance to Kerala.

1 Tapioca
2 Sweet potato
3 Other Tuber crops
   i) Yams (Amorphophallus and Dioscoreas)
   ii) Colocasia
   iii) Coleus
4 Coll season root crops

In addition to the above potato, carrot, radish and beet root can also be grown in the high ranges of Kerala.

A. TAPIOCA

INTRODUCTION

The area under tapioca in Kerala state is estimated to be 3.23 lakh hectares with a total production of 51.25 lakh tonnes. The average yield of tapioca in the state is 15855 kg per hectare. The year-wise area under tapioca and its production as well as average yield in Kerala for the period, from 1955-56 to 1976–77 are given below.

Year-wise Area ('000ha), Production ('000 tonnes) and Average yield of Tapioca in Kerala

Year	Area (in '000 ha)	Production (in 000 tonns)	Average yield (kg/ha)
1955-56	222.13	1594.10	7061
1960-61	242.20	1683.00	6949
1965-66	229.68	3095.66	13478
1970-71	293.55	4617.19	15729
1972-73	304.83	5692.36	18674
1973-74	306.45	5659.52	18468
1974-75	317.88	5625.12	17696
1975-76	326.87	5390.22	16491
1976-77	323.28	5125.52	18855

Detailed district-wise area and production are given below.

District-wise Area and Production of Tapioca (1976–77)

District	Area (in ha.)	Production (in tonnes)
Trivandrum	66633	946189
Quilon	85816	1414248
Alleppey	28677	433596
Kottayam	40262	812487
Idikki	9759	184933
Ernakulam	14334	215010
Trichur	9225	134224
Palghat	7954	130605
Malappuram	29338	344722
Kohzikode	8574	96715
Cannanore	22706	412795
State Total	323278	5125524

The area has increased from 222130 hectares to 323280 hectares from 1955-56 to 1976–77. With this 50 per cent increase in area the production rose from about 300 per cent (from 1594100 tonnes to 5125520 tonnes). This can be attributed to the contribution by research such as improved methods of culture and popularisation of high yielding vartieties.

Resume of work done

In Kerala research works on tapioca was first started under the Botany Department of the Kerala University. With the establishment of C. T. C. R. I., at Trivandrum intensive research on all aspects of the crop was being conducted. The important items of work carried out so far cover collection of germplasm, selection from introduction and intervarietal and interspecific hybridizations. Some of the introductions like M4 have gained popularity and large scale acceptance in the state. The breeding progamme launched by the Institute are aimed to evolve varieties that suit different purposes for which they are uilized viz, human consumption, industries and cattle, feed. A number of outsandintg hyprids capable of giving higher yields with better quality have been evolved and released. Recently two varieties of tapicoa were released viz. Sree Visakham (H. 1687) Sree Shaya (H 2304) which gave average yields of 44.05 and 44.90 tonnes per hectare. Earlier high yielding hybrid varieites viz. H. 97, H.165 and H. 226 were also releasd by the C. T. C. R. I.

Detailed investigations to determine the best standards of culture, manuring, water management etc. to increase productivity; investigation of the physiological, biochemical, post-harvest technology and economical aspects of these crops; and survey investigation and control of major diseases and pests are the principal research activities of the Institute,

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

The efforts at tapioca improvement may be directed in the following lines for producing cultivars that

a) are high yielding
b) are resistant to pests and diseases particularly mosaic bacterial wilt disease.
c) Contain low levels of prussic acid, particularly for cultivars intended for use as food.
d) produce high quality tubers with a high content of starch aud low content of fibre·

e) are able to mature early and yet do not deteriorate if they are not harvested immediately.

f) have a high protein content

g) have stout non-spreading roots and minimum of foliage

h) are adapted to a wide range of environmental conditions.

In addition to the improvement auggested above studies on the following aspects also requlre immediate attention.

1) Studies in the time of planting

2) Studies on planting material and the best mode of propagation.

3) Determination of optimum spacing for each variety.

4) Optimum nutrient repuirement

5) Studies on intercropping in coconut gardens, alone and in suitable combinations.

6) Studies on maturity index in relation to quality and yield.

7) Studies on physiological factors influencing tuberization.

8) Studies on storage

9) Studies on processing methods

10) Studies on industrial uses viz, utilization of tapioca starch for the manufacture of automobile fuel, alcohol, etc.

B. SWEET POTATO

INTRODUCTION

Sweet potato is grown in nearly all parts of the tropical and subtropical world, and in the warmer areas of the temperate regions. In Kerala sweet potato occupies an area of 5400 hectares with an annual production of 26837 tonnes. The average yield of sweet potato in the state is nearly 5 tonnes. The year wise area of sweet potato in Kerala for the period 1955-56 to 1976-77 are given below.

Year	Area in '000 ha.
1955-56	8.40
1960-61	8.03
1965-66	8.21
1970-71	5.43
1972-73	5.33
1973-74	5.42
1974-75	5.40
1975-76	5.88
1976-77	5.96

There is a trend of general decline in area under sweet potato which is evident in the table given above.

RESUME OF WORK DONE

At the C. T. C. R. I. intensive research work on sweet potato on various aspects is in progress. Some work on the same crop is also in progress at the college of Agriculture, Vellayani. Introduction of varieties from all over the world, and selection from introductions and intervarietal hybridisation are the improvement works being carried out. The presence of incompatibility and nonflowering habit in certain clones are the major handicaps in the hybridisation work. Three sweet potato hybrids evolved by the C. T. C. R. I. viz, H. 268, H. 478 and H. 620 have been found to be promising in the district trials. H. 620 was found to be quite suitable for paddy fallows during January-April. Two promising varieties of sweet potato developed at the Institute recently viz, O. P. 1 and O. P. 2 are now under minikit trial in 100 farmers' fields in different parts of Kerala.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

The aims of crop improvement in sweet potato follow the general aims of crop improvement generally.

1) Higher yields

2) Resistance to diseases and pests especially sweet potato weevil.

3) Shorter growing season

4) improved tuber quality

In addition the following aspects are also to be explored

1) Determination of optimum time of planting for different regions.

2) Studies on planting material and the best mode of propagation.
3) Determination of optimum spacing
4) Optimum nutrient requirements
5) Studies an maturity index in relation to quality and yield.
6) Studies on physiological factors influencing tuberisation.
7) Studies on processing methods.
8) Determination of optimum water requirement

C. OTHER TUBER CROPS

(Yams, Colocasias and Coleus)

INTRODUCTION

Yams and colocasias were part of the traditional system of cultivation in Kerala from early times. They are characterised by high starch content and better keeping quality apart from the high yielding potential which is common to most tubers.

Yams, colocasias and coleus together occupy an area of 31800 hectares with an annual production of 3,10,000 tonnes.

RESUME OF WORK DONE

The C. T. C. R. I., Trivandrum has initiated collection of varieties of these tuber crops. Apart from this no systematic work for their improvement by way of agronomic studies and breeding work has been undertaken on these tuber crops.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

The problems facing the tuber crops viz. Dioscoreas, Elephant foot yam, Colocasias and Coleus are numerous. Indeed most of the problems facing crop production in the developing contries seem to be present in the case of these tuber crops also. Future line of work is therfore suggested in all aspects of studies.

a) Germplasm collection: A wide range of variations exist in all the kinds of tuber crops dealt with. Therefore an exhaustive collection from within India and outside has to be taken up and the most promising types are to be selected for further experimentation.

b) Adaptability trial

Since suitability of varieties to agro-climatic regions is an important criterion for successful cultivation, the superior varieties isolated must be subjected to adaptability trials and named varieties released.

c) Determination of optium cultural and manurial requirements viz, tillage, spacing, intercultural operations and NPK requirements and season of planting.

d) Optimum irrigation requirement

e) Selection of planting material and determination of the optimum size of the planting material. In yams yields of 12.5 tonnes per hectare are considered good but the quantity of tuber produced is only about five times the quantity of tuber planted. As a consequence the farmer can only sell or utilize four-fifths of his harvest; he must have one-fifth of it for use as planting material. There are very few other crops where the ratio of material planted to material harvested is so low. Unlike tapioca and sweet potato, where the commercial planting material is not edible, yam is commercially propagated by tuber material which could alternatively have served as food. Therefore the determination of optimum size of seed material is of great importance to yams.

f) Shortening the growing season
g) Increasing the yield by hybridisation
h) Tolerance to diseases and pests
i) Production of semi-erect varieties
j) Production of stout, ovoid tubers having a tough skin resistant to bruising.
k) Have a high protein content and a desirable flavour and texture in the cooked form.

D. COOL SEASON ROOT CROPS

Potatoes, radish, carrot and beet root are the cool season vegetables that could be grown mostly in high ranges only. While potato can be grown only in the hills having high elevations the othe three root crops can be cultivated in the plains also to a limited extent. Therefore to start with introduction and selection of the above root crops also deserve attention.

9. OIL SEEDS

A. SESAMUM

INTRODUCTION:

In Kerala, the total area under sesamum is 11782 hectares and production 3265 tonnes. The average production is 260 kg/ha. The per hectare production has shown a decreasing trend in the last 20 years from 321 kg/ha in 1955–56 to 260 kg/ha in 1975-76. Sesamum is grown in an area of 7270 hectares in the coastal sandy tract of Central Travancore (Onattukara). This area is included in the Quilon and Alleppey Districts. Here sesamum is grown as a third crop in the low land paddy fields during December to April. This is the main production centre for sesamum in the State because nearly 2/3 of the total production is from this area. As an upland crop sesamum is grown in an area of about 3814 hectares in the Central Districts of Ernakulam, Trichur, Palghat and Malappuram during August to December. However, the state produces only a fraction of its requirements of sesamum oil and hence depends on the neighbouring states for meeting its demands.

RESUME OF WORK DONE

A scheme for research on oil seeds started functioning at Mavelikara in 1958. It was shifted to the Rice Research Station, Kayamkulam in 1962. Because of its location at Kayamkulam the scheme was concentrating on the improvement of sesamum in the low land paddy fields of Onattukara. The main object of the scheme is to evolve high yielding varieties resistant to pests and diseases and to conduct agronomic and manurial experiments to determine the most economic cultural and manurial practices for the crop. The following are the salient research findings and achievements in the scheme.

An improved variety: 'Kayamkulam - 1" was evolved by pure line selection in the local variety and reared for general cultivation in 1971. It is a short duration high yielding variety having 80-85 days duration with 20-30' per cent increased seed yield over the local variety. This variety is very popular in the Onattukara region and similar areas.

A spontaneous multipoded mutant was isolated from the variety Kayamkulam – 1. This is being developed into a high yielding variety.

The best time of sowing was determined as the first week of January.

The optimum seed rate is 5 kg/ha.

Optimum spacing is 15cm×15cm. Broadcasting seeds evenly is the recommended practice for ensuring uniform stand of the crop.

Interculture twice on the 15th and 25th days after sowing was found to be the best. During the two intercultural operations the crop shold be thinned to a spacing of 15cm×15cm.

Usually the crop is grown under rainfed conditions. Significant increase in yield was recorded when irrigation was given twice at vegetative phase and once at reproductive phase.

The optimum NPK reqnirement is 30 kg N, 15 kg P_2O_5 and 30 kg. k_2O per hectare over a basal dressing of 5 tonnes of cattle manure or compost.

Urea was found to be the best nitrogenous fertilizer for the crop.

Nitrogen applied in two split doses gave the best results. A basal dose of 15 kg/ha should be applied in the soil and the second dose of 15 kg. is to be given as a foliar spray of urea (2% concentration) 2 days after sowing.

Irrigation experiments conducted at the Agronomic Research Station, Chalakkudy have indicated that surface irrigation during the critical stages of 4 to 6 leaves, branching, flowering and pod formation resulted in an increase in yield by 35 to 52%. Two irrigations, one at the vegetative phase (4-6 leaf stage of branching) and the other at the repoductive phase (flowering or pod formation) was the best registering maximum yield and water use efficiency. In case of single irrigation it can be best given in the reproductive phase either at flowering or at pod formation.

Basic research on certain aspects related to the improvement of sesamum was conducted at the College of Agriculture, Vellayani. The salient findings are:-

Increase in pod setting and seed yield was observed when plants where sprayed with the growth regulator 2, 4-D at the time of flowering. However, a decrease in oil content of seeds was noticed in treated plants.

Application of the male gametocide FW. 450 ten days prior to flowering was effective in inducing

pollen sterility as the first step for exploitation of hybrid vigour in this crop.

Tetraploids were induced with a low frequency by colchicine treatment. The oil content of seeds in tetraploids was low. The tetraploids did not breed true in later generations.

Gamma rays at medium doses (20 to 30 K rad) was found to be effective in inducing mutations.

Research on sesamum is being continued at Kayamkulam. The following projects are now undertaken.

1. Maintenance and evaluation of germplasm. A total number of 86 local and introduced varieties are being maintained. These varieties were evaluated on the basis of characters such as plant height, number of branches, number of pods and yield of seed. Based on yield potential, 30 varieties were selected for further detailed comparative studies.

2. Varietal trial:- The objective is to develop the best suited variety for the wet lands of Onattukara. Initial evaluation trials have revealed that the multipoded mutant, Vayalellu, KRR-1 and TMV-3 are suitable to the locality in addition to Kayamkulam-1.

3. Initial evaluation trial of hybrid cultures: Fifteen multipoded cultures derived from the cross between PT. 58-35 and Kayamkulam-1 are under evaluation trial. There cultures appear to be promising. The trial is being continued.

4. Yield trial of multipoded mutant. The multipoded spontaneous mutant isolated in Kayamkulam-1 during 1969 has recorded higher yields. Evaluation trials of this mutant are in progress.

5. Determination of suitable agronomic practices to obtain uniform population in the bulk crop of sesamum.

6. Study of the multipoded mutant at different levels of NPK.

7. Studies on the diseases of sesamum and their control.

8. Invsstigations on the effect of graded doses of P and K on the yield and oil content of sesamum. This is undertaken at the College of Agriculture, Vellayani.

3. RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK.

In spite of the fact that sbout a third of the area under sesamum is in the uplands of the central districts very little attention is paid on its improvement in this area. This problem deserves immediate attention. The season is from August to December and varieties maturing in 100 to 110 days are cultivated. An important problem during this season is the heavy incidence of diseases. Some work on varietal screening was done at Kayamkulam but the upland conditions in the central districts are different from those at Kayamkulam. The work on improvement of sesamum in the uplands must be located at Mannuthy or Pattambi.

1. About 1/3rd of the area under sesamum in the state is in the central districts of Ernakulam, Trichur, Palghat and Malappuram. In this area sesamum is grown under upland conditions in Palliyals and modan lands. High yielding varieties suitable to these conditions have to be evolved.

2. High yielding short duration varieties are necessary for the wet lands of Onattukara.

3. Varieties resistant to drought and phyllody disease have to be evolved.

4. Multiplication and distribution of seeds of improved varieties have to be undertaken. Conditions for storage of seeds have to be standardised.

5. Management practices including cultural operations and manurial schedule have to be standardised for wetland and upland conditions. These practices will ensure uniformity in plant population under field conditions.

6. Lack of irrigation facilities leads to uneven stand and yield fluctuations.

7. The multipoded mutant isolated from the variety Kayamkulam-1 shows variable expressivity. Optimum cultural and manurial requirements have to be evolved for this variety.

B. GROUNDNUT

INTRODUCTION

Groundnut is cultivated in an area of 17510 hectares in Kerala with an annual production of 23148 tonnes. Thus the average yield works out to 1322 kg/ha. The area under the crop increased from 13200 ha. in 1955-56 to 17510 ha. in 1975-76 ie. by nearly 32% in the last 20 years. The per hectare yield increased from 1096 kg. to 1322 kg ie. by 20.6% during the same period. The entire area under groundnut in Kerala is in Palghat district.

As a rainfed crop groundnut is grown during the period from May to September. This is the peak growing season in the State. The rainfall pattern in Palghat district is highly favourable for the crop during the above season. The varieties recommended are TMV-1, TMV-2, and Pollachi-3. The seed rate (Kernel) is 75 kg/ha for spreading type and 100 kg/ha for bunch type for pure cultivation. For mixed and intercrop the seed rates are comparatively low. Seeds are dibbled at spacing of 25 cm × 25 cm for spreading and 15 cm × 15 cm for bunch varieties. A manurial schedule of 2 tonnes of cattle manure or compost, 1 to 1.5 tonnes of lime and NPK at doses of 10,50 and 40 kg/ha are recommended. Cattle manure is applied as basal dressing and lime at the time of flowering. Weeding, inter-culture and manuring should be over by 45 days after sowing. Disturbing the soil afterwards will interfere with the normal setting of pods and lead to reduced yields. Red hairy caterpillar and leaf roller, the two major pests can be controlled by dusting B. H. C. 10%. Tikka leaf spot disease can be avoided by prophylactic spraying of Bordeaux mixture.

RESUME OF WORK DONE

Preliminary trials have indicated that groundnut can be profitably grown as a mixed crop or companion crop with tapioca in the uplands. Bunch varieties of groundnut such as TMV-2, TMV-7, Pollachi-1 and Pollachi-2 can be intercropped with the non-branching tall growing tapioca variety M4. June is the best time for planting tapioca and groundnut. Tapioca setts may be planted 0.5 m apart on mounds. Groundnut seeds are dibbed on the same day at a depth of 5 cm. on both sides of the ridges at a spacing of 20 cm. Sufficient space has to be left at the lower side of the ridge. In case of mounds, groundnut seeds can be sown 25 cm. apart in concentric circles. In the top circle 6 seeds are dibbled 25 cm below the tapioca set and 14 seeds in the second circle below. Basal manuring can be given at the rate of 1 kg. organic manure per tapioca set and 200 kg. 17:17:17 mixture per hectare at the time of land preparation. 500 kg. each of fresh lime and ash per hectare can be given as first top dressing at the time of flowering of groundnut ie. 30 days after sowing. Earthing up and weeding are done at this time. The soil should not be disturbed after 45 days from sowing. Second top dressing can be given after the harvest of groundnut ie. 90 to 100 days after planting. Tapioca may be earthed up after incorporating 100 kg of 17:17:17 mixture per hectare. Normal plant protection measures recommended for the pure crop of groundnut may be adopted.

There is considerable scope for cultivating groundnut in non-traditional areas as inter-crop in coconut gardens and as catch crop during third crop season in double crop paddy fields. Preliminary trials have indicated that groundnut can be profitably cultivated during January to May in the wet lands of Onattukara as an irrigated crop. The possibility for groundnut cultivation in non-traditional areas and seasons needs detailed investigations.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. Varieties evolved in Tamilnadu are grown at present. High yielding varieties suitable to conditions existing in our state will help to extend the cultivation of groundnut to new areas and increase production.

2. There is scope for cultivating groundnut in non-traditional areas as inter-crop in coconut gardens. Vareities suitable for such conditions have to be evolved.

3. Preliminary studies have indicated that groundnut can be profitably cultivated during January to May in the Wetlands of Onattukara after the second crop paddy as an irrigated crop. Suitable short duration varieties have to be evolved.

4. Groundnut can be grown as a companion crop with tapioca in the uplands. High yielding bunch varieties have to be evolved for popularising this practice.

5. Evolving varieties with high shelling outturn and oil content.

6. Investigations on pests and diseases and the development of resistant varieties.

7. Management practices and fertilizer schedule have to be standardised for the following situations.

a. as a pure crop in wetlands.

b. as a pure crop in uplands.

c. as an inter-crop in coconut gardens

d. as a companion crop with tapioca.

8. Study of the role of the major and minor nutrients including the dose and time of application.

9. Liming is a regular practice in groundnut. Dose and time of application of lime in the soil types have to be standardised.

10. Assessment of irrigation requirement.

11. Development of suitable machinery of cheap and effective harvesting.

12. Formulating effective methods of controlling birds and rats.

C. OTHER OIL SEEDS

INTRODUCTION:-

The important crops grown in the state coming under this category are castor, oilpalm and sunflower. Castor is grown throughout the state in small scattered holdings. Oilpalm and sunflower are gaining popularity in recent years. As such figures on acreage and production of these crops are not available.

RESUME OF WORK DONE

Very little work is done in Kerala for the improvement of these crops with the object of increasing production. The department of Agriculture and Plantation Corporation are popularising the large scale cultivation of oilpalm in the state. The varieties Tenera and Dura are recommended for cultivation. Seeds are germinated under controlled conditions and seedlings raised with great care and attention. Twelve to fourteen months old seedlings are planted in the field at a triangular spacing of 100 metrs. Field operations include the maintenance of a suitable ground cover, pruning of leaves and manuring. The recommended doses of fertilizers for palms which have not started bearing are 225 g. N, 225 g $P_2 O_5$, 450 g. K_2O and 175 g Mg O per palm per year. The doses for productive palms are double that of the above. Fertilizers are applied in two doses during the pre-and post-monsoon periods. The doses can be corrected based on the results of leaf analysis. Assisted pollination is necessary in order to ensure complete fruit setting in the branch especially during rainy season and also when a number of palms is in female phase. The ripe fruits are harvested, processed and oil extracted.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. The feasibility of introducing varieties castor' oilpalm and sunflower released elsewhere and suited to our conditions will have to be tried.

2. Studies on optimum manurial requirements and suitable cultural practices will have to be conducted.

3. The influence of temperature on quick germination of oil palm seeds is an aspect to be studied.

4. influence of environmental factors on the physiology of flowering in oil palm has to be studied.

5. The possibility of mixed cropping in oil palm plantation has to be studied.

6. Pest and disease aspect of these crops need. investigation.

10. ESSENTIAL OILS & MEDICINAL PLANTS

A. ESSENTIAL OILS

GENERAL INTRODUCTION

Essential oils can be defined as odoriferous bodies of an oily nature obtained mainly from the plant kingdom. They are liquids under ordinary temperatures and volatilise without undergoing decomposition. These oils constitute indispensable ingradients of the necessities in many spheres of human activity. They are adjuncts of cosmetics, soaps, pharmaceuitcal preparations, perfumary, confectionary, ice creams, aerated water, disinfectants, tobacco, agarbathy incenses etc. Thus with such a wide internal usage and export possibilities, the essential oil industry in India has a vast and expanding business potential. Our total annual exports of aromatic materials and essential oils is now around Rs. 15 Crores, out of which 85 percent is shared by oil Sandalwood, Lemongrass and Palmarosa oil.

Kerala state, stratigically located in the southern part of India, and enjoying the varied locality factors like a high rainfall, temperature, elevation, proximity to the sea, varying soil conditions etc. is ideally suited for the several types of Aromatic plants. Kerala is having the monopoly in the production of Lemongrass oil. It is also started producing Vetiver Oil, Cinnamon leaf oil, *Eucalyptus citriodora* oil, Palmarosa oil etc. It can also produce oil of japanese mint, sweet basil and pachouli.

Lemongrass Research Station, Odakkali is the only centre in Karala, if not, in South India where studies on all aspects of Lemongrass, Vetiver, Palmarosa etc. are carried out systematically and several useful salient results were obtained.

LEMONGRASS (Cymbopogon flexuosus)

INTRODUCTION

Lemongrass oil of commerce popularly known as 'Cochin oil' in the world trade, is obtained from the red stemmed plants which is a very hardy one. Its cultivation is comparatively easier and the costliest inputs viz. fertilizers and P. P. Chemicals can be avoided. Moreover a fairly good return can be obtained from the third month onwards up to the 5th year at intervals of 2 months. Kerala state produces 750 MT. per annum whereas the total production in India is 800 MT. annually.

RESUME OF WORK DONE :-

The important work and the salient findings obtained at Lemongrass Research station, Odakkali, are given below.

441 type collections of Lemongrass are maintained. OD-19 is an improved variety released after screening and conducting yield trials. It gives 100% increase in the oil yield over local types with 85-90% citral content in the oil. The mode of reproduction may be sexual. The anthesis takes place by 3 AM and may continue up to 10 AM, the maximum activity being at 5.30 AM to 6.30 AM. The hot water treatment to incapacitate the pollen without injuring stigma has shown that treating the panicle before emergence at 50.5° for ten minutes may yield good results.

Transplanting of seedlings is found to be better than planting slips. The close spacing of 15×10 cm. gives the maximum grass and oil yield. The application of 2600 Kg. of compost and 1875 Kg. of wood ash per hectare per year was good for obtaining higher yield. Fertilizer application at higher levels did not yield results commensurate with the cost of production, in the past. But another trial conducted recenlty at Odakkali, it was found that 100 Kg. N/ha, in four splits gave increased yield of oil. Out of the seven micronutrients tried viz. Cu, bo, Zn, Mn, Fe, Mo & Si, copper gave significant increase in the grass yield. The yield of oil remained unaffected by the application of those microelements. 60 to 65 days interval of harvest was found to be the best for obtaining maximum oil production in the case of OD-19 when it was grown in hill tops. But when it was grown in lower areas 50 to 55 days were found to be sufficent.

In the distillation studies conducted it was found that providing a perforated disc above the water level in the country still will improve physical property of oil, when distilled. Distilling by using direct steam and under 20 lb. presure decreased the time of distillation and improved the physico-chemical property of oil. Condenser tube in coiled shape was found be more efficient in cooling the distillate compared to vertical tube. Wilting of grass in shade for 48 hours and comminution (reducing the shape) resulted in increased recovery of oil. Using the Aluminium container and keeping

in dark room was the best method of storage of oil without affecting the quality due to oxidation.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK.

About 15000 MT. of Lemongrass oil are annually required to meet the demand of our perfumary and pharmaceutical industries and for export need, where as the production figure remained static as 800 MT. for the last few years. To bridge the gap the research projects are to be taken up immediately with the following objectives.

To evolve a hybrid variety by adopting mutation breeding and polyploidy to increase the oil yield from unit area and the citral content. Breeding for tolerance to diseases like little leaf, blast and blight etc. are to be attempted.

The agronomic requirements of the crop when grown as intercrop with coconut are to be found out.

To design new type of stills and improve the existing design of country still to increase the efficiency of the distillation.

To study the non-citral constitutents in the oil with a view for exploiting its industrial utility.

VETIVER

INTRODUCTION

The essential oil distilled from the roots of *Veteveria zizanioides* is in considerable demand and is mainly used as a fixative in perfumery for blending in cosmetics and soap industry. The annual requirement of the oil is about 20 MT, whereas the production ranges from 7-10 MT.

RESUME OF WORK DONE

There as a number of varieties such as Musanagar, Bharatpur, Nilambur etc. Of these 'Nilambur' variety is a high yielder. Planting in beds gives higher yield of roots than planting in ridges. Planting of the crop in the month of May and June gives slightly higher yield of roots whereas June and July planting is better for getting increased oil production. Application of 20 Kg. of $P_2 O_5$ and 20 Kg. of K_2O per hectare is found to be beneficial for higher yield of roots and oil. Out of the Hybrids available at I. A. R. I, Hybrid clones-3 and Hybrid clones-2x are found to be promising strains. 12 Hybrid clones received through the Project Coordinator of ICAR on Aromatic & Medicinal Plants are being multiplied for conducting varietal trial.

The oil content in the roots was highest when harvested after 18 months at Pattambi and at Ambalavayal. In the Lemongrass Research Station, Odakkali also harvesting of the crop 17-18 months after planting has given maximum matured roots and oil yield. The essential oil is located in the external parenchymatous cells and the glandular hairs. Chopping of the roots into bits 4-5 Cm. in length makes the release of oil easier and recovery higher. Storage of roots after harvesting results in the loss of oil, particularly during the dry months of the year.

In order to prevent formation of troublesome emulsions, the distillate is kept running quite warm from the beginning until the end of distillation. The properties of Vetiver oil depends on the age of the root material and the length of distillation.

RESEARGH GAPS IDENTIFIED AND FUTURE LINE OF WORK:

The annual requirement of the oil is much less than the production. In order to achieve self sufficiency the following steps are to be taken.

Breeding for producing hybrids with desirable root characteristics and oil yield.

Development of suitable agronomic practices on planting, manuring and harvesting especially as an intercrop in coconut gardens.

Standardisation of suitable distillation technique under steam and water method for reducing the time of distillation (now 48 hours are required for completing one distillation)

Study of the physico-chemical properties of oils and their constituents for industrial utilisation.

PALMAROSA

INTRODUCTION

Essential oil of Palmarosa is produced from the flowering shoots and leaves of the plant. It is a good foreign exchange earner and occupies the third position in exports of essential oils. The present estimated demand for oil of Palmarosa is 50 MT which is likely to be increased upto 100MT. But the present production is only 25 MT. It is widely

used in the soap and and perfumery industries and for flavouring tobacco. Palmarosa crop was introduced at the Lemongrass Research Station, Odakkali from Maharashtra a few years ago and it has been found that the crop can be recommended for large scale cultivation in selected areas in the plains of the state as a rainfed crop. The cultivation and processing of this crop is similar to that of Lemongrass. The price of the oil is more than double of the Lemongrass oil.

RESUME OF WORK DONE

Cymbopogon martini variety Motia is propagated mainly by seeds although vegetative propagation is also possible. Transplanting is often practiced. Fertilizer trial conducted at Lemongrass Research Station, Odakkali has shown that application of lower doses of NPK did not increase the oil yield. Harvesting grass 5 to 6 days after completion of flowering gives the maximum quantity of oil with high geraniol content.

Wilting and drying of Palmarosa grass in shade for 24 hrs. during pre-monsoon season and 48 hrs. during post-monsoon season result in maximum production of oil. The average recovery of oil under Odakkali condition is 0.4%.

Central Institute of Medicinal & Aromatic Plants (CIMAP) evolved a superior strain of Palmarosa (viz. Haldwani) with 96% geraniol in the oil and its seedlings are under trial at Odakkali.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

In order to increase production of oil in Kerala the following steps are recommended.

1 Taking up of multipurpose breeding programme with the aim of evolving 'geraniol' rich varieties and varieties suitable to Kerala condition.

ii) Multilocational trials at different agro-climatical conditions of the state to select suitable varieties and standardise package of practices.

iii) Development of quick micro-chemical test for screening large populations in the field for identification of elated plants.

iv) Tissue culture for propagation of superior varieties on commercial basis.

v) Studies on physico-chemical properties of oil produced at various regions of the state and compare with ISI specifications.

CINNAMON (Cinnamomum zeylanicum)

INTRODUCTION

Kerala is having the largest cinnamon estate in the world, comprising of 250 acres which is located at Anchirakandy. The tree is usually grown for preparing quills from its bark. But it's leaves give an essential oil rich in Eugenol which is an important aromatic chemical in perfumery and pharmaceutical industry. The present price of oil is Rs.175 per Kg. Eugenol and Iso-Eugenol are now being imported annually for the Idustrial use.

RESUME OF WORK DONE

The studies conducted at Lomongrass Research Station, Odakkali revealed that the usual practice of harvesting the leaves twice in a year before South West Monsoon and after North East Monsoon gives maximum oil yield with high Eugenol content. Wilting of cut leaves under shade for. 24 hours gives higher percentage of oil recovery. It takes 5 to 6 hours to complete one distillation under water and steam method, where as under direct steam method it takes only 4½ hours.

RESEARCH GAPS AND FUTURE PROGRAMMES

i. Selection of suitable types for leaf oil purpose.

ii. Evolving superior hybrids, yielding high quality leaf oil.

iii. Stardardisation of pruning trees and suitable agronomic practices to get maximum production of oil with quality.

iv. Exploration of the possibilities of growing the crop as an intercrop in coconut and arecanut gardens.

EUCALYPTUS

INTRODUCTION

Eucalyptus citriodora oil known as oil of lemon scented gum is an excellent source of citronellal (65 to 85%), which is about double the citronellal content in citronella oil. Citronellal is used as a raw material for the preparation of citronellal, hydroxy citronellol and mentnol. It is now grown on a plantation scale in the wynad area. India's requirement of this oil has been estimated at 50 MT a year and the demand is on the increase. The estimtated production is 8 to 10 MT. only per year.

Resume of work done

Studies done at the Horticultura Station, Ambalavayal gave the following useful restults.

A linear increase on the yield of leaf and oil was noticed with an increase in the height of pollarding. The maximum yield of leaf and oil was obtained from plant pollarded at 10 m. though this was at par with pollarding at 8 m. close spacing of 2 m × 2 m was more economical.

Application of 400 gm. of Ammonium sulphate 60 gm. super phosphate and 25 gm. of muriate of potash per plant per year from 3rd year onwards was found to be beneficial for increasing leaf yield. The optimum time required for one distillation was two hours and the average percentage of oil ranged from 1.5 to 1.8% of the fresh weight of leaves.

Performance studies of this crop under the conditions prevailing in plain were done at Lemongrass Research Station. Odakkali and it was found that it can be cultivated successfully in plains also, as a rainfed crop.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

To select superior types suitable to high anges and to plains, with regards to herbage and oil yield. To evolve a proper method for vegetative propagation and to study its comparative merit with sexual propagation.

To identify the pests & diseases of the crop and to recommend suitable P. P. measures. To stuby the effect of intercropping with coffee and cardamom plantations in high ranges and in coconut gardens in plains, under irrigated condition.

MENTHA

INTRODUCTION

The genus *Mentha* yield's a number of commercial oils used in food flavouring, confectionary and pharmaceutical industries. Mentha oil is mainly used for the manufacture of menthol. Presently only one species viz. *Mentha arvensis* is cultivated on a large scale. *Mentha arvensis* was first inirodduce by Regional Research Laboratory, Jammu and then by CIMAP and they have been successful in the propagation of this crop in North India especially in U. P.

RESUME OF RESEARCH WORK DONE

Several studies have been conducted on *Mentha arvensis* at R. R. L. Jammu and at Central Institute of Medicinal and Aromatic Plants, Lucknow. With the result the crop has been spread in the entire Tarai District of U. P. and adjoining areas.

The preliminary trials conducted at the Lemongrass Research Station, Odakkali for the last few years showed that the crop comes up well only during monsoon season and two harvests could be done during that period. The herbage and oil yield obtained from monsoon harvests were found to be satisfactroy. But high mortality of plant is experienced during its growth period in dry months (from December to May). Inspite of irrigation the oil and herbage yield obtained during the months were not found to be satisfactory. But such preliminary trials conducted at Horticultural Research Station, Ambalavayal showed that sub tropical condition is more suitable for *Mentha arvensis* in our state. The studies conducted for the thesis work at College farm Vellayani showed that it comes up well under Vellayani conditions.

RESEARCH GAPS IDENTIFIED AND FUTURE LINES OF WORK

As far as Kerala state is concerned *Mentha arvensis* is a new crop. Detailed adaptive studies are to be carried out at various research stations located at different agro-climatical regions of the state for identifying suitable area for commercial cultivation, followed by standardisation of agronomic technique suitable to each area.

Effect of intercropping in Eucalyptus and coffee gardens (new planting area) in high ranges and in old coconut gardens under irrigated conditions in plains are also to be taken up immediately.

Possibility of cultivation of mentha in one cropped wet lands in high ranges also to be explored.

OTHER ESSENTIAL OILS (New Introduction)

Citronella grass

There are two types of citronella grass of commerce, Ceylon citronella (*Cymbopogon nardus*) and Java citronella (*Cymbopogon winterianus*). Citronella oil is the chief raw material for the formation of many of the isolates like citronellal, geraniol etc. and they are converted into some of the most widely used perfumery products such as citronellal,

hydroxy citronellol, esters of geraniol etc. Performance studies conducted at the Lemongrass Research Station, Odakkali have shown that Java citronella can be cultivated successfully only if irrigation facitities are available. Though ceylon citronella is more resistant to drought than Java citronella, the oil of Ceylon citronella is inferic r to the oil of Java citronella. So it can not be cultivated economically. Insecticidal principles are found to be more in oil of Ceylon citronella than in Java type.

BASIL OIL

Basil oil obtained from *Ocimum basilicum* (Sweet basil) fetches a good price now. The oil is used in high grade perfume blends. The trial cultivation conducted at Odakkali showed that it can be cultivated successfully provided crops are from the seeds of adapted plants for getting maximum number of harvests in a year.

Studies proposed on certain other aspects of Essential oils on the related new fields.

Insecticidal & Fungicidal Properties of Essential Oils

It is reported that the essential oils of Palmarosa, Citronella, Eucalyptus etc. possess marked fungicidal and insecticidal actions. Antiseptics of fairly high R.W. value can be prepared with the lemongrass oil as the chief germicidal constituent. The bactericidal efficiency of Lemongrass oil has been shown to be directly proportional to the 'citral' content.

Essential oils such as citronella, Lavendar, Lemongrass and Geranium have been employed as insect repellants. Detailed research has to be conducted in this new field, to select suitable essential oil for controlling pests and diseases of crops.

Floral concreates and absolutes from flowers

Another field which has received very little attention in our state is the preparation of floral concretes and absolutes from flowers of Rose, Jasmine and Ylang ylang. The concreates from the flowers of those plants are highly valuable material (from Rs. 3000/= to Rs. 10,000/= per Kg.) for preparing natural speritous perfumes. Studies on those plants are to be conducted both at Horticultural Research Station, Ambalavayal and at Vellanikkara.

Essential oil from edible spices

The essential oil distilled from dried berries of Pepper *(Pipper nigrum)* is an important article of commerce. It is used commercially for imparting an ppetizing flavour to meat products, soups, beverages etc. It is also used in perfumery to give a spicy note in oriental type of perfumes. The availability of cheap raw materials like light berries of pepper and low overheads can make the production of pepper oil in Kerala quite attractive. It gives 3 to 5% oil worth of Rs.500/= per Kg.

Production of green ginger oil is a commercially attractive proposition. This will fetch better returns from the crop. The oil has a characteristic aromatic odour depending on the variety of ginger. It is estimated that out of the total production of ginger in India only about 60% are dried, the remaining 40%, being sold as green ginger. The growers do not generally get a satisfactory price for their green gingers, which are used for culinary purposes. Moreover, being perishable it is to be sold locally. Detailed studies are to be taken up immediately by the Kerala Agricultural University regarding the varieties of pepper and ginger to be used for getting maximum essential oils and also its economy.

B. MEDICINAL PLANTS

GENERAL INTRODUCTION

The Indian system of medicine is predominantly herbal curing and is perhaps the oldest one. Our country is endowed with a wealth of natural flora of which as many as 2500 plants are known to have medicinal properties. India happens to occupy the formost place as supplier of medicinal plants and related products and had total export of crude drugs in 1974-75 worth around Rs. 31.4 crores. At the same time we are importing annually certain herbs and drugs worth of Rs. 19.2 lakhs. This situation explains the need to give stress on the cultivation of medicinal plants so as to link agriculture with the pharmacuitcal industry. Moreover several medicinal plants also happen to be aromatic plants. For example synthetic 'Vitamin A' is manfactured from the Lemongrass oil. Therefore there is tremendous scope for increasing the area under the medicinal plants of economic importance. Only very little research has been done in India on the cultivation aspects of the medicinal plants.

The principal botanical durgs which are having a good market abroad are *Ammi majus, Belladona, Cinchona, Dioscorea spp. Digitalis, Ergot, Isafgul, Opium, Rawolfia Senna & Vinca rosea.* The Hathi Committee report on development of Drugs & Pharmaceutical Industry in India has laid emphasis on the extension of cultivation and commercial utilization of the following crops.

1) Cinchona (Quinine & Quinidine)
2) Lemongrass (caratenoids & Vitamin A)
3) Degitalis lantana (cardiac glycosides)
4) Nux – Vomica (strychnine & brucine)
5) Vinca rosea (VLB alkaloids)
6) Rawolfia (hypertensive & CNS drugs)

There is also a very fast growing demand all over the world for cortico-steriods which are derived from plants like *Dioscorea deltoidea, Dioscorea floribunda, Solanum Khasianum* and related species. The cortico - steriods are the basic raw material for the production of birth control pills and many related and sophisticated drugs. The current world demand of 'diosegin' and related steriods is around 1000 MT. per annum. It is estimated that 25 MT of diosginin are produced in India annually where as our requirement is for 150 to 200 MT per year. Present cost of diosginin is Rs. 1250/Kg.

Since Kerala has not taken up the Medicinal plants mentioned above in large scale except Lemongrass, cultivation of the medicinal plants of economic importance is to be taken up soon under priority group with strong research support. Preliminary studies on the *Dioscorea spp.* are being carried out at Lemongrass Research Station, Odakkali and the result is quite encouraging.

Important Medicinal plants that can be grown in India Priority Group-I. (Steriod hormone bearing plants)

DIOSCOREA Spp.

INTRODUCTION

The discovery of cortisone in 1949 led to a world wide research for plants containing those compounds and to the discovery of the four dioscorea spp. *D. floribunda* from Central America, *D. composita* from Mexico, *D. deltoidia* from Western Himalayas and *D. prazini* from Eastern Himalayas. Their tuber contains steriodal sapogenins cheifly Diosginin. it varies from 3.7% depending on spp.

RESUME OF WORK DONE

Dioscorea floribunda was introduced from Central America in 1968 and the research work conducted at the Institute of Horticultural Research Bangalore since then has shown that it is the best adapted species for cultivation in South India. A composite strain viz. FB (c) I. has been released for commercial cultivation from that Institute. The package of practices of the same has also been standardised.

It is introduced at Lemongrass Research Station, Odakkali in 1977 and its performance is closly watched. The tuber sample from one year old vine gave 5.17% diosginin content on analysis which was higher than that of the crop raised at Bangalore (3%). The total tuber yield obtained from one year crop at Odakkali was lesser than the yield obtained at Bangalore.

RESEARCH GAP AND FUTURE LINE OF WORK

Adaptivity studies at different agro-climatical conditions of Kerala are to be conducted to locate the suitable area for large scale cultivation and the package of practices required for each region are also to be fixed by conducting experiments at various research stations.

Facilities for estimating Diosginin content in the tuber samples are to be provided either at Lemongrass Research Station. Odakkali or at the Central Laboratory in the main campus of the University.

Trials with Indian species may be conducted. *Costus specious* which is an annual and contains diosginin may also be tried at various stations.

SOLANUM KHASIANUM

INTRODUCTION

It is a wild brinjal type plant. Its fruits and seeds contain a glycoalkaloid called 'solasodine' which is used in oral contraceptive and steroid hormone preparations. On account of its endemic nature, very wide distribution adaptibility and annual growth habit *Solanum khasianum* can sustain a regular and steady supply of raw material for our steriodal industry. Besides, its requirements of soil types and inputs being modest, the cultivation does not require heavy financial outlays. Kerala can take up its cultivation successfully.

RESUME OF WORK DONE

A new selection RRL-2 developed at R. R. L. Jammu possesses desirable characters such as less number of spines, synchronous flavering, large berries and high solasodine content (5%). It is found that plants can be raised from stem cutting also. A net profit of Rs. 2000/= from one acre is possible.

Out of 27 Indian species of solanum, three viz. *S. incanum, S. indicum* and *S. torvum* are commonly found in Kerala.

RESEARCH GAP IDENTIFIED AND FUTURE LINE OF WORK

Multilocational trials with the known varieties are to be conducted at various research centres to select the most suitable one for each region. Collection of types and evaluation trials are to be conducted systsmatically. Possibilities for evolving hybrids with high alkaloid content are to be explored.

Proper agro techniques for increased production of fruits and seeds with higher alkaloid content are to be standardised.

PRIORITY GROUP II

Rauvolfia serpentina

INTRODUCTION

The discovery of reserpine group of alkaloids from an Indian plant viz. *Rauvolfia serpentina* in 1952 as a remedy for high blood pressure and certain forms of insanity is note worthy. The requirement of reserpine in India has been estimated to be 200kg. per annum for which 50 MT of dry roots are required. Present collection of roots from wildly grown plants is about 25 to 27 MT There is also a great demand for the alkaloid, as well as for the raw drug in the world market. Steps. therefore, will have to be taken to increase the present production to about 100 to 150 MT of dry roots per annum. This is possible only if the plant is brought under large-scale cultivation in suitable area, In Kerala it grows wild in certain districts.

RESUME OF WORK DONE

Cultivation trials have been conducted at a number of places in India during the past several years.

For the cultivation of the plant in large scale root cuttings of 3 to 5 cm. length is advocated and about 100 kg. of root cuttings are required for one hectare, Diploid selections evolved at IARI are now available for cultivation,

The trial on the effect of Propagation materials and NPK, on yield and alkaloid content of Rauvolfia conducted at Vellayani for thesis work during 1962-64 showed that the higher roots yield could be obtained by cultivation of seed-raised crop with the application of N, fertilizer. A higher recovery of alkaloid could be obtained by application of N and K and by adjusting the harvest season to the seed setting phase. Harvesting the roots after 15 months of planting has been found to be most economical for getting optimum yield of desired alkaloid content. The serious diseases reported are Fusarium wilt, leaf blight, powdery mildew, root-knot disease etc,

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

Varietal evaluation studies and production of quality planting material,

Fixing package of practices for different agro-climatic areas.

Effect of intercropping in coconuta nd Areacanut gardens and in plantation crops in their early stages of growth.

Conducting control trials for pests and diseases.

VINCA ROSEA (Catharanthus roseus)

It is a quick growing xerophytic and hardy wild ornamental plant possessing a great medicinal potential. The roots and stem of Vinca plant are offering promise for the cure of cancer. It is grown now wildly in Madurai and Tinnevelly Districts. The dried roots are exported for the production of anti-leukamic drugs.

This crop can be grown in the districts of Cannanore, Palghat and Trivandrum after conducting trials.

SENNA (Cassia angustifolia)

The plant known as Tinnevelly senna is an under shrub which can be grown on barren lands and poor soil. Its pods and leaves contain 'Sennoside' which is used as a laxative in medicine. It is now one of the chief drugs exported abroad and the value of its export was Rs. 2.7 crores during 1974-75 and there is ample scope for developing new market. It is now grown in extensive scale in Tinnevely, Ramanathapuram and Madurai Districts of Tamilnadu.

It can also be grown in a few Districts ef Kerala viz. Kannanore, Palghat and Trivandrum with research support.

PRIORITY GROUP III

Introduction and adaption trials are to be conducted on the following medicinal plants at various centres under the university.

Ashwaganda (Withania ominifera)

Its dried roots contain an important alkaloid.

Isabgul (Plantago ovata)

Its seed and husk of worth Rs. 2 crores are exported annually. It is recommended for intestinal disorders and for piles. Large scale cultivation is carried out now in North Gujarat.

Cinchona officinalis

Its bark yields quinine and allied derivaties. It is grown in large scale in the Government Farm near Gudallur in Nilgiri district.

It can be tried in high range stations.

Ocimum sanctum

It is a house hold herb in Kerala. Its leaf oil is reported to be antiviral, antibacterial and antifungal.

CONCLUSIONS

Our country has attained self sufficiency in growing cereal crops and it is now high time to focus attention on Industrial crops. Considering the importance of the aromatic and medicinal crops in the agricultural economy and the export trade, greater attention has to be given to such crops.

Though Kerala has immense potentialities for growing different medicinal and aromatic plants of economic importance, she has unfortunately remained far behind. So the crops under this group deserve special attention in the development programme in the next Five Year Plan of this state. Side by side intensive research work should be taken by the Kerala Agricultural University for improving the plant types and cultivation technology for expanding the cultivation of these crops as field crops. Introduction of the study of Aromatic and Medicinal plants as part of the undergraduate and post-graduate curriculums in the Horticultural College under Kerala Agricultural University, deserves consideration.

In Kerala there is already so much pressure on land. Therefore the main source available for the cultivation of these plants is our forest area. In plains, incorporating these plants into the integrated cropping pattern is the only way for covering large areas under these plants. To achieve this objective, the economic impact of such a system via-a-via the other crop combination has also to be closely established.

11. SUGARCANE

INTRODUCTION

Sugarcane is one of the main cash crops of Kerala and it is cultivated over an area of 9500 hectares of which about 8400 hectares are in Quilon, Alleppey, Kottayam and Idukki Districts. The remaining area of 1100 hectares is in Palghat District. This crop is grown under a variety of soil and climatic conditions. For high yields it requires rich, well drained, soils. Such areas lie along the river banks. Sugarcane is also cultivated in hilly areas.

The total production of sugarcane in terms of gur is 54000 tonnes. This production is not sufficient to run the 3 sugarcane factories in the state. In the last 15 years the area under sugarcane remained almost static but the total production increased from 38000 tonnes in 1960-61 to the present level of 54000 tonnes. This was due to an increase in the per hectare production from 4165 kg. in 1960 61 to 5414 kg. in 1975-76. The production has to be considerably increased to meet the cane requirements of the factories and sugar requirements of the State. With this end in view the Kerala Agricultural University has started a Sugarcane Improvement Project at Thiruvalla in 1973. This is as well a centre of the All India Co-operated Sugarcane improvement Project.

The varieties of sugarcane now recommended for cultivation are CO. 419, 785 and 997. The season is November to December. In hilly tracts where sugarcane is grown as rainfed crop planting is done in August. Setts of 20-25 cm. length having a minimum of 3 eye buds are cut from the upper 1/3 region of canes. The setts are planted at spacing of 25 cm. in furrows made 80-90 cm apart in low lands. in hilly tracts planting is done in pits at a spacing of 20-30 cm. in contour rows 75 cm. apart. The seed rate is 35000 to 40000 setts per hectarer Two intercultural operations at 45 and 90 days after. planting and 8 to 10 irrigations are recommended. Under irrigated conditions inter-cropping with a short durationpulse crop is advisable. In such cases the pulse crop should be sown immediatey after planting of setts. The manurial schedule recommended is cattle manure or compost or pressmud, lime and NPK. The specific dose of NPK depends on the soil type. Organic manures, lime and P are given as basal dose. N. and K are applied in two split doses at 45 and 90 days at the time of intercultural operations. Pest and disease problems can be considerably reduced by planting healthy and clean setts. Delayed harvesting should be avoided as it will lead to a reduction in the yield of cane and recovery of sugar. Two ratoon crops can be successfully raised.

RESUME OF WORK DONE:-

The following research projects are now undertaken by the Sugarcane improvement project at Thiruvalla.

Varietal trial: Varieties suitables to the different agroclimatic conditions have to be developed. 12 varieties are under trial for releasing better ones than those now recommended.

Zonal trial: The cane varieties received from Coimbatore, Anakapally, Bangalore, Padagaon and Nasik are tested in the Zonal trial.

Fertilizer trial: Optimum fertilizer doses for the different soil tpyes of Kerala have to be standardised. The response to Nitrogen, Phosphorus and Potash is being studied.

Study of the response of early and midlate cane varieties to graded doses of Nitrogen from 80 to 240 kg. per hectare in combination with optium doses of phosphorus and potash.

Soil application of silicate slag to study yield and quality in Sugarcane.

Identification of suitable pulses such as cowpea greengram and black gram for companion cropping with sugarcane.

Exploring the possibility of introducing rice as an intercrop in sugarcane.

Sugarcane is an important cash crop of the State. it is a crop that meets the raw material requirements of the sugar industry. The crop is grown under diverse agro-climatic conditions. A number of factors limit the production of cane in the chief growing areas. They have to be investigated urgently. The problems confronting sugarcane cultivation in the Chittoor area of Palghat district need special attention.

RESEARCH GAPS IDENTIFIED AND FUTURE LINE OF WORK

1. About 60% of the area under sugarcane is in the districts of Quilon and Alleppey. In this area sugarcane is grown on the river banks. Production

can be considerably increased by evolving high yielding varieties suitable to the rich alluvial soils.

2. Nearly 20% of the area is in the Idukki District. Varieties suitable to high altitude conditions will help to increase production in this area.

3, The Farming Corporation of Kerala is popularising sugarcane cultivation in the newly cleared hill areas in Quilon District. Here sugarcane is grown as a rainfed crop. Development of drought resistant varieties suitable to the hilly area will lead to increase in production.

4. The crushing capacity of the Sugarcane factories can be fully utilised only by making available to them sugarcane throughout the year, Staggering production is possible by developing short, medium and long duration varieties.

5. Ratooning of sugarcane helps to reduce cost of cultivation. Varieties which will stand larger number of ratoons have to be identified.

6. Grassy shoot and ratoon stunting lead to low yields, particularly in the ratoon crop. Resistant varieties can increase production.

7. Large quantities of cane are now used as seed material. Planting single budded setts in the nursery and transplanting sprouted setts in the fields will help to save seed material.

8. Management practices and manurial schedule have to be standardised for the river bank areas, hilly regions, high altitude conditions and the Chittoor area.

9. Yield of cane can be considerably increased by planting setts at the most appropriate time and by providing irrigation facilities.

10. Inter-cropping sugarcane with rice and legumes in the low lands, red onion in the Chittoor area and drought resistant legumes in the hilly areas will help to increase productivity.

11. Special management practices are needed for inter-cropping sugarcane with legumes.

12. Investigations on pests and diseases of sugarcane and the recommendation of effective methods of control.

12. FLORICULTURE

Introduction

This is an untouched field as far as Kerala is concerned. It has ample scope in our State. It helps not only in beautifying the land scape but in earning foreign exchange through the export of cut flowers.

Resume of work done

Research on flowering and ornamental plants is meagre in the State. Large collections of such plants are maintained by private gardeners in cities. Development and propagation of ornamental plants is done by the nursery men depending on the results of research available in other states. A floriculture improvement scheme started functioning at Vellanikkara under the Kerala Agricultural University in 1975. The following research projects are being undertaken.

Improving the method of cultivation of Rose. Continuous pruning in rose is effective to increase the number of flowers. Pruning is done soon after the shedding of all petals on a flower bunch at a point 3 leaves below the flower. The size of the flower can be increased by pruning to retain only 2 or 3 flower buds.

Improvement in the method of cultivation of bulbous plants. The planting of well developed hippeastrum bulbs collected soon after the vegetative stage can be adjusted to have flowers when we need them. The plant can be induced to flower when required.

Improvement of agro-techniques for obtaining higher yield and better quality in Jasmine and other annuals and the improvement of seed production techniques. The scented double variety of Jasmine grown locally produce only one flush of flowers during the South West Monsoon.

However, the plants produce flowers in summer also if irrigated. A number of varieties of Marigold have been introduced. Spungold and Valencia are good varieties. Maximum seed setting is during summer.

Collection and maintenance of orchids. Sixteen varieties have been introduced and their performance studied. Techniques have been perfected for propagation by cuttings. Orchid embryos do not germinate and survive under ordinary conditions. They have to be germinated under specific laboratory conditions.

Collection and maintenance of Bougainvilleas Hibiscus and Ixora.

Research gaps identified and future line work

1. Introduction and acclimatisation of different types of ornamental plants suited to our conditions.

2. Trials on the pruning of different ornamental plants.

3. Trials to determine suitable cultural practices and optimum manurial requirements to different ornamental plants.

4. Pest and disease problems of different ornamental plants.

Work on the above lines will make available to the gardeners of our State large collection of ornamental plants and techniques for their development and propagation.

13. FODDER CROPS

Introduction

Research on foddder crops is carried out as a part of the All India Co-ordinated Project for research on Forage crops at the College of Agriculture, Vellayani since April 1971. A research project for the improvement of the popular fodder crops has also been taken up in the department of Agricultural Botany, College of Agriculture, Vellayani. Some work on these crops is also in progress at the Instructional Farm, Mannuthy as well. Fodder research and development adtivities are also attended by the institutions like Central Plantation Crop Research Institute and Kerala Livestock development and milk marketing Board.

The area cultivated under fodder crops in the state is estimated to be 985 hectares and hence a wide gap exist between the production and the requirement of green fodder for feeding the large cattle population in the state. The pressure on land in Kerala is such that maximum area is utilised for food crops and hence not much land could be spared for fodder cropping. The two probable types of land that can be put to forage cropping on a large scale are the lands with overcast shadows of perennial crops and the summer rice fallows. Stress was therefore given mainly on forage intercropping in the coconut gardens under rainfed conditions.

Varietal improvement and the agronomic studies on the most popular fodder crops were the two main aspects of research work undertaken on fodder crops. The following are the important fodder crops on which research work is carried out at present.

1. Guinea grass
2. Hybrid napier grass
3. Dinanath grass
4. Maize, Teosinte and their hybrids.
5. Fodder sorghum
6. Perennial legumes such as stylosanthes and Atylosia.
7. Cowpea
8. Fodder trees and shrubs.

Importance of grass legume mixture in the animal nutrition has been well understood and hence work on these lines is also taken up. Preliminary studies on the possibilities of Silvi-Pasture system, evaluating the production potential of grasses and legumes under varying combination with forage trees have also been started. Apart from the studies on the individual fodder crops, studies on fodder cropping pattern comprised of crop mixture and rotation of crops have been taken up for evolving the most economic fodder cropping patterns for the different agro-climatic conditions of the state.

Resume of work done

Varietal improvement

In order to evolve a drought resistant and high yielding guinea grass type, interspecific hybridisation was taken up between *Panicum repens* and Guinea grass *(Panicum maximum)* at the College of Agriculture, Vellayani. The seeds collected from the crosses did not germinate probably due to sterility of the seeds collected.

With the same objective of evolving a high yielding Guinea grass type possessing drought and disease tolerant characteristics, seeds of Guinea grass were subjected to the chemical mutagenic substance Ethyl methane sulphonate (E. M. S.) at three concentrations of 0.1%, 0.2% and 0.3%. The progenies were planted in the main field and were observed for tiller number, green and dry fodder yield and flowering behavour. Based on these observations, a total number, of seven non-flowering and eight high tillering vigorous clones were identified. The slips of the fifteen selected plants were transplanted in another field along with parental variety. Based on the tiliering, forage yield, non flowering nature and drought tolerance, further selections are being made

Varietal improvement of Guinea grass was also taken up through introduction and selection from 1973 at the college of Agriculture, Vellayani. Thirty types of this grass were obtained from within and outside the state and was screened for their yield potential and other important characters. The study revealed that the type FR 600 followed by FR 599 were the most promising types with regard to green and dry matter yield. Highest leaf-stem ratio was recorded in the variety FR 533. These materials are further studied. A similar study was conducted at the Instructional Farm Mannuthy also with 24 entries under two levels of nitrogen manuring and was observed that the 'Improved Guinea' largely cultivated at Mannuthy to be the best type for the conditions existing at Mannuthy. At Thumburmuzhi, the varietal trial with three Guinea grass types indiated that the variety Mackuenni to give the highest fodder yield.

Varietal improvement work on hybrid napier with the object of evolving high yielding disease resistant varieties was attended to at the College of

Agriculture, Vellayani and at the Instructional Farm Mannuthy through introduction and selection. At Vellayani, the total number of collections tested were 17 while at Mannuthy, 8 varieties were included in the trial. These studies indicated that the variety HBA-BN-5 was top ranking at Vellayani while NB-21 was the suitable variety at Mannuthy with regard to the yield of fodder.

Initial evaluation trial on Dinanath grass *(Pennisetum pedicellatum)* was started at Vellayani during 1973-74. In this evaluation trial, 14 entries were tested for the green matter, dry matter production and other ancillary characters such as height, tiller number and leaf-stem ratio. The highest green fodder yield was recorded by the variety PP 33 (64.8 tons) and JP 12 (64 tons) in two cuttings per year. The yield potential of this grass was found to be much higher than that of the perennial fodder grasses like hybrid napier and Guinea grass.

Varietal improvement of lucerne was also taken up at the College of Agriculture, Vellayani. The varieties of lucerne available at present are not found to come up well under Kerala conditions and hence varietal improvement of this crop was taken up at Vellayani through introduction and selection. Seeds of twelve varieties of lucerne were collected from different centres viz. Gujarat, Tamil Nadu, Palampur and Simla. These varieties were studied in replicated trial plots after treating with the bacterial culture. All the varieties were found to be unsuitable probably due to high temperature and low pH condition of the soil.

A varietal trial of cowpea was conducted for evolving a high yielding multicut bushy variety of cowpea at the College of Agriculture, Vellayani. Among the varietis tried, the variety C-152 was found to give highest fodder yield. Pure seeds of this variety were collected for mutation breeding work.

A project for the collection and evaluation of the indegeneous and exotic varieties of fodder crops is functioning at the College of Agriculture, Vellayani. These collections include a large number of parennial and annual grasses, and legumes, trees and shurbs of forage value green manure and cover crops. The yield potential of these collections are being studied both during the monsoon and summer months.

Forage Agronomy

The agronomic experiments conducted with Guinea grass in the open under the rainfed condition have brought out the following results.

a) Guinea grass responded upto 200 kg nitrogen per hectare. The maximum greenfodder yield of 44 tons per/ha per year was obtained for the highest level of nitrogen applied. The fodder yield of 39 tons and 37 tons per hectare were obtained at the nitrogen levels 150 kg and 100 kg per hectars respectively.

b) Information of the fodder yield due to nitrogen application schedules like full basal, half in June followed by the remaining half dose in October or four equal split applications during the year has also been collected. It has been found that the yield of green fodder was highest in the treatment in which full dose of nitrogen was applied as basal. This information appears to be different from what is expected, since generally the application of nitrogen in split doses boosts up the development of vegetative organs of the plants.

(c) Effect of lime on the yield of Guinea grass was also studied by applying lime at three levels. Effect of lime on the yield of green fodder was not significant. However, an increase of 9 percent of yield was recorded, due to the application of lime at 1000 kg per hectare.

(d) Studies on the interval of cutting of Guinea grass at 30, 45 and 60 days have shown that cutting grass at an interval of 30 days was the best to give a maximum yield of 43.6 tons of fodder.

The fertilizer trial with three levels of nitrogen conducted at Vellayani on three types of Guinea grass isolated from the screening trial conducted earlier showed that there is not much varietal difference between the types FR 600, FR 599 and Machuenni. However, the maximum green matter yield of 49.3 tons was recorded by the variety Mackunni obtained from the National Agricultural Research Station Kitale, Kenya.

The performance of Guinea grass was studied in the coconut gardens and the following were results of the trials.

1. Among the three different spacings trted, the closest spacing of 40cm × 20cm recorded the highest fodder yield of 31.38 tons per hectare.

2. Cattle manure to supply 50 kg nitrogen per hectare has been found to give highest yield of 31.48 tons per hectare compared to no cattle manure.

3. Trials conducted on intercropping of pulses like cowpea and horse gram with Guinea grass have

shown that the total forage yield could be increased by intercropping of pulses with this grass.

The yield potential of Guinea grass and hybrid napier cultivated under coconut gardens as an intercrop as well as in the open was studied under identical condtions of management. It was found that the yield of Guinea grass was higher than hybrid napier both under the open and as an intercrop in the cocount gardens during both the years of trial. It was also found that the yields due to different levels of nitrogen were not statistically different. The intervals ot cutting at 45 days recorded the maximum fodder yield though it was nct statisticaliy different for the 30 days interval of cutting.

A fodder production potential trial was conducted at Vellayani to study the performance of the annual crops like maize, jowar, cowpea and their combinations for the two seasons of the year compared to the yield of perennial grasses like Guinea grass and hybrid napier. It was found that a continuous crop of Guinea grass was the best cropping programme to get maximum fodder yield followed by hybrid napier.

In a similar experiment designed to study the yield potential of Guinea grass, hybrid napier (along and with cowea mixture) and two annuals viz., maize and sorghum alone and with cowpea, it was found that hybrid napier alone or hybrid napier with cowpea produced the highest fodder yield. Thus, under Mannuthy conditions hybrid napier performed better than Guinea grass. Trials were undertaken to study the performance of Dinanath grass to various levels of nitrogen and phosphorus. The results indicated that there was no significant difference between the nitrogen levels on the green matter and dry matter production. Levels of phosphorus also showed no remarkable influence on the yield of this grass.

Manurial trials with different cowpea varieties viz. Calicut 78. Russian Giant, FOS_1, Co_1, and Kunnakulam local and C-28 were found to be fairly, suitable fodder varieties. The variety C-28 was found to give higher fodder yield of 19 tons per hectare. A combination of 30 kg of potash and 90 kg P_2O_5 was found to give the highest fodder yield. At Chalakudy, the fodder variety Karnataka local has been observed to produce good fodder yield under irrigation in the summer rice fallows.

At Mannuthy, New Era Cowpea at a manurial dose of 15:60:30 has been found to give a higher fodder yield of 24 tons per hectare.

Trials with maize have shown that varieties like Ganga 5, Ganga safed 2, Deccan, Teosinte etc. to be suitable fodder varieties. Highest yield of 33 tons of green fodder was recorded by hybrid maize varieties. A combination of 120 kg nitrogen and 60 kg P_2O_5 has been found to produce the highest fodder yields.

Five varieties of fodder sorghum were compared at Vellayani. The variety JS-3 was found to be the best with a fodder yield of 35 tons per hectare.

Studies on the perennial fodder legumes like stylosanthes and Atylosia were undertaken for their persistant growth and yielding ability. The results of the trial so far conducted have indicated that stylosanthes is the best among the perennial legumes for yield and persistant growth.

Studies for evaluating the effect of nitrogen levels and row spacing on the yield and quality of hybrid napier grass with and without legumes, the production potential of grass/legumes under varying combinations with forage trees, effect of plant population on the yield and quality of Koob-abool and phosphorus nutrition of *stylosanthes gracilis* are some of the important items of study that are in progress at Vellayani.

Research gaps identified and future line of work breeding

Guinea grass

i) Hybridisation between Guinea grass (*Panicum maximum*) and *Panicum repens* is to be continued for evolving drought resistant and high yielding varieties of Guinea grass.

ii) Mutation breeding to evolve improved Guinea grass varieties tolerent to (1) drought conditions and (2) suitable for growing under the partially shaded conditions.

iii) Multilocation trials with the following promising Guinea grass types to study their adaptabitity disease and drought resistance.

Types (a) Mackuenni
(b) Ft 599
(c) FR 600
(d) Improved Guinea (Mannuthy)

iv) Evaluation of polycross progenies of selected clones of Guinea grass to explore the possibitities of large scale production of polycross seedlings.

Hybrid napier

i) Collection and screening of available hybrid napier varieties for disease resistance and high yield at different University centres.

ii) Breeding hybrid napier varieties through hybridisation and selection.

iii) Mutation breeding of hybrid napier exposing the slips to gamma rays and chemical mutagens.

Legumes

i) Breeding long duration, profusely branching and multicut cowpea varieties suitable for growing in the coconut gardens.

ii) Breeding lucerne varieties through introduction, selection and mutation breeding for evolving suitable varieties for growing under the Kerala conditions.

iii) Survey and collection of perennial legumes for selecting varieties with persistant growth habits.

iv) Survey and collection of trees and shrubs of fodder value and study their behaviour and reaction towards pruning.

v) Multilocation trials with the available perennials legumes.

Agronomy and Soil Science

i) N, P, K requirement of hybrid napier and Guinea grass under rainfed and irrigated condition.

ii) Evaluation of calcium and phosphorus nutrition of fodder legumes (annuals and perennials).

iii) N, P, K nutrition and their management on stylosanthes.

iv) Foliar nutrition of cowpea, Guinea grass and hybrid napier with reference to macro and micro nutrients.

v) Intercropping of hybrid napier, Guinea grass and sataria grass with and without legumes like stylosanthes, and welvet beans.

vi) Time of sowing of fodder maize.

vii) Height of cutting in relation to regeneration of Guinea grass.

viii) Studies on the suitability and potentials of Silvipasture systems comprising of trees of timber, fodder and other economic value with various forage grasses in the marginal lands.

ix) Adaptability trial with forage crops sudias fodder maize, sorghum and pulses in the rice fallows.

Forage Entomology

1. Survey of insect pests affecting forage crops.
2. Control of insect pests by chemical means and its influence on feeding value.

Pathology

1. Studies on the organisms responsible for the fungal diseases on hybrid napier and guinea grass.
2. Chemical control of pathogens on the forage crops and its influence on the feedinh value.

Animal nutrition

i) Feeding trial with dinanath grass.

ii) Processing of paddy straw during Viruppu season to reduce feed loss and for enhancing its nutritive value.

iii) HCN content of tapioca leaves at different moisture regimes.

iv) Studies on the utilisation of cocoa pods as cattle feed.

In order to intensify the fodder research, it is highly essential to start a fodder research institute with a full complement of staff. Departments like breeding, agronomy and soil science, animal nutrition, entomology and pathology may be organised and such a multidisciplined approach would be necessary to Co- ordinate the forage research work.

14. FARM ECONOMICS, EXTENSION, STATISTICS AND NURITION

A. AGRICULTURAL ECONOMICS

Resume of workdone

1. Economics of production of principal crops

Studies on cost of cultivation have been conducted by the State Planning Board and the Department of Statistics, Government of Kerala with regard to paddy and coconut. Also the Kerala University is undertaking studies on paddy and coconut which are of a continuous nature.

Cost of production studies on important crops and livestock products will have to be studied in detail for the whole state. Paddy, coconut, tapioca, pepper, rubber, tea, coffee, cardamom and milk may be included for the purpose. Such studies would be of great relevance to make policies.

In the case of paddy the Kerala University during 1962-63 conducted studies entitled "Economics of farm management in Kerala" in which coverage was only two districts viz., Quilon and Alleppey. The State Planning Board undertook a study on the cost of cultivation of paddy - an analytical tool for evaluation – during April 1971. The coverage of the study was limited to four districts viz., the package districts of Palghat and Alleppey, with the IAAP districts of Trichur and Quilon as control. The Kerala University is at present undertaking a study on the cost of cultivation of paddy under a scheme sponsored by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India. The study is understood to be of a continuous nature. No report on this is published so far. The Kerala Agricultural University in 1978 initiated a study on cost of cultivation of paddy which is in progress.

The Kerala Agricultural University in 1978 initiated a study on cost of cultivation of Sugarcane in the hinterland of Chittoor Co-operative Sugar factory. The work on this project is in progress.

In the case of Coconut the Department of Statistics, Government of Kerala, conducted a study on the cost of cultivation during 1961-62. The Kerala University is also taking up cost of cultivation studies at present under the same programme mentioned above viz.. the scheme sponsored by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, Government of India. This study is also of a continuous nature. However no report is published so far.

With regard to Pepper, the Bureau of Econamics and Statistics, Government of Kerala, had collected data on area, production and cultivation practices. Cost of production was not included in this study. So the University may take up cost of production studies of pepper, a foreign exchange earner.

The biggest problem facing tapioca grower is the fluctuations in demand. A close substitute for rice, the demand for tapioca is negatively correlated with the price of rice. Systematic studies on cost of production of the crop have not been done so far.

Cost of production studies in the state have not been carried out with regard to the other important crops viz., rubber, coffee, tea and cardamom.

Apart from cost of production studies, studies on economics of farm production should include studies on efficiency of input use and input combinations. Farm management studies conducted by the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India relating to the periods 1962-63, 1963-64 and 1964-65 were published in 1972, constitute the major work in this area. However, these studies pertain to an era when traditional farming technology was in vogue. The State Planning Board, during 1973-74 conducted an Evaluation of high yielding varieties. This was limited in coverage.

2. Farm records

Preparation of the farm records for the farmers of Kerala is an important area of work. Practically no work in this direction has been done in Kerala. Maintenance of proper records by the farmers will provide financial and physical information about the farm business. They can also supply information helpful in decision making. So a project on 'Farm Records' may be taken up by the Department of Agricultural Economics.

3. Agricultural Finance and Credit.

The Planning Board, Kerala had conducted a study of 'poverty, Rural indebtedness and Money lending practices in Kerala', which was published in September, 1975. This study throws light on the rural indebtedness and the practices of money lending by non-institutional agencies. The R.B.I. Document on rural debt published in June, 1965 also gives the indebtedness position of the State. Another report was of the R.B.I. on two-tier co-operative credit structure in Kerala. Published in

December, 1973. No studies have been conducted to assess the extent of overdues and its causes. Similarly studies on utilization of credit are not available.

4. Agricultural Marketing

The Agricultural Marketing Section of the Department of Agriculture, Kerala State had brought out a report on 'survey of important markets in Kerala' during September 1966. This survey covered all the important markets in Kerala and gave details of their location, classification. periodicity of commodities transacted and methods of transactions. Much scope is there to organise studies on price trends, price spread, cooperative marketing, commodity surveys etc.

5. Constraints in Adoption of Improved practices.

Another area of study is adoption of improved agricultural practices, with particular reference to Socio-economic constratnts which hinder adoption. The State Planning Board in 1969 conducted an evaluation study on adoption of improved agricultural practies. This study now is a decade old and new studies in the changed situation are called for.

6. Rural Labour Problems

The main work in this area is the reports of the second Agricultural labour enquiry conducted by Labour Bureau, Simla during 1956-57 and Rural Labour Enquiry 1963-65. There hava been a few studies by individuals on Agricultural wages.

The Kerala Agricultural University conducted a Seminar on Problems of Rural Labour in Kerala in 1978 and papers were presented on various aspects of Rural Labour, including agricultural labour. As these papers were based on researches of individual research scholars, they were limited in scope and coverage.

Research gaps identified and future line of work

In the light of the foregoing brief review, the areas in which work needs to be done could be identified.

I. Farm Management and Economics of production of crops, Livestock and other products.

1. Cost of production studies-cost of production studies have to be conducted periodically, if not on a continuous basis. Apart from paddy and Sugarcane, other major crops to be studied are Coconut, Arecanut, tapioca, pepper, banana, Cocoa, rubber, cardamom etc. Similar studies have also to be done in respect of milk and other dairy products, cultivated forest products, as also in respect of acquaculture.

2. Apart from cost studies, studies on efficiency of input use in crop and livestock production are very essential. Similarly, socio-economic impact of machanization in agriculture is also an important area of study.

3. Studies on socio-economic factors helping and hindering adoption of improved agricultural practices also needs to be studied.

4. Project on farm records-different types of farm records are being maintained in the Government and other private farms. But coming to the cultivator level their knowledge on farm records is very limited. Hence when we approach a cultivator for gathering some information he is not able to give it. To avoid this, it is felt vary essential to suggest certain farm records to the cultivator so that they can maintain them very easily and without much effort.

II. Agricultural Finance and Credit

This is another important area where a lot more work needs to be done. Within the broad area, the following specific problems for research are indicated viz., extent and causes of overdues, economic feasibility and repayment capacity of farm investments, effect of agricultural finance on beneficiary farmers, growth and performance of different agricultural financing institutions, credit problems of small and marginal farmers etc.

III. Marketing and Prices

There is considerable scope for research in this area. Study of different marketing institutions with reference to market conduct and performance of intermediaries, study of individual crop, livestock, fishery and forest products with reference to efficiency of marketing, study of behaviour of prices of individual commodities etc. are the major items of work which could be taken up immediately.

IV. Rural Labour

Studies on problems of rural labour in general and labour in agricultural pursuits have to be undertaken on a regular basis, with reference to work, wages and welfare.

V. Agro-industries.

The efficiency of agro-industries has an important bearing on agriculture land hence studies on agro-industries in general and agricultural processing industries in particular needs to be under taken.

VI. Rural Development.

As agriculture is the back bone of the rural economy, issues involved in rural development have a direct bearing on agriculture. The immediate operational implication of rural development is to find ways and means to improve the income and levels of living of rural people. Agriculture has to make positive contributions in this direction. Over the long term, the relative contribution of agriculture to national income will tend to decline and hence the population depending on agriculture has also to decline. All these involve readjustment problems which have to be studied by the agricultural economist.

B. AGRICULTURAL EXTENSION

Adoption & Social Change

The process of adoption and diffusion of agricultural technology is very complex. This area has attracted the attention of research workers in the field of Extension Education and Rural Sociology. In India many research studies have been completed in different parts of the nation. These research findings in the field of Agricultural Exiension resported in Scientific Journals can be grouped into the following areas.

1. Adoption Process
2. Attributes of Practices that affect adoption
3. Personnel, social and situational variables that influence the adoption process
4. Communication in the adoption process
5. Problems of adoption

Researches in the above areas, especially from 2 to 5 are of very great practical importance. The findings of studies in these areas can guide the extension activities more effectively. As our society is different from the societies in other parts of the nation the findings of such studies elsewhere may not be directly applicable in our society. Such differences from society to society have already been brought out by researchers and they have pointed out the need for undertaking research studies in the areas from 2 to 5 in every society.

The review of diffusion and adoption studies till 1970 and published in the book "Researchers in Extension Education" reveals that no such studies have been conducted in Kerala. Nair (1970) studied the adoption of high yielding paddy varieties from an extension education point of view. But this was a study limited to a small area. No other studies have been reported which deal with the various aspects of diffusion and adoption of new agricultural innovations from the point of view of extension education.

In Kerala research in the field of Extension Education is new. Only recently we have startered attempts for objective studias. In the area of adoption we have a project on a limited scale which tries to study the different aspects of adoption of high yielding varieties in Trivandrnm Districts. The same will have to be repeated in other districts of the state so as to get a comprehensive and deep insight into the different aspects involved in the spread and adoption of high yielding varieties. Same type of studies will have to be undertaken for all crops which will bring out the different functions that either hinder or influence the adoption of improved practices in important crops.

COMMUNICATION AND EXTENSION TEACHING METHODS

The importance of communication and the role of extension methods in the Extension Education process need no emphasis. The acceptance of their importance has prompted researchers to undertake research studies in the above areas. Researchers conducted are mainly in the following areas.

1. Suitability of extension methods (single and in combination) for various communication situations.
2. Relative effectiveness.

3. Information source use by different people in different situations and factors releated with it.

4. Content analysis of agro-information it Mass media.

5. Study of difficulties and bottlenecks in agro-information communication.

Many studies have been completed in the above areas in other parts of the nation. These studies in Communication and Extension Methods summarised and published in the book "Researchers in Extension Education" (1970) reveal the total absence of any such study in Kerala. Tampi (1972) studied the relative effectiveness of two extension methods under Kerala conditions. As the findings of the studies in the above areas can be made use of for increasing the efficiency of extension service there is urgent need to formulate research projects in the above areas.

RESUME OF WORK DONE

1. Training: Research has been done in Programmes of Training farm youth. Amongst youth, Agarwal (1956) studied the vocational interests of school boys as well as their leisure time activities and leisure pursuits, Bhatt & Raheja (1960) studied the effect of age and education of youth on their gain of knowledge and skill. Rao (1964) studied the needs, interests and aspirations of school-going boys. Singh and Prasad (1965) studied the educational benefits of youth club activities in the school situation and their relation to interest, knowledge and skills of the student. Similar studies were also conducted by Singh and Haque (1966).

Research has also been done in the training of farmers and farm workers and extension personnel. Pisharody (1962) studied the suitability of training of village level workers in relation to their job in Kerala State. Chowkidar (1968) studied preservice training needs of VLWs related to their job. Sharma (1966) Sigha and Gill (1967) and Shukla (1967) studied the training needs of the Extension officers in Animal Husbandry and or Gramsevaks and the BDPOs towards training programme. Menon and Nair (1971) studied the training needs of the Junior Agricultural Officers in Kerala. Preservice Training Programme of Gramsevaks were also studied by Somasundran (1966) in Andhra Pradesh. Rai (1962) also studied the training needs of VLWs in Bihar.

2. Administration; Researcher have been done on Panchayath Raj Administration in Rajasthan and Andhra Pradesh. Evaluation studied have also been conducted by the programme evaluation organisation. Bhale Rao (1967) viewed Indian Administrations' fundamental feature as increasing interplay of policies and administration at all levels of the Goverment. Programme Evaluation Organisation's fifth evaluation study report (1958) concluded about inadequacy of staffing according to needs, circumstances and lack of coordination. Sahai *et al.* (1959) Warren (1963) and Ram Subhag Singh studied the administrative systems, heirachial structure and interdepartmental and institutional coordination of the Government in relation to implementation of agricultural production programmes. Administrative decentralisation in relation to the new strategy of agricultural production was studied by Reddy (1970) in Andhra Pradesh. Prasad and Nageshwar (1967) studied the inter and intra departmental coordination in IADP (Delhi). Palled and Lakshmana (1968) conducted case studies in the jobs and duties of the BDO's in Mysore. Similar studies were conducted by Brar (1967) in Lubhiada. Tampi (1969) studied the role of panchayat members in planning and execution of agricultural development programmes in Kerala. An observation of the administrative activities of the village Extension Officers of Kerala was also studied. Role of Agricultuial Extension officers in programme planning was also assessed by Sharma (1968).

Research gaps identified and future line of work

1. What should be the effective administrative and coordinated set up or arrangement for different categories of training.

2. Assessmenr of training needs in the field of agricultural research and development.

3. What should be the approach and methodology of training so as to improve the technical competence of personnel in different feilds in agricultural administrative set up.

4. What are the potentialities of Institutional Training programmes that will be broad-based and adaptable in terms of organisational and personal needs.

5. How should the training programme cope up with the advancement in the fields of Research, Extension and Administration towards rapid technological development in agriculture.

6. What should be the coordinated and integrated approach of training programmes that shall

be undertaken to successfully implement the agricultural strategy.

7. What shall be the nature of follow up and evaluation in respect of specific programmes of training in the field of Agricultural Development

8. What shall be the nature and extent of involvements of official and non-official agencies in training and development.

Agricultural Administration.

1. How does a state develop an effective extension organisation at the state, district, block and village levels that will permit planning and execution of a unified programme of extension Education for Agricultural Development.

2. How does a state organise to achieve Unity of direction, Supervision and Coordination of staff efforts at state, district and block levels.

3. How does a state achieve flexibility in the organisation structure in order to make it responsive to changing situations and areas of programming responsibility.

4. How does a state organise an extensio service for better coordination, and work with other organisational groups and agencies.

5. What should be the extent and levels of decentralisation in the proposed set up.

6. What should be the role of Agricultural Universities in Agricultural Development programms and their relationship with State Department of Agriculture.

7. What should be the Goverment's basic policy regarding farming, farm credit, marketing and prices of farm produce, Agro-industries, as well as utilisation and investments on land.

8. What should be the administrative system adequate to the job and the needs of the programme.

C. AGRICULTURAL STATISTICS

The Department of Agricultural Statistics is to work in collaboration with the other Departments by rendering supporting statistical technology in the proper conduct of the experiments for the full elucidation of information required and also in the proper analysis of data for the full utilisation of information.

The supporting statistical technology in the design and layout of experiments involves the following.

1. Appropriate design for the field experiments or sample survey as the case may be.

2. Information on the optimum plot size for experiments.

3. Information on the appropriate measures for the quantifiable observations to be taken.

The technology in the analysis of data involves the proper methodology in the analysis for extracting the entire information available.

Resume of work done

The present position of technological development is outlined below.

1. Designs for field experiments or sampling designs for sample surveys

Appropriate designs are available for experiments to meet all possible requirements. So also in the conduct of surveys, the present knowledge is sufficient for all practical purposes.

2. Information on the optimum plot for experiments.

Optimum plot size for experiments with a number of crops has been worked out in different stations in India and abroad. But there may be slight variations between locations. Usually this is not considered a serious problem. Further, it is wasteful to conduct uniformity trials to assess the optimum plotsizes for experiments for the various crops in each station. The lacuna of knowledge was only in the case of vegetable crops which also has been filled up, by a recent publication of the Institute of Agricultural Research Statistics which covers most of the vegetables. For the remaining crops experiments are being laid out at Mannuthy.

3. **Information on the appropriate measures for the quantifiable observations**

For the most observations there is no problem is defining the observations. But in cases like intensity of the disease, method of assigning scores for the different grades is used.

4. **Proper methodology in the analysis of data for extracting the full information contained in the data.**

There is no dearth in the menthodology for proper analysis in the various situations. The reason for not making full use of the information is not the lack of available kowlege of the person who is dealing with the date. In most experiments analysis is done for each season separately and combined analysis may not be attempted. Similarly for trials with varieties where data on yield attributes are recorded, it is possible to utilise the data to obtain information on the genotypic correlation and path coefficients giving the contributions of yield components on yield. This is not done in most cases. In trials of imporoved varieties over different soil types the data can be utilised to choose the best variety which is suitable for all the localities or environments by using the method of stability parameters. This is not being done. In trials involving various form of nutrients at differents levals, It is possible to estimate the efficiencesss of the various forms compared to a control which may be the form of the nutrient used by the majority of cultivators. In fertilizer trials the optimum doses of nutrients to maximise produciion as well as the level to maximise the profit of the cultivator can be worked out. Further the critical levels beyond which application of fertilizers will be uneconomical, also can be worked out. The economics of cultivation can be worked out in all experiments.

The statistical data obtained from sample surveys and published by Government Departments also require closer study and analysis. Futurology has developed into a branch of science. The available Agricultural Statistics can be utilised to predict the population, requirement of food grain, production of food grains etc. This exercise will be useful in planning for development. Different models of growth can be tried and the effects of the number of years required for achieving set pattern of development can be studied.

Fuller utilisation of data implies greater bulk of computations. This naturally leads to the use of more sophisticated computers. At present the Department of Agricultural Statistics has only desk calculators. But we require programmable minicomputers and also ancillary facilities for making use of the more powerful computer in the University of Kerala. Programmable micro computers are available at a cost of Rs. 35000/- For making use of the more powerful computer at Trivandrum we require a programmer, who can prepare computer programming for the computations required. Further a punching and verifying machine and the required staff will be required here for punching the programmes and the data, so that the cards can be taken to Trivandrum for getting the analysis done in the computer.

The research workers who collect the data have to be education as to the possibilities of exploiting the data and in the interpretation and utilisation of the results. This can be done by conducting refresher training in Agricultural Statistics for the research workers in the various disciplines. This has already been proposed and sanctioned eventhough not actually implemented.

The personnel of the department can tackle the minor problems or gaps in knowledge that they came across in the actual working of these items of work.

Researh gaps identified and future line of work

A lot of valuable information which would help better planting and increasing production needs to be collected both in agriculture and animal husbandry.

Some of the topics on which more light is to be shed in relation to animal husbandry in the state are:

1 Annual milk production

2 Proportion of crossbreed cattle according to age and other attributes.

3 Intensity of incidence of various diseases among the livestock.

4 Annual egg production and the contribution of the unorganised sector into it.

5 Livestock management practices followed by the farmer.

6 The annual production of hides, hoofs, bones and horns.

7 The number of various categories of livestock slaughtered.

8 Age specific mortality of various catagories of livestock.

9 Annual production of meat.

10 Economics of production of various livestock products.

11 Constraints in the easy adoption of livestock farming as a new means of livelyhood.

Of these, item (2) is expected to be covered by the 1977 census of cattle. On item (9) the information is partial and pertains only to Trichur taluk (and in this case the analysis is yet to be completed). Studies are to be undertaken on the basis of all the remaining items.

Similar problems as above exist in the field of agriculture also. There is need to assess

a) Crop-wise optimum levels of inputs with a view to maximising production.

b) Means for increasing the labour intake by the agricultural sector.

c) Intensity of cropping patterns.

d) Area under H. Y. V.

e) Constraints in the easy adoption of H. Y. V.

f) Reasons for the drop in productivity of certain important crops.

g) Crop weather relationships.

The assessment of areas under H. Y. V, and other important crops of the state may be available from T. R. S. (timely reporting scheme). Some elementary work of not much consequences have been done on some of the topics given above.

Research in the above topics listed under agriculture and animal husbandry may induce research of fundamental nature in statistics. Research in horticulture, plantation crops, multiplicle cropping and animal husbandry may call for new designs and new functional relationships between different aspects. These designs and relations may have to be deviced a new. Hence fundamental research in designs, sampling, functional models etc. may have to be taken up.

D. FOOD AND NUTRITION

Man requires food for his sustenance and agriculturists are responsible for the production of this food-both of plant and animal origin. Effective planning and the provision of adequate diets for the people of the world has become one of the most important problems confronting mankind, Today's agriculturists are faced with the immense problem of providing enough of the right kind of food for the present population and at the same time, planning for the ever increasing numbers particulary in the developing areas of the world.

In this situation, scientists in the field of agriculture as well as in the allied fields, have aptly realised the need for increasing food production both quantitatively and qualitatively. This awareness has brought in consequent changes in the frontiers of education and research, especially in areas pertaining to Agriculture. This change is welcome, mainly because, tne ultimate goal of education and research in the field of agriculture is pointed towards the maintenance of a good state of nutrition and well being among the people and thus leading the Country to prosperity. Hence, the Aguriculturists must be familiar with the fundamentals of the Science of Foods and Nutrition.

With the above goal, the Food science and Nutrition section of College of Agriculture, and College of Horticulture may take up research projects in the field of foods and nutrition, with special reference to food habits, supplementary feeding programmes, effective utilization of locally available food, problems relating to the vulnerable and down troden sections of the population, which are dealt in detail later on in this paper. These may help us to understand the present and immediate problems of the locality, and to chalk out and implement effective programmes to wipeout some of the major agricultural and nutritional problems facing the state, and the country at length.

Food Habits

A great head-way has been made in our country, in recent years, in building up scientific knowledge

with regard to nutritive value and composition of foods; the food nutrients – their role and inter relationship in maintaining the homeostasis of the human and animal body. (Studies done by National Institute of Nutrition, ICHR, Hyderabad). But in the collateral field of study of food habits and of getting people to make effective use of scientific information, only pioneering work has been done. This aspect deserves more attention, especially in the state of Kerala, where we have a paradox, of having ample resources on one hand, and illeffects of environmental which influences nutritional status of man or community on the other as rightly observed by Nagarajan, 1977, (Nagarajan, V. Food Agriculture and Nutrition situation in India, Part II Nutrition Vol. II, No. 2, 1977 P. 22)

Hence, as a preliminary step for future development, collection of sound basic data on food habits and the resources available, is essential. A series of studies are to be taken up on food habits, and its relation to the existing nature of food production, processing and distribution existing medical practices influencing food habits and the physical, social and cultural factors affecting food habits of the local population.

In the light of the above studies on food habits, attempts are to be made to develop flexible methods suitable to solve emerging problems. The existing media available for disseminating knowledge on principles of foods and nutrition should also be studied and never methods are to be developed, if necessary.

The Supplementary Feeding Programmes

Nutrition policies developed in India have lead their way to Supplementary and Demonstration feeding programmes, which involves production and/or feeding of protective foods to the vulnerable sections of the population along with nutrition education. Applied nutrition programme is one of such programmes implemented by the Department of Development at the Block (NES) level. The Agricultural College at Vellayani acts as a centre for the implementation of the programme, and it gives necessary technical guidance. In this capacity, research projects concerning the aspects of ANP have been organised and conducted by the College of Agriculture, Vellayani. Some of such projects are: The attitude of extension personnel and rural women towards the programme, influence of kitchen gardening and ANP Camps on rural women, gain in knowledge due to ANP Camps by the participants, factors motivating women to participate in the camps, and the credibility of various mass media used to impart knowledge on nutrition etc. Nutritional and objective evaluation of other feeding programmes, like the SNP, CNP, etc. could also be done.

Utilization of locally available foods

The knowledgs regarding the nutritive value of foods locally cultivated / and / or consumed are essential if they are to be used effectively, and this may also help in planning Nntrition Education programmes. Hence studies on locally available foods whose nutritive value has not been found out (especially some green leafs, vegetables and fruits) are to be identified and analytical studies on the nutritive value of locally preserved and processed foods and their shelf life could form a major activity of the research institutions. The biological efficiency, and nutritional contribution of food combinations known from time immemmorial could be investigated. eg. use of roots and tubers with fish (Tapiocs, and fish) roots and tubers with legumes etc.

New research projects could also be developed in testing the acceptability and cooking qualities of new varieties of food-stuff or newly introdced foods.

Development of vulnerable and downtroden section of population.

Along with studies on general food habits of population attention is to be focussed on the study on the nutritonal status of vulnerable sections of population eg. infants, pre-school and school children, pregnant and lactating mothers and those specially living in urban slums, Tribal areas and rehabilitation centres or woking in industries and agricultural farms. The year being the "year of the child", rescarch on current trends in infant feeding, supplementary foods used for infant and child feeding, development of balanced weaning foods or formula with locally available foods, nutritional status of pre-school and school chidlren, incidence of blindness in children due to Vit. A deficiency in Kerala etc. could be taken up by the various institutes of Kerala Agricultural University.

15 SOIL CONSERVATION AND FARM MACHANISATION

Introduction

Soil conservation and farm machanisation are two important branches of agricultural rechnology which hither to received very little attention in the research activities of Kerala Agricultural University. It is true that a Department of Agricultural Engineering was started with the very inception of Agricultural College at Vellayani more than two decades ago. The department has been successfully imparting undergraduate education to students ia such areas as farm machinery, soil conservation, irrigation, drainage and crop processing technology. For varied reasons the department could not make any significant contribution in the field of research.

Realising the importance of research in these fields the Department of Agriculture, Kerala State, started two research stations namely the Soil Conservation Research Station at Konni and Research Testing and Training Centre at Vellayani. Somehow these efforts have also not produced the desired results.

In all the other important branches of agricultural science, excepting in soil and water conservation and machanisation, Kerala Agriculturai University has a strong research set up. For all round development of Agriculture it is imperative that University take early steps of bridge this gap. It is suggested that no full-fledged research stations namely Soil and Water management Research Centre and Research and Development Centre for Farm Machinery may be started to initiate research and in these two important branches of agricultural technology.

It may be argued that why a new research station for Soil and Warer management is to be started in Kerala when eight major regional research stations under the I.C.A.R. in different regions of India have been conducting research on the same subject for the past 20 years. These stations, based on their studies, have given very significant recommendations. These recommendations in flew cases are useful for Kerala but in most cases cannot be adopted as such because of the unique conditions of of topography and climate existing here.

Kerala has very undulating topography with hills, hillocks and valleys. These valleys are mostly paddy fields. During rainy season surface and subface run off from the surrounding hills drain into the paddy fields making these fields water logged. During this season drainage is the main problem in the paddy fields while soil erosion is the most serious problem on the hills. Cultivation on slopes over 50% are not uncommon in Kerala. Usually all conventional text books on soil conservation recommend that lands having slope over 40% should be put under efforestation and natural vegetation should not be disturbed. The pressure of population on the land is so much that this recommendation cannot be followed here. The recommended practice in Kerala is to construct California or Puertorico type terraces and to pitch the down hill side with stones for stability. This method is very effective but cost of pitching on the down hill side with stones is becoming prohibitive. Now it has become necessary to find out alternative cheaper but effective methods of construction of bunds. Taking advantage of high infiltration rate of most of hill soils of Kerala, it may be possible to develop a combinations of mechanical and agronomical methods for checking soil erosion. For this detailed investigations are necessary.

The annual rainfall in Kerala is very high but it is not well distributed. Nearly 80% of the total rain occurs during the six months from June to November. The months of January, February and March are the driest months receiving less then 3% of the total rain. The soils are comparatively shallow usually less than 3 or 4 metres deep, and only limited quantity of water can be stored in the soils. Most of the rain that falls on the hills go as surface or sub-surface runoff. In the month of December stored moisture in the soils and in the months of April and May summer shower to a large extent meet the consumptive use requirements of crops. The most critical months are January, February and March. Supplementary irrigation becomes necessary during those months. But in large areas water is not available during this season as the shallow wells and tanks dry up. Further deepening of wells and tanks will be of little use because of the limited depths of water bearing strata. We may have to adopt the dry farming techniques developed recently or evolve new techiques to raise a successful crop during these months.

Most of the double Cropped paddy fields lie fallow from January to April for want of irrigation facilities. These constitute a very large potential area for taking an additional crop. This is very important since there is practically no scope in Kerala for bringing new lands under plough. Crops like sesamum, pulses, groundnut, vegetables and

even short duration tapioca can be grown. Even if water is made available, spreading water efficiently on these level lands with high rate of infiltration, becomes a difficult problem during summer. Irrigation water application efficiency will be too low and very large quantity of water will be lost in deep percolation. Since paddy is cultivated during two seasons, the level of the land cannot be disturbed. Development of a technology for efficient use of limited water available in this season, without disturbing the land level, is very important because of large areas which are now lying fallow during summer can be put under highly remunerative crops.

Drainage problems in Kuttanad especially in the peat and muck soils ('kari) whic have unique physical, chemical and biological properties, require careful study. The ordinary drainage practices that are used in mineral soils are not suitable here. The peat and muck soils which have been developed from the residue of trees and shurbs deposited there thousands of years back contain partly decomposed organic matter. As the field level is below the surrounding water level, there is always an up ward movement of water from the sub-soil to surface. This brings along with it harmful by products of decomposition of organic matter which when come into contact with roots of plants adversely effect them. Yield has been consistently poor in these lands. Development of suitable drainage practices which will prevent the rise of toxic salts into the rootzone is of prime importance because 'Kari lands' occupy a substantial area.

Collection of hydrological data is another important work that calls for immediate action. Hydrological data, especially for small agricultural water sheds, are not available. Such data for a period of 25 years or more are available for many important locations in India. As we are already lagging behind, action has to be taken to initiate this work without any further delay.

The other special problems which require immediate attention include lands slide, torrent training, stream bank protection, sea erosion and road side erosion.

The state of Kerala offers considerable scope for research on farm machinery because of its unique farming practices, topographical features, high rainfall, small holdings, diversity of crops, pressure of population on land and large contigent of organised agricultural labourers. The agricultural equipment developed in other parts of the world as well as in other parts of India were developed with the objective of saving labour. They are mostly big machines intended for large scale cultivation. The situations in Kerala are different; here the holdings are small and number of under employed agricultural labourers is large. Any attempt to introuduce labour saving devices will be strongly resisted by the organised labour force; never the less there are situations where human labour cannot replace machinery. Pumping water for irrigation of large areas and spraying orchards having tall trees are the obvious examples of such situations, selective mechanisation is therefore inevitable.

'Petti & Para' are used in large numbers in Kuttanad and 'Kole lands' for dewatering. These machines have very low efficiency. The efficiency of 'Petti & Para' is as low as 20% to 25% while that of mauufactured axial flow pump is as high as 75%. It means that a 15 HP maufactured pump will deliver as much or even more water than a 50HP 'Petti and Pare'. There is considerable scope for improving the efficiency of the 'Petti and para'. But 'Petti and Para' has some advantages over manufactured pumps. They are cheep and are fabricated with materials available locally their repair and maintenance can be attended to be by local artisans. Improvement in the design of 'Petti and Para', retaining its present advantages is one of the important items of work that requires immediate action.

A problem which has assumed great magnitude recently is the menace caused by the rapidly propagatting aquatic weeds like salvinia aud water hyacinth which have now infested virtually all districts in the State. Mechanical control of these weeds and their utilisation for compost production are subjects which require immediate attention.

Another compulsive necessity of the day is to generate employment. The most potential source for this is agro- based cottage and small scale industries. The proposed Research Centre has an important role to play in this. The centre may undertake a survey for identifying industries suitable for each area based on the availability of raw materials and other resources. The centre may then prepare production blue prints for each of these industries by developing requisite technology at the Centre itself or by acquiring it from elsewhere in

India or abroad. This can be then transmitted to willing enterpreneurs for starting new industries.

As the conditions in Kerala are distinctly different we have to develop our own package of small implements suited to our conditions.

Resume of work done

As already pointed out very little work has been done in the Kerala Agricultural University in this important branch of Agriculture Technology.

(a) Soil and water conservation

Under the Sweedish International Development Agency assisted Scheme for Research on integrated water use a few soil and water conservation Research Projects have been initiated during 1978-79. The ongoing expervation are:

1. The effect of methods of cultivation on runoff and sub soil storage of moisture.
2. Optimum cross setion of contour bunds.
3. Cropping system and soil consevation practices on sub soil storage of water and crop yield.

Research on Mechanial measures to prevent Soil erosion has been doue in Oottacamund and the topography thera is some what similar to that of the high ranges in Kerala. They have found out various rules to fix the vertical interval, grade and crosa section of terraces and bunder under different topographical conditions.

The bench terraces recommended for Nilgiris are not suitable for Kerala conditions as the depth of soil is very shallow and the levelling of land on individual terraces will expose underlying rocks in most of the hilly areas in Kerala. Nilgiris has very deep soil and bench terraces are suitable for their conditions.

b) Irrigation and Drainage

Under the integrated Project for Reserarch on water management and Soil Salinity, studies were initiated at the Agronomic Resdarch Station, Chalakudy from 1974-75 on the Engineering aspects of irrigation and drainage. The following project were under taken.

Studies were conducted to findout a method for reducing the percolation loss in paddy fields. The methods tried were puddling with different types of implements like country plough, power tiller and wet land puddler and sub soil compaction. The soil was sandy loam. None of the treatments showed any significant variation and it was concluded that in light soils a good puddle cannot be created whatever be the methods used for puddling. In heavier soils results are likeiy to be significant as observed in different parts of India.

Another study conducted at the centre revealed that the mean value of IW/CPE ratio for rice was 1.45 during Puncha season. This is in agreement with result obtained in I. R. R. I., Philipines.

Exploratory studies were taken up to tap the shallow ground water available in rice fields for surface irrigation in the low lying fields. it was assessed that the sub-surface water tapped by a single tile line can irrigate 0.5 to 0. 65 hectare of rice. In other words, a well laid out system would enable us to recycle the sub surface water in considerable area during Mundakan season. The installation cost was Rs.7/- per metre, including labour charges and cost of tiles. No operating expenses are invlved for collection and conveyance of water through tiles.

A cheap drip irrigation equipment was developed and successfully tested. The advantage of this equipment is that it is cheap and the equipment can be fabricated and installed by the farmer himself. The cost of equipment per hectare is Rs. 3500/- to Rs' 4500/-. The equipment will last fo 5 to 6 years and once installed no additional labour is required for diverting water during irrigations.

Hydrological Investigation conducted by tha soil conservation Research Stations under the Indian Council of Agricultural Research have found out the values constants for different months for calculating the consumptive use of crop based on Blaney-criddle Method for three locations in Kerala, namely Calicut, Cochin and Trivandrum.

(c) Farm Machinery

For taking up worthwhile projects on development of machinery a fully equipped workshop is necessary. However with limited facilities available, the Department of Agricultural Engineering, College of Agriculture, Vellayani has taken initiative in implementing nine projects listed below:

1. Development of a Granular Fertiliser application for wet land paddy.

2. Development of a Seed Drill for upland paddy.

3. Development of a manually operated weeder for row crops like tapioca.

4. Design and fabrication of a wind powered water pump.

5. Preliminary studies on mechanical control of floating type aquatic weeds.

6. Preliminary studies on equipment for soil excavation for reclammation of Kayal areas.

7. Development of low cost garden tractor.

8. Development of a low cost paddy drier.

9. Adaptive design and development work on innovations in Agricultural Engineering from Kerala and elsewhere.

These projects are at different stages of execution. A prototype of an equipment for mechanical control of floating type aquatic weeds has been fabricated and was tested. The equipment worked satisfactorly and the further improvements are going on.

Research gaps identified and future line of work

About 50 problems which require urgent attention have been identified. They are to be taken up on a priority basis in the proposed Research Stations for Soil and Water Management and Farm Machinery and equipment.

A. SOIL AND WATER MANAGEMENT

(a) Soil erosion control measures

1. Development of a cheap method for controlling erosion in the steep hills of Kerala.

2. To evolve specification for various mechanical measures for soil conservation.

3. To study and recommend suitable grasses and legumes for stabilising earthern structures.

4. To study methods to reafforest denuded and highly eroded areas in forest and in the Catchment of Major reservoirs.

(b) Cropping pattern & water conservation measures

1. To study and recommend suitable cropping pattern for different areas based on soil type, land slope and water availability.

2. To evolve suitable dry farming techniques to raise a crop during the dry months.

3. To develop methods for reducing evaporation and percolation losses from tanks and ponds.

4. To study water conservation methods through storage tanks including a survey of ancient practices in Kerala.

(c) Irrigation

1. To study the water requirement of crops grown in Kerala.

2. To develop a technique for water saving irrigation for rice.

3. To develop a technique for efficient irrigation in the rice fallows during dry months to raise a good cash crop.

4. To evolve a suitable recommendation for irrigation of different crops based on critical growth phases.

5. To devise methods for reducing seepage losses in canals.

6. To devise a cheap method for drip irrigation

7. To study the effect and economics of sprinkler irrigation especially for plantation crops and vegetables.

8. To develop an effective method for surface irrigation on steep slopes.

(d) Drainage

1. To study the effect of tile drains in removing toxic salts from the root-zone of rice plant in pest and muck soils of Kuttanad.

2. To develop methods for recycling surface and sub-surface drainage water for irrigation.

(e) General

1. To study the reclamation problems in 'Poonathal Padam'.

2. To develope a technique to reduce percolation loss in paddy fields.

3. To study the complex problems of Kuttanad by 'system' approach.

B. MACHINARY DEVELOPMENT

a) Land Development

1. Design and development of Soil levelling equipment for paddy fields.

2. Design and development of a device for extraction of 'mud blocks' from under water for reclamation and bund forming works in Kuttanad.

3. Design and development of a small dredging equipment for reclamation work in Kuttanad.

4. Design and development of a deep water puddling equipment.

b) Water lifting devices

1. Improvement in the design of the body 'Petti and Para' for increasing its efficiency

2. Improvement in the design of impeller of 'Petti & Para' to increase its efficiency.

3. Development of a jet pump attachment for increasing the centrifugal pump discharge under low head conditions.

4. Development of a paddle pump for low head, high discharge applications.

5. Development of a floating axial flow pump.

c) Seeding equipment

1. Adaptive development work on low land and upland seed drills based on I. R. R. I designs.

2. Development of seed dibbling cum fertiliser drilling equipment for dry sown paddy.

d) Weed control

1. Development of weed control implements for dry sown and wet land paddy.

2. Design and development power operated aquatic weed harvestor.

e) Insect, pest and rodent control

1. Development of an efficient light trap for nsect and pest control

2. Development of mechanical and electrical devices for rodent control.

f) Nutrient application

1. Development of a device for placement of fertiliser under puddled conditions.

2. Development of an equipment for placement of granular fertiliser.

g) Threshing device

1 Development of cheap and efficient manually operated thresher.

2. Development of a small power thresher.

h) Post harvest epuipment

1. Development of manually operated winnowing and seed cleaning equipment.

2. Development of cheap paddy drier.

3. Development of equipment for cutting lemongrass into small pieces to improve the oil recovery.

4. To develop a coconut husk processing equipment.

5. To develop a straw bailing equiqment

6. Development of tapioca chipping machine.

i) Alternative energy source development

1. To develop a wind powered pump

2. To device a Bio-gas conversion technique

3. To study the aspects of efficient use of solar energy for different agricultural needs.

j) Mechanisation Research

1. Study the feasibility of selective mechanisation in Kerala.

2. To study the prospects of mechanised cultvation in 'Pokkali' lands.

16. SOILS AND AGRONOMY

The soil is the most important natural resources of a country. It is by the agronomic management of the soils that we produce our food. A proper under standing of the soil characteristics is an essential prerequisite for the efficient management of the soils. As far as Kerala is concerned it has been found that 88 percent of the soils are acidic in reaction, 60 percent are medium in regard to available N and 65 percent are low in available phosphorus and 75 percent are low in available potassium. On such soils we grow a wide variety of food crops and plantation crops. Considerable amount of work has been done in the past on the soils of Kerala, but more detailed work is yet to be done on some aspects. The major areas in which further work is to be pursued have been identified and discussed below.

1. THE MANAGEMENT OF ACID SOILS BY LIMING

Introduction

Soils become acidic for various reasons such as the leaching away of bases by excessive rainfall, removal of nutrients by higher plants and micro-organisms, production of carbondioxide and organic acids by the decomposition of organic matter, im-proper use of commerical fertilizers and by the production of mineral acids such as sulphuric acid under certain conditions. Agricultural crops are able to tolerate soil acidity to various extents, but extreme acidity is harmful. The presence of toxic factors, poor microbial activity, unavailability of N, P, K, Ca and Mg, etc are some of the unfavourable environmental factors associated with soil acridity. Application of lime is the remedy recommended for the management of acid soils. In Kerala, the application of lime at the rate of 600 kg per hectare has been recommended in the package of practices for rice. More specific recommendations for individual fields are made on the basis of soil test results.

Resume of work done

The results of experiments conducted in different parts of Kerala have not always been consistent. It has been reported that rice yields in *Kari* lands could be increased from as low as 300 kg/ha to as much as 1200 kg/ha by the application of lime. During the period 1961-66 the Department of Agricultural Chemistry in the College of Agriculture, Vellayani conducted a series of liming experiments in Kuttanad and found that liming resulted in increased rice yields and the economic dose of lime was found to be 1120 kg/ha (Annual Report of the CMA Scheme, 1966). Kabeerathumma (1969) has reported that the optimum dose of lime for maximum efficiency is half the lime requirement for Karapadom soils and full lime requirement for the *Kari* soils of Purakad and Ambalapuzha. In a pot culture experiment conducted using the Vellayani Kayal soil, Sivan Nair (1970) found that lime at half the lime requirement had several beneficial effects on the growth, yield and quality of rice. According to Nambiar (1961) liming improves the microbiological activity in the soil, thereby making more nitrogen available to the rice crops.

Biswas and Goswami (1973) have reported that the application of lime to *Kari* soil at the rate of 2000 kg/ha resulted in yield increase ranging from 58 t › 85 percent. In Karapadam soil the application of lime at 1000 kg/ha resulted in yield increases ranging from 34 to 52 percent. According to Gopalakrishnan (1973) the application of iime to Pokkali soils at the rate of 500 kg/ha increased the yield of rice by 20 to 30 percent.

However, the trials conducted at the Model Agronomic Research Centre, Karamana, (Annual Report 1971-72) failed to record any significant effect for liming on rice yields. Similarly, trials conducted in cultivators fields in Trichur, Quilon, Trivandrum and Malappuram districts also did not give any response to applied lime. From the Rice Research Station, Moncompu also it is reported that rice does not show any response to lime application. (Personal communication)

From the above results it appears that the liming of acid rice soils requires more careful study. It is possible that the PH value or the lime requirement of the soil is not the only factor which determines the necessity for liming, but also the actual level and availability of Calcium in the soil. Hence, more work has to be planned and carried out in this direction.

Research gaps identified and future line of work

1) Determination of the critical level of Calcium in soils and plants below which response to liming can be expected.

2) Calcium status and availability in the soils of the various rice growing areas of the state.

3) The optimum level of lime application in ime responsive soils for maximum yield.

4) The optimum time and method of application of lime.

5) Comparative efficicaes of various liming materials in different agroclimatic regions.

6) The physical properties of liming materials sech as the degree of fineness in relation to their effectiveness for neutralising soil acidity and improving soil productivity.

2. PHOSPHORUS NUTRITION OF RICE

Introduction

Studies conducted in India and abroad reveal that rice fails to respond to Phosphate fartilization even though upland crops grown on the same soils show positive ressponse. The work carried out in our state also has yielded conflicting results. Adequate phosphate in the soil is esential for nitrogen uptake and if P is limiting plants do not grow normally and yields are depressed, (Lockward, 1959). TU-soils where P is deficient hardly any benefit can be derived by adding Nitrogen and Pottassium. Research findings in favour of phosphate manuring are plentiful, but at the same time there are also results which do not indicate any significant yield response for rice to phosphate application. It appears that the response of rice to phosphorus depends on several factors and as such it may be neccessary to study each soil type in respect of its response to added phosphatic fertilizers.

Resume of work done

A series of field experiments were undertaken in the water-logged sandy loam soils of Pattambi almost from the very inception of the Rice Research Station. The results of experiments conducted at the Station during the period 1933-68 were summarised and the results show that the response of rice to phosphate manuring was not significant. (Nair and Pisharody, 1970). On the other hand, in the alluvial clayey soil of Monkompu (plt 4.5) the application of superphosphate and bonemeal at the rate of 45 kg $P_2 O_5$/ha resulted in significantly higher yields of rice as compared to the no phosphorus treatment (kurup and Ramankutty, 1969)

The role of magnesium as a carrier for Phosphorus has been investigated by several workers (Varghese and Money 1965. Ayyappan Nair and koshy, 1969). Their findings generally agree that magnesium aids in the better utilisation of added phosphates. The erratic and inconsistent response of rice to added phosphates in lateritic soil has been investigated by the application of phosphates in conjuction with magnesium and spartin, a commercial product containing secondary and trace elements. It was seen that magnesium and spartin has no significent influence either on grain yield or on enhancing response to phosphate application. (Nair et al, 1972).

The lack of response to added phosphates is attributed to fixation of phosphates in soils especially when active iron and aluminium predominate. With a view to obtaining a clearer understanding of the mechanism of P fixation in soils and the nature of retained Phosphates, certain investigations were carried out by Koshy and Brito-Mutunayagam (1965). They found that added soluble phosphates were fixed in soils in the form of iron and aluminium phoshates, but they did not, however, totally exclude the possibility of some adsorptinn mechanism preceding the chemical precipitation.

Raj and Shetty (1973) found that soil reaction played an important role on the availability of plant nutrients and thereby influenced crop yields. Through a statistical study they examined the correlation between PH, lime and available phosphorus (taken individually and in combination) and yield of grain and straw of Ptb 10 rice variety grown at the Rice Research Station, Pattambi, with 36 treatments representing various combination of lime, green manure and superphosphate, Very high correlation were obtained between PH and grain or straw yield, this being improved slightly by the introduction of available phosphorus with PH in a multiple correlation.

The lack of response to phosphates in research stations might be attributed to the high fertility status of the soil due to continuous and regular applications of phosphatic, fertilizers. Hence, the response was studied in cultivators fields through the all India Co-ordinated Agronomic Research Projects by conducting field traials. The results indicate that in the districts of Palghat and Trichur there is no response to added phosphates; But in Quilon, Alleppey, Malappuram and Trivandrum District the response to added phosphate is positive. It must be understood that the results in cultivaior's fields are based on one year's trials only. In the districts of Palghat and Trichur also there were cer-

t ain pockets where response to P was obtained in these trials. It is yet to be investigated whether response to Phosphorus will be obtained if phosphates are applied continuously for two or more seasons in these fields. If trials are carried out at the same location for four or five seasons their results will give more reliable information. On this basis field trials were laid out in Research Stations to find out whether phosphatic and pottassic fertilizers can be skipped from the manurial schedule of rice for one or two seasons after application in one season. The results obtained at the Rice Research Station, Pattambi indicate that for better production of grain yield it is advisable to apply P and K once in two seasons and that there is no harm if the applications are skipped for two seasons. The studies also reveal that if P and K are applied in higher quantities continuously there is possibility of yield reduction. It has been reported that high amounts of Phosphatic fertilizers may cause deficiency of zinc to the rice crop. (Prabha et al, 1971).

One reason for the lack of response to phosphatic fertilizers may be the fact that native P in soils exists is a state of dynamic equilibrium between the less available and more available forms. When the available form is removed by a crop a fresh supply passes on from the less available to the more easily available form.

Research gaps identified and future line of work

1. Of the three major plant nutrient elements, N, P and K, the most difficult to understand is P and its availability to plants. The measurement of available P by the present methods itself is a question to be examined in detail. Attempts should be made to evolve suitable methods for determining available P in soils and to correlate it with crop response.

2. Pot culture or field experiments should be carried out in different soil types to locate more specifically the areas where response is obtained to added phosphatic fertilizers.

3. In soils where no response is obtained experiments should be conducted to find out whether the lack of response is due to the high fixing capacity of the soil, or due to more phosphate becoming available as a result of water-logging.

4. Experiments should be carried out to find out whether response to P and will be obtained in the presence of higher levels of other nutrients, especially N and Ca.

3. MICRONUTRIENT STATUS

Indroduction

Trace elements or micronutrients such as copper, zinc, boron, chlorine, Molybdemum, Manganese and iron have been established as essential elements for the nutrition of plants. Of these elements Mn and Fe are generally required in slightly larger amounts than the others. All these elements are equally essential and the lack of any one of them will result in crop failure.

Resume of work done

The soils of different parts of India differ markedly in the micronutrient status and availability. But soils of similar geological and pedological origin show similarity within a particular range of variation. The information on the distribution of micro-nutrient elements in Indian soils is summarised below:-

Copper:- The total content as well as the form of copper varies widely in different parts of India. The availability of Cu is found to depend on a number of factors of which PH, organic matter, Calcium carbonate and the amount and nature of clay are the predominent ones. A negative correlation between PH and the amount of available Cu has been noted widely.

Zinc:- Both total and available zinc shows wide variations in Indian soils. Exchangeable Zn increases with decreasing PA. Application of phosphatic fertilizers may result in reduced zinc availability.

Iron: The most significant factor affecting the availability of iron is soil reaction nnd aeration. The redox potential and the presence of soluble complexing agents are other factors which govern the availability of iron. In submerged rice soils large quantities of iron are present in the water-soluble ferrous form.

Manganese: Manganese exists in Indian soils in various forms, such as the water-soluble, exchangeable and higher oxides. There exists probably a dynamic equilibrium between these various forms, controlled by number of factors such as the PH, oxidation reduction potential and microbiological activity fluctuating under the influence of various soil and climatic conditions. The total manganese content is positively correlated to the percentage of

clay and the finer fractions of the soil. Submergence leads to the reduction of the higher oxides of Mn to the more soluble manganous form.

Boron:- The total B content of Indian soils varies from 3.0 to 600 ppm, but in acid soils the variation is found to be in the range of 3-100 ppm. If has been reported that the liming of acid soils reduces the availability of B to plants.

Molybdenum:- The total Molybdenum content of soils is generally in the range of 0.5 to 5.0 ppm. The availabe of M_0 content varies from 0.10 to 0.90 ppm. The availability of M_0 decreases with decrease in the PH and can be considerably increased in acid soils by liming. Organic matter also helps to increase the availability of M_0 in acid soils.

In Kerala:- The distribution of the micronutrient elements in Kerala soils has been investigated systematically during the last 12 years. The work carried out is reviewed briefly below:-

Iron and Manganese:- Phisharody (1965) studied the forms and distribution of iron and manganese in six soil profiles of Kerala. He noted that the variations in the water soluble. exchangeable. reducible and active forms of Fe were from 9.0 to 45.1, 6.2 to 58.6, 5.0 to 100.8 and from 26.9 to 202.4 ppm respectively. Similarly the water soluble, exchangeable, reducible and active forms of Mn ranged respectively from 1.8 to 14.8, 10.2 to 80.0, 8.0 to 124.2 and from 35.5 to 159.6 ppm. These results indicated that the soils were adequately supplied with available form of Fe and Mn.

Molybdenum- Rajagopalan (1969) investigated the distribution of Mn and Mo in fourteen profiles representing the major soil groups of Kerala. He eoted that the total Mn content varied from 103.8 to 950.0 ppm with an average of 445.9 ppm, The variations in the exchangeable and reducible forms of Mn were from 1.5 to 82.5 ppm and from 2 0 to 400.0 ppm respectively. The total Mo content of these profiles varied from 0.7 to 2.6 ppm. From these results also the general conclusion is that the levels of Mn and Mo in the soils examined are satisfactory.

Coppor and Zinc:* Praseedom (1970) studied the distribution of Cu and Zn in the 14 profiles which Rajagopalan examined for Mn and Mo. Total Cu varied from 5.0 to 32.50 ppm, the range in available Cu being from 0.13 to 4.7 ppm. Total zinc ranged from 3.5 to 100.00 ppm, the variation in available Zn being from 0.25 to 8.0 ppm. With the exception of a few samples all the soils were found to be adequately supplied with Zn and Cu.

Balakrishnan Nair (1970) found that the levels of available Cu and Zinc in the soils of Onattukara and Kuttanad were generally satisfactory. However, a pot culture study indicated that rice responds to Cu and Zn in these soils. The response was more in the Kuttanand soil than in the Onattukara soil.

George Varghese (1971) investigated the fertility status of the alluvial soils of Kerala with special reference to the distribution of Cu varied from 1.10 to 4.05 ppm in the surface layers from 0.80 to 2.65 ppm in the second layers and from 0.65 to 4.35 ppm in the third layers. Similarly the variations in available Zn in the three layers were 2.40 to 6.48 ppm, 1.80 to 6.20 ppm and 1.20 to 4.50 ppm respectively. Judging from the critical limit of 0.5 ppm for available Cu and Zn it is to be concluded that the alluvial soils studied were well supplied with both Cu and Zn.

Valsaji (1972) studied the distribution of available Cu and Mn in 16 profiles each of the Amaravila and Marukil series and found that both these series contained these elements well above the critical limit.

Gopinath (1973) found that total Cu ranged from 13.8 to 23.0 ppm in the surface samples of *Kari* soils with an average of 19.0 ppm. The variation in available Cu was from 0.4 to 1.5 ppm. Total zinc in these soils varied from 12.5 to 41.6 ppm in the surface samples with an average of 27.0 ppm. The range in variation in available Zn was from 0.8 to 1.6 ppm with an average of 1.4 ppm.

The above results are in agreement with the general assumption that acid soils in the PH range of about 4.5 to 5.5 are ususally well supplied with Cu and Zn, However, the survey conducted by the staff of the Co-ordinated Project on micronutrients at Coimbatore indicated that the deficiency of Cu and Zn may be fairly wide-spread in Kerala soils. This indicates the necessity for more careful, detailed and elaborate investigation of the distribution of the micronutrient elements in the soils of the State.

In this context it is signicicant that response of rice to Zn application has been reported from some

areas in the State. It may so happen that chemical tests may indicate the adequacy of an element in the soil and yet the element may not be available to plants due to interactions and antagonisms.

Research gaps identified and future line of work

Some of the problems to be investigated in the future are indicated below:-

1. The distribution of total and available micronutrients (including Boron) in different soil types.
2. The downward distribution of total and available forms of micronutrients in representative soil profiles.
3. Investigation of the different forms in which the micronutrients exist in Kerala soils.
4. Fixation of micronutrients by soil minerals, organic matter etc.
5. Indentification of areas of micronutrient deficiency and toxicity.
6. Study of symptoms of micronutrient deficiency in various crop.
7. The effect of the application of micro-nutrients on the growth and yield characters of differenf crops.
8. Determination of the critical limits of the micronutrients in the different crops.

4. PHYSICAL PROPERTIES OF SOILS

Introduction

Seven major soil groups and twelve agroclimatic regions have been identified in Kerala. The soil groups identified are the virgin forest soils, the laterite and associated soils, the red soils, the alluvial soils, coastal sandy soils, peaty soils and the black soils. The agro-climatic zones of Kerala are the Onattukara region, the coastal sandy tract, the southern, central and northern midland regions, the northern midland region of the Malapuram type, the highlands, the Palghat area, the redloam belt, the black soil tract, the Kuttanad region and the High ranges. Considerable amount of work has been done in the past in the Depertment of Agricultural Chemistry on the chemical and fertility aspects of these soils, is rather meagre. The information on hand is restricted mostly to the data on the mechanical analysis of differnt soils carried out by postgraduate students and research workers to obtain basic informatioin for other investigation. Much work remains to be done on the other physical aspect of Kerala soils such as structure, plasticity, aereteori ground-water fluctuations, soil moisture relationship etc. A correct assessment of these characteristics is essential for suggesting the necessary management practices for each soil type.

Resume of work done

Wide variations are noted in the physical properties of Kerala soils. The texture varies from heavy clays of the hydromorphic soils to the sandy texture of the coastal alluvium. The variations in the structure are from that of single grains of the coastal sands to the puddles of paddy soils. Cultural operetions exert their influence on the structure and modify it constantly. There are certain soils which presnt special management problems. The soils of the Poonthalpadam are in highly dispersed state and require careful study. The soils of Kuttanad are likely to present new problems with the prevention of salt water entry by the construction of tha Tanneermukkom Barrier. These problems have to be carefully investigated and remedies discovered. Practically no information is available on properties related to soil moisture such as plasticity, stickiness, expansion, waterholding capacity, wilting coefficient, hydroscopic coefficient, permeability, infiltration capacity, etc, of the various soil groups of Kerala.

Research gaps identified and future line of work

Some of the major problems to be investigated in this area are listed below:-

1. Textural variations in soils and correlation to other soil properties.
2. Structural variations in the major soil groups and correlation to other soil properties.
3. Aggregate analysis of different soil types.
4. Determination of single value constants and their relationships to other soil characteristics.
5. Determination of soil moisture constants for different soil groups.
6. Study of the moisture release curves for different kinds of soils.
7. Study of the infiltration rates, hydraulic conductivity, etc, of different soils.
8. Fffect of management practices on soil structure and other physical properties.

9. Investigation of suitable practices for maintaining the proper physical properties in soils.

5-SOIL TEST CROP RESPONSE STUDIES

Introduction:-

Soil testing is an essential pre-requisite for the scientific and economic management of soil fertility. If soil testing is to become meaningful there should be significant correlation between soil test data and the up-take of nutrients by crops. Hence, the necessity for soil test crop response studies.

At present there are seven soil testing laboratories and two mobile soil testing units in Kerala. These laboratories are following the colorimetric organic carbon method for available nitrogen, Bray's No. I reagent (Bray and Kurtz, 1945) for available P and the neutral Ammonium acetate extraction (Hanway and Heidal 1952) for available potassium. These methods were developed in the temperate regions and their suitability for tropical soils has yet to be established.

Resume of work done

Only very little work has been done in Kerala on soil test crop response studies. The meagre work done and the results obtained under green house conditions require confirmation under field conditions. The work done elsewhere is briefly reviewed below:-

Nitrogen:-

Available N is determined either by an extraction method or by an incubation method. The extraction method comprises of modified Valkley and Black's method and the alkaline permanganate distillation method.

In valkley and Black's method only the easily oxidizable form of organic matter is estimated. Kalbande (1964) found this fraction to be the best index of N availability to wheat. But Subbiah and Bajaj (1968) could not corroborate this conclusion as they found that soils richer in organic matter responded ro added nitrogenous fertilizers.

Based on the alkaline permanganate method Subbiah and Asija (1956) classified soils into low, medium and high fertility classes. Ramamoorthy (1967) and Bajaj (1967) found this method as ideal for evaluating the nitrogen supplying power of soils, According to Venkateswaralu (1971) the variations in fertilizer nitrogen recommended by this method may be significant only under low levels of production.

In the incubation method the nitrate or ammonia formed in two weeks under specified condition is taken as the index of nitrogen in the determinatien of the ammonia formed by hydrolysis as a result of autoclaving the soil under high pressures. According to Venkateswaralu (1971) the ammonia formed by incubation is more useful to predict the nitrogen status of unfertilized soils.

Phosphorus:-

The most widely used methods for determining available P are the Olsen's method (Olsen et al,1954) using 0.5 M NaH CO_3 and the Brey's No. I method (Bray and Kurtz, 1945) using 0.025 NHCl containg 0.03 N NH_4F.

Olsen's method has been found to be particularly suitable for alkaline soils and also for acid low land soil (Datte and Kamath, 1959, Kanwar and Datta 1970). Working with Kerala soils, Nair (1965) did not obtain significant correlation between P extracted by Olsen's reagent and plant uptake under arable conditions, but obtained significant correlation after sumbergecnce. Datta and Kamath (1959) extracted soils with different reagents and found that extractants involving acid solution generally removed higher amounts of the soil P.

Potassium:- Neutral Ammonium acetate is generally used for the estimation of available Potassium. Tamhane and Subbiah (1958) found that no single extractant was equally suitable for all soils. They further observed that Morgan's extractant-soluble K, percentage K saturation and dil HNO3 soluble-K showed moderate to high correlation with crop response in red and laterite soils of Bihar and the alluvial soils of Kerala and Mangalore.

From a study of the comparative efficiencies of different extractants like Dyer's one percent citric acid, Morgan's reagent and 0.5 $NHNO_3$, Oommen and Iswaran (1962) found that 1% citric acid and 0.5 N HNO_3 were the most suitable reagents for the coastal alluvium of Mangalore and the red loam

soils of Bihar respectively. Datta and Kalbande (1967) reported that K extracted with the Hunter and Pratt reagent gave a good relationship with yield and K uptake by rice. Ramamoorthy and Paliwal (1965) studied the availability of potassium in a number of Indian soils by different methods and found that the K absorption ratio by the rapid methods showed very high correlations with crop response. But this method is too complicated for use in routine analysis, Kanwar (1971) has pointed out that neutral N Ammonium acetate can be used for available K in soil testing until better methods become available.

The suitability of the various methods for available N, P and K discussed above has not been tested systematically for Kerala soils. Further it may also be necessary to test rice soils after keeping them incubated under submerged conditions because the physico-chemical properties of flooded soils are very much different from those of the upland soils.

Research gaps identified and future line of work

1. Pot culture studies to evolve suitable extractants for available, N, P & K.
2. Field experiments to verify the results obtained in the pot culture studies.
3. Attempts to find out a single extractant for different nutrients, which will facilitate the analytical work in the soil testing laboratories, considerably.

6. PLANTATION CROP SOILS

Introduction

The plantation crops grown in Kerala are rubber, tea, coffee, oil palm, cocoa and spice crops such as cardamom, pepper, clove and nutmeg. These crops are grown mainly in the High Ranges and the Midland region. Apart from studies conducted on the soils of the High Ranges and Midlands from the pedological point of view, no systematic work on these soils in relation to each of the above crops have been undertaken except in the case of rubber by the Rubber Research Institute and in the case of tea and coffee by the respective research organizations.

Resume of work done

On a review of the past work done in this field, it is seen that the work done is of a sporadic nature with emphasis on studies on the effect of deforestation or on the influence of a particular type of vegetation on soil properties. Thus the effects of forest rype ie. deciduous, shola and ever green on soil properties were studied by Thomas (1964) while the effects of deforestation on nitrogen, organic matter and available, and total potassium levels on soils were studied by Chaly (1963). The effect of a teak vegetation on laterisation was studied by Jose (1968) and it was found that replanting with teak did not accelerate laterisation though it caused temporary impoverishment and hardening of the lateritic material originally present. Studies of Nair (1969) revealed that the levels of organic matter in the forest type of soil was critical in deciding the availability of various nutrients. Aiyer (1975) studied soil profiles from cardamom growing areas and found that the total nitrogen status of the surface samples varied from 0.1 to 0.4 percent while percentage of available nitrogen to total nitrogen varied from 10 to 15. The available potassium levels of the surface soil varied from 10 to 30 kg/ha. The soils were well supplied with calcium but were poor in magnesium. The available phosphorus was extremely low to the extent of 5 to 10 kg/ha. But it has to be pointed out that these studies have not been conducted in relation to specific crops and their response to added nutrients.

The mid-land region of Kerala is covered by leterite and lateritic soils, poor in base status and all the other major plant nutrients. Besides the soils are also acidic. It is in these soils that the cultivation of ginger, turmeric, cocoa and pepper are popular or becoming popular either as pure crops or mixed crops. The alluvial soils are particularly suited and therefore cropped to nutmeg especially in the flood plains of the Periyar river. The High Ranges with its forest type soil are occupied by cardemom, tea, etc. In short, there is not much relevance between soil types and the crop cultivated in them in the conditions existing in Kerala State. Under such a situation, soil studies have to be directed with the aim of assessing the best management practices particularly with reference to manuring It is pertinent to point out that the fertilizer recommendations made at present for crops like ginger, turmeric, cocoa, oilpalm, cardamom etc, are based mainly on the past experience, theoretical assumptions and deductions rather than on statistically laid out experimental results on different soil types. Thus there is a need for conducting well

laid out experiments on these crops in different soil types where they are at present cultivated.

Further, in view of the fact that most of these crops are now being cultivated on highly deteriorated lateritic soils or soils in deforested areas which are at present rich, but likely to deteriorate in the long run. Such studies should not be confined to the major nutrients only. Liming materials especially those containing calcium and magnesium, micro-elements etc, will also receive attention along with the above. This has to be particularly emphasised because many of the diseases observed are pre-disposed by secondary or micronutrient deficiencies.

Since it may take about 10 years to establish a new plantation to conduct new experiments, it will be desirable in the interest of collecting necessary data in the minimum time and with the minimum expenditure to conduct experiments in existing plantations in various locations. While conducting such experiments it will be desirable to conduct not only agronomic research but also collect necessary information on fertility status of the soils vis-a-vis the nutrient status in different plant parts.

This will enable correlation between the utrient levies in different plant parts, and the fertility status of the soils. Thus suitable plant parts should be standardised for diagnosing deficiency/ toxicity levels of nutrients. In some of the plantation crops like cocoa and pepper standardisation of the reflect (Plant part) has already been done in foreign countries. These could be re-standerdised if necessary. For other specific crops standardisation will be required. Research, therefore, will have to be directed on a multi-disciplinary level.

Most of the plantation crops are grown in deforested areas and these areas are increasing at the expense of the forested area. One of the factors which guide the increase in the particular type of plantation crops like oilpalm is, the economics of the immediate returns. The loss in soil fertility and the deterioration of soils are not taken into consideration in deciding the choice of the crop from a well defined crop cafeteria. There is need to assess the deterioration in soil fertility and quantity this in terms of rupees before we decide on the choice of the particular crop.

Research gaps identified and future line of work

Under the above circumstances the areas which have to be investigated in detail are the following:-

1) Choice of different plantation crops based on long term projections on economic returns vis-a-vis loss of plant nutrients and soil deterioration especially in forested areas. For this the extent of deterioration undergone by soils in plantations of different crops of more of less identical age compared with virgin forests from the same locality will have to be studied and projections made for future deterioration with the help of mathematical models. These will have to be taken into consideration along with other criteria for expanding the area under any particular crop.

2) Standardisation or re-standardisation of foliar diagnostic techniques for finding out nutritional deficiencies particularly for perennial plantation crops. These are long term programmes for which separate experiments are not required. Manurial experiments on such crops should always be detailed with foliar diagnostic programmes also. This will enable the development of an expertise for recognising visual symptoms of deficiency/toxicity. With a view to confirming such symptoms wherever necessary, nutrient culture experiments on these plantations crops may also have to be taken up.

3) The root distribution studies will have to be taken up to assess the volume of soil on which the plants feed upon. Such studies are particularly important for deciding the depth of sampling for collection of soils for analytical work, placement of fertilisers etc.

7. VARIETAL ADAPTABILITY TO SEASONS IN RICE

Introduction

Weather and crop yields are intimately related. Yields are high when weather conditions are optimum for growth and development. Much of the fluctuations in production are the result of the varieties of weather. This necessitates the study of the reaction of crop varieties to changes in weather conditions in order to exploit fully their yield potential.

The advent of monsoon determines the time of sowing (planting) of rice in our state and consequently the weather factors like rainfall, temperature, light and humidity play prominent roles in crop performance. Some of the restraints that monsoon imposes on productivity of rice in the tropical rice growing areas like Kerala are low light intensity, short day length, irregular moisture supply, floods and temperature. Our traditional tall varieties which

have been evolved by natural selection, are well adapted to such hazardous environments and poor management levels unlike the modern 'wonder rices' which are more exacting in their requirements.

There is no clear cut evidence that light is a limiting factor in rice production in our state. In fact, higher yields are obtained from 'modern' varieties when they are grown in the cloudy and wet 'virippu' season. These weather conditions prolong the vegetative phase and this may be the reason for better performance of the dwarf varieties in the virippu season.

The second crop season is characterised by moderate rainfall, relatively high temperature at the early vegetative and ripening phases of the crop and shorter photoperiods. These conditions shorten the vegetative phase of most of the high yielding dwarf rices. Consequently, rice yields are low in the mundakan season.

There is paucity of quantitative data on the influence of light intensity, spectral composition and temperature on growth habit and yield of rice varieties in our state.

Resume of work done

A few studies have been conducted in this area at the Rice Research Station, Pattambi using dwarf *indica* rices like Jaya, IR 8, Sabari, Aswathi, Thriveni, Annapoorna and Rohini and several pre-relase rice varieties. These studies have revealed that most of the varieties are highly suited for the cloudy first crop season, with Jaya topping the varieties tested. Yields declined as the date of planting was delayed from July through December. The lowest yields were recorded when the varieties were planted in the month of November. A positive correlation with flowering duration and yield was also noticed. The minimum fluctuation in flowering duration was observed in Triveni and Annapoorna among the released varieties. Consequently, these varieties performed satisfactorily in both the seasons.

A recent study conducted at Pattambi using varieties belonging to early (Cauveri, IET 1444, RP 4-14), medium (Jyothi, Bharathi) and late (RPW 6-17, IET 3b57; Mashuri) duration groups, indicated photoperiod sensitivity of the varieties tested, although its magnitude varied with individual varieties. The ranges in flowering duration were 68 days to 106 days in the early group 78 days to 102 days in the mid duration group and 95 days to 123 days in the late duration group. The duration of flowering increased in all the varieties in response to the match of the planting season for March to June and then it dropped abruptly in July, again to rise in August. A fall in flowering duration was observed in plantings done thereafter. This is attributable to the shorter photoperiods (September to January) in the second crop season. Thermosensitivity of the varieties might be another factor for this phenomenon.

The planting time manifested its influence on grain production in all the varieties. The crops planted in the rainy first crop season (June-August) had higher yields compared to plantings done thereafter. A general decline in dry matter production was observed in all the groups of varieties from September through December. This type of crop performance is seen in most parts of Kerala when high yielding *dwarf* cultivars are raised.

Research gaps identified and future line of work

In view of the difference in crop performance during the virippu and mundakan seasons, the reaction of rice varieties to weather phenomena have to be studied in detail and quantitative data gathered so as to fix up varieties for each season. Available evidence also indicates the need for evolving varieties which are not thermosensitive. Effect of temperature on the availability and absorption of nutrients, growth pattern, respiration etc, of our varieties also merit attention.

8. AGRONOMY OF RICE IN PROBLEM SOILS

Introduction

There are different groups of problem soils in Kerala, the chief among which are (1) the acid *kari* soils of Kuttanad, (2) the saline *pokkali* and *kaipad* soils of Ernakulam and Cannanore Districts and (3) the Poonthalpadam soils of Chittoor. The cultivation of rice in these soils is often an uncertain, risky and hazardous venture. Considerable amount of work has been done on the management of the *kari* soils, but very little work has been carried out on the agronomy of rice in the *pokkali*, *kaipad* and *Poonthalpadam* soils.

Resume of work done

Most of the work done of the *kari* soils has been directed towards identitying the reasons for their low productivity. Narayana Iyer (1928) attributed the infertility of these soils to deficiencies in phos-

phoric acid and lime and to toxic concentration of water soluble salts. For the reclamation of these soils he recommended liberal applications of lime and phosphatic fertilizers and the draining away of water-soluble salts. Narayana Pillai and Subrahmanian (1931) found that free sulphuric acid, as well as the sulphates of iron, calcium and pottassium were formed in these soils. This finding was later confirmed by Sabramoney (1947), Nair (1945) concluded that the differences between different types of *kari* soil consisted primarily in the quantities of organic matter which they contained. After carrying out a comparative study of the *kari* soils of Kerala with similar soils of West Bengal and Orissa, Gopalaswamy (1958) suggested a liberal system of drainage and lime application for the better management of these soils. Sukumara Pillai and Money (1967) noted that microbiological activity in the *kari* soils was very meagre. Gopinath (1973) found that the levels of copper and Zinc in the *kari* soils examined by him were satisfactory for rice production. Varghese (1973) has carried out a study of the morphological, physio-chemical properties of the kari soils and found that they were characterised by C/N ratio as high as 45.2, and cation exchange capacities in the range of 9.4—35.5 meq/100g. These soils also had a high sulpher content of the order of 3.0% most of which was in the organic form. Koshy and Abraham (1976), in a study of the soils for a crop failure area at Kanyakkone in Kottayam district, found that the conductivity and water-soluble salts were within tolerable limits in the surface layers. But with increase in depth the pH decreased whereas the conductivity and water-soluble iron increased.

The above studies indicate that the causes of poor yields in the *kari* soils are extremely high acidity, low levels of available nutrients and toxic concentrations of soluble salts.

The 'pokkali' and 'kaipad' soils occurring in the Ernakulam and Cannanore districts are acidic and saline at the same time. They are saline because of the intrusion of sea water. The general characteristics of some of these soils were first studied by Gopalakrishnan Nair (1963) Varghese *et al.* (1970) found that the 'pokkali' soils were highly deficient in phosphorus and Calcium but fairly high in potassium and magnesium. The contents of total soluble salts, chlorides and sulphates varied with the weather conditions of the locality. Aiyer and samikutty (1977) carried out a study of the seasonal variation in the levels of salinity, pH and other relevant soil parameters at three locations representing three types of saline soils viz., Pokkali, Kaipad and Orumundakan. The period of study was from March 1976 to February 1977. It was noted that the Pokkali and Kaipad soils exhibited high levels of salinity in the summer months. The salinity rapidly decreased to critical or below critical levels by August and this level was maintained till December-January. The pH a and conductivity levels of the surface waters closely parallelled the pH and salinity levels of the soils.

The Poonthalpadam soils cover a little over 1000 hectares in the Chittoor Block. These soils are in a highly dispersed state and range in depth from 1 – 4 feet. Calcium carbonate nodules are also seen in some places. A bed of limestone is seen beneath the slushy layer. The physical properties such as plasticity, cohesion and expansion and shrinkage are similar to those of the regular soils of the Decan. No systemic work has been done on these soils, so far, but a study has just been intiated in the Department of Agricultural Chemistry of the College of Agriculture.

As far as the agronomic management of these soils is concerned, the application of lime has been recommended fdr the reclamation of the *kari* soils. Still crop failures are common in the *kari* areas due to breach of bunds, sub-soil salinity, improper drainage and the presence of toxic factors. The pokkali, kaipad and Orumudakan soils are being cultivated by adopting special methods of cultivation and by using salt resistant varieties of rice. Suitable agronomic practices are yet to be evolved for the Poonthalpadem soils.

Research gaps identified and future line of work

1) Newer and more effective methods of drainge and irrigation should be developed for the *kari* lands.

2) Cropping patterns such as rice–rice–pulses, rice-rice-prawn or rice–prawn should be tried and the most suitable one adopted.

3) More detailed investigation of the fertility status of these soils should be carried out.

4) Methods of applying fertilizers to the rice crop in the pokkali soils should be developed.

5) The physical and chemical characteristics of the Poonthalpadam soils should be studied in detail.

6) Methods of improving the structure of the poonthalpadam soils should be devised.

9. AGRONOMY OF PLANTATION AND SPICE CROPS

Introduction

Plantation and spice crops play a very important role in the economy of Kerala State. Rubber, Tea, Coffee snd Oilpalm are the more important among the plantation crops, which are grown in the mid-land and highland regions. Coconut and arecanut are also grown on a plantation scale in the lower physiographic positions. Pepper and cardamom, are the more important of the spice crops grown in Kerala. Of late there has been a growing interest in the cultivation of crops such as cocoa, nutmeg and cloves.

Resume of work done

As far as coconut and arecanut and concerned, systematic work on the various aspects of cultivation of these crops is being undertaken by the CPCRI as well as the Kerala Agricultural University. Research work on the agronomy of rubber, tea and coffee is being undertaken by the research institutes attached to the respective Boards and by the UPASI. The oil palm plantations are now following the management practices recommended in other countries. Some work has been done by the Kerala Agricultural University in the agronomy of pepper, but more work is to be done for evolving better management practices for this crop, as well as other crops such as cardamom, cocoa. clove and nutmeg.

Research gaps identified and future line of work

Future work should aim at the characterisation of soils suitable for each crop, the cultural practices to be adopted, doses and method of application of fertilizers and other agronomic practices.

10. ORGANIC RECYCLING IN MIXED FARMS

Introduction

Kerala being a food deficit state and the per capita availability of cultivated land being extremely low (0.11 ha) all agricultural programmes should be aimed at obtaining the maximum possible returns from unit area. In addition to obtaining economic returns of agricultural crops the farms should also produce milk, meat and eggs to supplement the nutritional needs of the population. The majority of the small farms in Kerala do maintain a few milch animals. Although this practice has been there from time immemorial no systematic work has been done in this direction with a view to making the farms self sufficient in respect of the feeds and fodder which the cattle require. Further, it is necessary that the crop residues and animal wastes are also utilized fully and put to the maximum use.

Recently a team of international experts visited China to study their rural development programmes and they made an important observation that in all the communes they visited organic materials like night soil, animal excreta, crop wastes, oil cakes, city garbags, ash, silt and mud from riverbottoms, and weeds and aquatic plants were being recycled efficiently for agricultural use.

Resume of work done

As stated earlier no systematic work has been done on organic recycling in Kerala State. It is reported that trials conducted at the CPCRI, Kayamkulam and Kasargode have shown that the mean yield of coconut palms could be increased by 29 percent by maintaining cows in coconut gardens intercropped with fodder crops. The foliar yellowing of root-wilt affected palms was also considerably reduced. The Kerala Agricultural University has recently initiated a project for integrating goat rearing with banana cultivation.

Research gaps identified and future line of work

In order to assess the over all benefits of mixed farming and to develop an alternate husbandry in the small farms of Kerala with coconut, banana, fodder grasses and legumes and tapioca as pivotal crops and cow, goat and poultry as livestock a comprehensive project may be undertaken. This project should have the following objectives:

1) Development of a farming system with the inclusion of crops, livestock, poultry and fishery in a mutually symbiotic manner.

2) Maintenance of cows, goats and poultry and fishery by conducting suitable feeding trials reducing the use of concentrates to a minimum and by recycling the crop residues and animal wastes.

3) Evaluation of the economics of mixed farming under Kerala conditions.

4) Assessment of the employment potential of mixed farming.

In Kerala it might be possible to have self contained farms of area one hectare which will be able to support 2 cows, one goat and 50 hens in addition to growing crops such as coconut, tapioca and rice. Fifty per cent of the area may be utilized for coconut cultivation intercropped with banana and fodder grasses and legumes. Twenty five percent of the area may be set apart for rice and the rest for tapioca and other tuber crops. All along the boundaries fodder trees like *Thespesia populnea* and *Erithrina indica* may be grown as a source of fodder for the goat. A fish pond of suitable size also can be maintained in this farm in which some inland fish varieties can be grown. In such a unit the recycling of farm produce, crop wastes and animal wastes can be carried out in a mutually benefical manner.

Research should be undertaken in developing small farm units of the above kind suitable to Kerala conditions.

17. CROP PESTS, DISEASES AND WEEDS

Uncertain and unpredictable weather factors, occurrence of epidemics due to pests and diseases and the ravages of weeds constitute the important constraints to crop production. Soil health problems such as deficiencies or excesses of minerals in soils, inadequate nutrient status, inadequate drainage etc. often aggravates the operation of the above constra ints.

Agriculture is the main industry in India, particularly so in Kerala. It is of utmost importance that we attain self sufficiency in food as an infrastructure for major developments in the industrial and other priorty sectors. Intensification of research efforts in selected gap areas indisperable for the attainment of this goal.

The status paper on crop pests, diseases and weeds has been prepared to light on the research gaps of fundemental and applied nature in these areas and thereby to help formulation of appropriate research programmes.

1. ENTOMOLNGY & NEMATOLOGY

A. NEMATOLOGY

Introduction

Organised research in plant Namatology has been in progress in India only during the past fifteen years. A scheme for rasearch on plant parasitic nematodes was in opiration in the Department of Entomology, College of Agriculture, Vellayani from 1967. A section on Nematology was established in this Department in 1976. Sevaral projects including one All India Co-ordinated Research Project on Nematode Pests and their control are currently in progress. The section is now undertaking research programmes in the mojor areas like (1) Nematode survey (2) Namatode biology (3) Nematode diseases (4) Nematode control.

Resume of work done

Studies carried out so far in the section have shown that plant parasite nematodes operate as a limiting factor in crop production. The root-knot nematode (*Meloidogyne spp*) infecting bhindi, brinjal, tomato, gourds and other vegetables, sugarcane, pulses, banana, pepper and cardamom, the burrowing nematode (*Radopholus similis*) occuring on banana, rice, sugarcane, and ginger; the spiral nematode (*Helicotylenchus spp*) parasitic on brinjal, bhindi, banana, pepper and ginger, the rice root namatode (*Hirschmaniella oryzae*) and *Aphelenchoides besseyi* infesting rice; the lance nematode (*Hoplolaimus indicus*) infesting sugarcane; the citrus nematode (*Tylenchorhynchas semipenetrans*) on citrus and the cyst nematodes (*Heterodera oryzicola*) infesting rice are some of the important nematode problems in Kerala. The population fluctuations of soil nematodes with reference to climatic condition and soil types have been studied. Trials on the use of organic amendments in the control of parasitic nematodes have given encouraging results. Studies on the interaction of root-knot nematodes on nodule bacteria revealed that nitrogen fixation by nodules bacteria will be adversly affected in the presence of the root-knot nematode. Control trials with nematicides indicated that yield of vegetable could be increased by nematicidal application.

Work in progress

The following projects are at present in progress under the nematology section.

1) Survey of plant parasitic nematodes affecting cultivated crops in Kerala.

2) Use of granular pesticides in controlling root-knot nematodes on vegetables.

3) Studies on nematode diseases of ginger.

4) Effect of nemagon and dasanit on control of nematodes of banana.

5) Comparative study of different nematicides on control of namatodes of banana.

6) Population dynamics of banana nematodes.

7) Effect of organic amendments on the control of the burrowing nematode (*Radopholus similis*) and lesion nematode (*Pratylenchus spp*) on pepper and ginger respectively. Under the All India coordinated Research Project on Nematode Pests and their control, the following items of work are progressing.

8) Intensive survey on Rice and Pepper and random survey (in 2 districts) on banana and pineapple to investigate the plant nematodes found associated with the above crops.

9) Two field trials (i) nematicidal and (ii) integrated control experiment on brinjal for control of root-knot nematodes.

10) Crops loss studies on rice due to rice-rot knot nematode.

11) Trials on nematicidal control of the rice-rot nematode.

12) Nematicidal control of root-knot and burrowing nematodes infesting pepper vine.

The next few years will be crucial for the rapid development of Nematology in this part of the country and the section of Nematology has to develop and strengthen research on both basic and applied aspects. It has to be ensured that applied research in Nematology, is developed in active support of fundamental research.

Research gaps identified and future line of work

The following problems are identified for taking up research on plant nematodes in the Kerala State.

1) Ecology of root-knot nematodes.

2) Crop loss caused by different spp. of plant parasitic nematodes, and the pathogenecity of these organisms.

3) Interaction of soil pathogenic microflora and the plant nematodes in vegatable crops (brinjal, bhindi, cowpea etc.) pepper vine and banana.

4) Occurence of plant parasitic nematodes and their importance in rice areas where the production was static at low levels for the past 10—15 years.

5) Survey of arecanut gardnes infested by the yellow leaf disease to evaluate the role of plant parasitic nematodes in the disease incetation/agravation.

B. BIOLOGICAL CONTROL

Introduction

The adoption of pest management systems based on the integration of all feasible methods of control in a complimentary manner to maintain pest & population levels below the economic threshold levels, is considered to be very essential to sustain ecological equilibrium. Biological control involving the utilization of parasites, predators and pathogenic microbes is an important componont of the pest management programmes.

a) Insect pathology and microbial control.

Bacteria, viruses, fungi, protozoa nematodes and protozoa are reported to invite diseases in insects and the utilization of the promising agent/agents as a natural mortality factor in the ecosystem is ideal for pest management. Over 1,000 insect diseases are known at present. Originated in the first half of the 19th century. insect pathology made rapid advancement during the past fifty years and has now emerged as a distinct branch of bioligical science. Commendable work in this field has been done in countries like U. S. A., U. K., U. S. S. R, France, Czekoslovakia and Poland.

Resume of work done

Together with the development of insect pathology efforts for utilisation of these microorganisms in control of pests also were in progress and there was a spurt in these activities from 1950 onwards. Microbial control of insect and other arthropod pests has now got established as a feasible proposition. Some of the outstanding examples of successful microbial control projects are the control of Japanese beetle, *Popillia japonica* using milky disease bacteria in U. S. A. and Europe and the use of *Bacillus thuringiensis* against several caterpillar pests in many parts of the world. The European pine saw fly, *Neodiprion sertifier* is being effectively controlled by the use of a nuclear polyhedrosis virus in U. S. A, Canada and United Kingdom. The corn case worm *Heliothis zea* is another pest which is effectively controlled by using a nuclear polyhedrosis virus.

Work done so far in India on insect pathology and microbial control conaists mostly of recording diseases of some common crop pests. These have been reviewed by Kumer and Ramekrishnan (1976). Detailed investigations on insect disesses have been undertaken only in a few instances (Jacob, 1972; Jabamani, 1973; Lathika, 1973; Nair, 1975).

In Kerala, organised studies in insect pathology is limited. Very little is known of the potential microbes that are pathogenic on our insect pests. Accurate identification of the agents is vital even at the level of strains. Preliminary studies made in the College of Agriculture, Vellayani has revealed the occurrence of certain virus and fungal diseases of some common crop pests (Jacob and Thomas, 1971. Jacob *et al*; 1971, 1972, 1973; Asari *et al*; 1977). These observations indicate the potentialities of the field of Insect Pathology. Kerala also offers much scope for microbial control particularly by the use of fungal pathogens in view of the high humidity conditions prevailing in the state throughout the year. The microbial control appears to be promising against some of fhe major crop pests like *Nephantis serinopa* and Rhinoceros beetle on coconut, leaf

rollers, army worm, brown plant hopper and leaf hoppers on rice Epilachna beetles, various leaf feeding caterpillars and sucking insects on vegetables etc.

Research gap identified and future line of work

Considering the lack of basic information in the field of insect pathology and the scope for microbial control in Kerala, the following lines of work are proposed:

1) Survey and identification of bacterial, viral, fungal and nematode diseases of common crop pests.

2) Detailed investigations on the disease including their utility for microbial control.

3) Standardization of methods of mass propagation and field application of potential pathogens.

4) Toxicity to human beings and beneficial and production insects.

C. USE OF PARASITES, PREDATORS

Resume of work done

The work done in Kerala on the biological control of insect pests mainly related to the control of major pests of coconut particularly the black headed catterpillar *Nephantis serinopa*. Pioneering work on the biological control of this pest was done in Kerala (Rao et al. 1948). Basic studies on the natural enemey complex associated with *N. serinopa* have been carried out by many workers (Nirula et al. 1958; Jayaratnam, 1963, Chandrika & Nair, 1971; Abraham 1978; Kunjamma & Abraham 1973; Joy, 1978 Narayanan, 1964). Work done on the major crop pests of other crops include the rice BPH (Abrahan *et al*, 1973) leaf folder (Abraham *et al* 1973)

Research gaps identified and future line of work

The following aspects of work are proposed under biocontrol using parasites and predators.

1) Utilization of mirid bugs and spiders in the control of the BPH

2) Control of rice stem borer *sirpophagas incertulas* using the egg parasites *Trichogramma sp.*

3) Control of Epilachna beetles using *chrysocharis johnsoni* (Eulophidae)

4) Bio-control of *Aphis craccivora* occurring on leguminous crops.

D. INSECT TOXICOLOGY

(a) Studies on the residues of various insecticides on crop and soil

Introduction

The indiscriminate use of insecticides undoubtedly pollute the plant and animal products and cause direct health hazard to human beings. Besides the residues of these insecticides and their metabolites distributed in soil, water, nontarget crops, weeds, air and other components of the eco - system cause serious hazards. Comprehensive studies on pesticide application in relation to terminal residues is an essential requirement.

Resume of work done

Fragmentary information on residues of DDT, BHC, lindane, endrin, carbaryil, malathion, phosphamidon, dimethoate, parathion, phorate, disyston, carbofuran and solverix on a few crops like paddy, sorghum, sugarcane, bhindi, brinjal, cauliflower, cabbage, cowpea, knolkhol, peas etc. have been gathered in institutions like the I. A. R. I., New Delhi; C. F. T. R. I., Mysore; C. P. P. T. I., Hydrabad; Central Food Laboratory, Calcutta; P. A. U., Ludhiana and Tamil Nadu Agricultural University, Coimbatore (Anon. 1983; Reghuraj *et al.*, 1973; Rajukannu *et al.*, 1875; Sathpathy *et al.*, 1974; Bhattarcharjee *et al.*, 1975; Kathpal and Dewan, 1976; Verma and Pant, 1976; Narayanaswamy *et al.*, 1975; Rajukannu *et al.*, 1976). Chemical and/or micro-biological assay methods have been adopted for the above studies. No information is available on the residue of various insecticides in plant and animal products exposed to pesticide application in our state. Since the soil and climatic factors prevailing in Kerala are totally different from the areas where such studies have already been initiated these results will not be applicable under our conditions. Hence, studies will have to be initiated and intensified in this field in the state.

A pesticide residue analysis laboratory is being organised at the College of Agriculture, Vellayani and the residues of phorate in cowpea when applied in soil along with seeds have been worked out. The translocation and persistence of systemic insecticides in paddy when applied at different growth stage and doses of fertilisation of paddy are being studied.

Research gaps identified and future line of work

Besides these, many areas of top priority are currently identified. These are:

1. Monitoring of pesticides residues on plant and animals products like paddy grain and straw, fruits of plantain, tubers of sweet potato, fruits of mango, various leafy and fruit vegetables, milk and flesh of cattle, eggs of poultry where frequent application of pesticides are made.

2. Monitoring of pesticide residues in the human environment viz. water, air, non-target crops and weeds, fish and other fauna, wild life, domestic animals, etc.

b) Studies on the pesticide microbial interactions in soil

Introduction

Systemic insecticides, fungicides and weedicides are being extensively introduced in soil for crop protection. The application of these chemicals often shows some stimulatory effect on the plants probably by affecting the microflora and fauna in soil. This temporary advantage may be offset in the long run since these pesticides may cause serious alterations in the basic components of the soil environment.

Resume of work done

The adverse/favourable impact of such treatments have already been indicated in the studies reported elsewhere (Chelliah, 1972; Tewari *et al.*, 1972; Kandaswamy *et al.*, 1972; Kandaswamy *et al.*, 1974; Satpathy, 1974; Pandian, 1975; Oblisamy *et al.*, 1976; Swamiappan and Prasad, 1976; Veeravel and Bhaskaran, 1976).

However, basic studies relating to the impact of the pesticides on the chemical and physical properties of the soil, the mineralisation of nitrogen in soil, microflora and fauna, availability of fertilizers and manures in the soil, etc., have to be investigated in detail.

Research gap identified and future line of work

The impact of various systemic soil insecticides, fungicides and weedicides on the following aspects require elaborate studies:

1) the microflora and fauna of the different soil types of Kerala,

2) the mineralisation of nitrogen in soils,

3) the availability of manures, fertilizers and other soil amendments added to the soil, and

4) the resistance of the plants to pests and diseases.

E. INSECT ECOLOGY

Introduction

The study of insect pests in relation to the environment can be of immense practical utility in crop protection. Scientific pest management should be based on a sound knowledge of the ecology of the organisms.

Resume of work done

Studies conducted at the I.R.R.I. (Bae and Pathak, 1970; Cheng and Pathak, 1971) have revealed that the optimum temperature for the development of various stages of *Nilaparvata lugens and Nephotettix impicticeps* varies much and that fluctuating temperatures are more favourable for the build-up of population than constant temperature. Kirmoto (1966) studied the effect of crowding of *N. lugens* nymphs on the determination of wing form of the adult hopper. Overcropping has produced macropterous forms and the effect is followed by lengthening of the developmental period of nymphs.

Not much of ecological studies have been undertaken in Kerala.

Research gap identified and future line of work

The following studies are suggested to be taken up in future.

1) The effect of major components of the abiotic environment on the biology and population build up of important pests of crops.

2) The effect of crowding of nymphs and the availability of host plants on the development of brachypterous and macropterous forms of BPH.

3. Impact of plant population densities on the development and build up of important crop pests.

4) Studies on the estimation of loss due to important crops pests.

5) Relative suceptibility of crop varieties to infestation by major pests.

6) Effect of various levels of nitrogen on the population build up of tissue borers of rice and sugarcane.

F. INSECT PHYSIOLOGY

(a) Insect-host plant relationships:

Introduction

The search for crop varieties resistant to insects has attained great momentum after the inherent draw backs of synthetic insecticides have been exposed. A number of these resistant varieties have so far been evolved which include Co-1251, 1256, 1263, PTB 18 and 21 against gall fly and Co, 299, 313, and 331 against sugarcane stem borer etc. The mechanism of resistance, which clearly understood, can be utilised for the breeding of more resistant varieties in many of these plants.

Another line of fruitful pursuit can be the assessment of consumption and utilisation of food by insects. A great deal is known about the qualitative nutritional requirements of insects. The quantitative aspects of insect nutrition have, however received less attention and there have been only a few studies, conducted in our country.

Resume of work done:-

Gupta and Singha (1960) have undertaken a study on the excretion and its products in stored grain infesting beetles. Krishna and Saxena (1962) measured the quantity of food ingested by infesting stored food material. Mathur (1967) has studied the utilisation and digestion of major food nutrients in the lepidopterous larvae. The effect of humidity and some antibiotics on the digestion and utilisation of food by insects has been explored by some Indian workers (Sharada and Bhat, 1957; Shamala *et al.* 1956, 1960). Studies on the consumption, digestion and utilization of food by the larve of polyphagous pests have been carried out in the Department of Entomology, College of Agriculture, Vellayani also (Dale and Chandrika, 1971; Premkumar *et al*, 1977).

Insects show marked difference in the ability to infest different plants in a locality. Some insects attack most of the plant species, where as others confine themselves to a few or only one of them. Under identical ecological and geographical conditions the above difference in the infestation of plants by different insects are determined by physiological factors. These factors involve an interaction of different responses of insect to plant and various characertistics of these plants. Much knowledge on these aspects is still lacking under Indian conditions, eventhough there are a few exploratory works on these lines to cite (Saxene, 1962; 1964; 1967; and 1969 and Vaidya, 1969).

Research gaps identified and future line of work

The following lines of study are proposed under insect-host plant relationships.

1. Studies to locate mechanism of resistance to insects in plant varieties.

2. Assessment of consumption, digestion and utilisation of food plants by insects.

3. Factors affecting host-plant selection by insects.

b) Utility of insect hormones, deterrents and attractants for the control of Crop Pests.

Introduction

Insecticides still remain fhe major solution for most of the insect maladies. But they have many inherent drawbacks which include disruption of the ecosystem, resurgence of pests and resistance of insects to insectcides. The Search for safer, easily bio-degradable and more specific insect control agents is being continued all over the world. These studies were highly rewarding and led to the birth of a new group of pesticides known as the "third generation pesticides". Insect hormonal analogues, analogues, deterrents and attractants are a few members of this new group of chemicals. Elaborate laboratory studies abroad have clearly indicated that the application of third generation pesticides for insect control in quite a feasible proposition.

Resume of work done

Juvenile – hormone analogues have been triad extensively for insect control in many other countries. They have been shown to cause mortality to eggs and pupae, to induce sterility in adult females and to produce morphogenetic changes in the last instar larvae. Mehrotra and Phokela (1969) have studied the changes in amino acid composition caused by JHA's on the desert locust, *Schistocerca gregaria*. Singh (1974) has reported the metamorphic aberrations caused by ZR-515, a JHA on the mustard aphid, *Liaphis erysimi*. In Kerala, the feasibility of using JHAS for insect control has been explored and found to be highly encouraging with the rice swarming caterpillar, *Spodoptera mauritia* (Krishnadas, 1975).

Antifeedants (phagode terrents) form another group of chemicals of promises for insect control. Insects do not feed on treated foliage and ultimately starve to death. The advantage of using these compounds are; (i) that they are specific and (ii) they are less toxic to mamals. (Joshi *et al*. 1969) have reported the antifeeding properties of triphenltin acetate against the tobacco caterpillar, *Spodoptera litura*. Many insects in our country have been tested with antifeedants and most of them were susceptible to their action (Regupathy, 1973 and Sarawathy Ammal and Dale, 1974)-

Research gaps identified and future line of work

Very little study has been conducted in India with attractants. Dale and Nair (1966) have successfully used protein hydrolysate as an attractant for the adults of the melon fly *Dacus cucurbitae*. More study is needed for exploring the possibility of using attractants for insect control.

INSECT TAXONOMY

Pest management systems are essentially species specific and the correct identity of the crop pests is hence of great importance in applied Entomology. Studies on the taxonomy of crop pests of Kerala are extremely inadequate and the following items of work are to be takan up in a priority basis.

a) Establishment of Centre for the Kerala Agricultural University collections similar to the NPC of the IARI.

b) Basic studies on the systematics of taxa of major importance in each order.

2. PLANT PATHOLOGY

A. MICROBIOLOGY

(a) Biological nitrogen fixation:

Studies on the three major aspects of biological nitrogen fixation are in progress in the leading laboratories of the world and they are:

1. Genetic engineering of nitrogen fixing organisms.

2. Enhancing the nitorgen fixing capacity of the *Rhizobia* in legume root nodules.

3. Search for new nitrogen fixing organisms and their association with non-leguminous plants.

It may not be possible to undertake fundamental research on all the above aspects under our conditions. Hence research on applied aspects of biological nitrogen fixation which is likely to give immediate results has to be taken up.

At I. A. R. I. and in many Agricultural Universities in India, much work has been carried out in the field of biological nitrogen fixation and they have developed suitable strains for mass culturing and distribution in their area of operation. Since the soils in Kerala are acidic and lateritic in nature and the legume crops cultivated in the State are different from the rest of India, it is considered essential that strains are developed exclusively for the State.

According to Diatloff and Brok well (1975) efficient strains have to be selected on the following basis: (a) ability to fix more nitrogen (b) competetive ability with native strains for infection sites on the roots of host legumes (c) nitrogen fixing ability over a range of environmental conditions (d) persistence in soil for long periods (e) capacity to survive adverse physical conditions such as desication, heat etc, (f) strain stability during storage and growth (g) ability to multiply rapidly in broth and (h) ability to survive in peat. Studies on strain improvement for maximum nitrogen fixation have to be started in Kerala State keeping in mind the above guidelines.

(b) Utilisation of Agricultural wastes and industrial by-products

In Kerala State many by-products, which can be converted into useful products, are now wasted. Examples of such products are liquid endosperm of coconut, cashew apple, wood wastes, etc. It will be highly beneficial if trials are conducted to utilize these waste products into economically useful products by microbial activity.

B. EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES

Introduction

Spores of many fungi, including those of plant pathogens, are disseminated by the agency of wind. A proper understanding of the factors that favour the production and liberation of spores of pathogens and those which favour infection will undoubtedly help in formulating criteria for forecasting crop diseases. If the presence of a particular pathogen in the atmosphere could be detected and the different environmental factors under which pathgeon can cause infection and multiply rapidly are known, it would be possible to forecast with a high degree of preci-

sion, the incidence of the disease. Such forecasting of crop diseases will be very helpful to farmers, since it would enable them to take adequate precautionary measures at the appropriate time.

Rice crop in Kerala is subjected to a number of diseases, the most important of which is the blast caused by *Pyricularia oryzae*. In other states of India also, this disease is prevalent. Its outbreak occurs in certain areas year after year while in other locations it is of seasonal occurence. Blast occurs in epiphytotic form generally under conditions of intensive cultivation and increased application of nitrogen fertilizers.

Resume of work done

Padmanbhan (1965) observed that according to prevailing meteorological conditions viz, minimum temperature and relative humidity, the rice seasons could be designated as favourable and unfavourable for the development of blast disease. Concomitant occurrence of a minimum temperature of 26°C and below and relative humidity of 90 percent and above favoured the outbreak of blast, provided it occurred during the susceptible stage of plant growth (Chakrabarti and Padmanabhan, 1968; Chakrabarti, 1971 and Padmanabhan *et al*. 1971). Reports from outside India (Hemmi and Abi, 1932; Suguki 1941; Takahashi, 1968) also suggest that a temperature ranging from 24-26°C was favourable for germination, penetration and establishment of plant pathogen in nature. A low night temperature of 24-26°C with high relative humidity of 90 percent and above favoured germination of conidia of blast pathogen and a higher temperature of 26-28°C occurring in the early part of day time might be required for the establishment and further development of the pathogen inside the tissues. Sadasivan *et al*.; (1965); Obata *et al*. (1965); Ramakrishnan (1966) and Subramonian (1967) determined the relationship between predisposition of the host by low night temperature and development of blast disease. In Kerala, Maheswari Amma and Sam Raj (1973) observed that spores of *P. oryzae* exhibited a night maxima in December during which period the highest spore load usually occurred around 02.00 hours. A shift in the nocturnal pattern of spore liberation to a forenoon pattern was noted in March. A correlation was noted between the spore load of *P. oryzae* and the severity of blast infection. Bhavani Devi *et al*; (1975) also observed that the conidia of *P. oryzae* exhibited a night maxima, the highest load occurring around 01.50 to 5.00 hours.

Even though some investigations on the factors favouring the development of a few other diseases of rice have been conducted elsewhere, no work on these lines have been done in our State.

Research gaps identified and future line of work

Relationship between incidence and development of blast, brown spot, bacterial leaf blight and meteorological factors:

a) Rice blast: **(i) Determination of inoculum density in the atmosphere.**

Air sampling-Population of conidia of *P. oryzae* to be measured using Hirst spore trap.

(ii) Determination of weather elements:

Temperature, humidity, rainfall, total sunshine hours and dew are to be measured employing appropriate methods.

(iii) Measuring disease intensity:

Under different seasons and micro and macro climatic conditions, rice can be grown and disease intensity can be measured.

(iv) Correlation studies

Correlation can be worked out between inoculum density, meterological factors and disease intensity.

The same procedure can be adopted for other foliar diseases of rice and other crops.

C. BIOLOGICAL CONTROL OF SOIL BORNE PLANT PATHOGENS

Introduction

The use of chemicals in the control of soil-borne plant pathogens poses many practical difficulties. To avoid these difficulties non-chemical control methods like biological control have been attempted by various workers. The modifications of soil environment through organic amendments is usually practised as a means of biological control of plant pathogens.

Resume of work done

Ever since the beneficial effect of green manuring on the control of scab of potato was observed nearly 50 years ago, considerable attention has been given to studies on the effect of organic amendments on a number of root rot, wilt and nematode diseases (Venterpool, 1940, Zentmeyer, 1963; Singh and Sitaramaih, 1966; Singh 1968, Rajan, 1972). Several diseases caused by soil borne pathogens have been effectively controlled by soil amendments; eg; wilt

of betel vine, sclerotial diseases of paddy, soft rot of ginger, bacterial wilt of tomato, root-knot of vegetables etc. One of the main drawbacks of this method is that one and the same method cannot be successfully adopted under different climatic conditions. Depending upon the physical and biotic factors of the soil, amendment may aggravate or decrease a disease.

In Kerala, very little work has been done for the control of disease by biological means. Balagopal *et al*;. (1974) studied biological control of soft rot of ginger by the addition of organic amendments and found that the incidence of disease was negligible in plots enriched with amendments whereas 60-65 percent of the plants were infected in control. Rajan and Menon (1975) studied the effect of organic soil amendments on the control of sheath blight disease of rice. They found that the intensity of the disease can be reduced singnificantly by the addition of organic soil amendments.

Research gaps identified and future line of work

The following lines of work are proposed:

1) Use of industrial wastes such as coconut pith, arecanut husk, saw dust, cashew shell powder etc. and green leaves as soil amendments and their efficiency in the control of important soil-borne disease of Kerala.

2) Effect of amendments under different soil types.

3) Survival of pathogens in soil amended with different organic materials.

4) Determination of the time of applicalion to achieve maximum control of the disease.

5) Mechanism of action of amendments.

D. BACTERIOLOGY

Introduction

The beginnings of phytobacteriology date back to 1874, when T. J. Burril of Illinois, U.S.A. related *Erwinia amylovora* as the etiological agent of the fire blight disease of apples. It was Erwin F. Smith of the United States Department of Agriculture who, after nearly 40 years of intensive research on bacterial plant diseases, laid the foundation of this branch of plant pathology.

The losses due to bacterial pathogens are considerably high on crop plants. Therefore, studies on bacterial plant diseases should be adequately covered at all levels, in the research laboratories in the class rooms and in the farmers fields. In the past nine decades a number of bacterial diseases have been described from many parts of the world. The latest edition of Bergey's Mannual of Determinative Bacteriology has listed over 200 species of phytopathogenic bacteria.

Resume of work done

In India, the study of bacterial plant diseases has gained momentum only recently. During the period from 1947-1960 several bacterial plant diseases were reported and described. The bacterial blight of rice, the citrus canker, black arm of cotton, black rot of cruciferes, brown rot of potato, soft rot of vegetables, bacterial wilt of solanaceous plants and the sugarcane gummosis are the most serious and devastating ones. The attention given to this group of plant diseases is not adequate and much more efforts are required to tackle this problem.

Kerala, having heavy rainfall and high relative humidity, coupled with moderately high temperature, is well suited for the development of bacterial diseases. No organised efforts have so far been made to investigate the bacterial diseases prevalent in the State. Bacterial leaf blight of rice, wilt of solanaceous plants, citrus canker, blight (wilt) of tapioca and 'Chenthal' of cardamom are some of the serious bacterial diseases occuring in Kerala. Investigations on some aspect of these have been attempted. However, a lot more remains to be studied for evolving satisfactory measures for their control.

Research gaps identified and future line of work

1. Survey of the bacterial diseases of crop plants during different seasons.

2. Assessment of loss due to important bacterial diseases.

3) Studies on the fundamental aspects such as,

a) mode of entry of the pathogen.
b) methods of dissemination
c) host-parasite relationship
d) survial of organism
e) Influence of climatic factors on the incidence and spread of disease.
f) variation in the pathogen
g) identification of the pathogen based on morphological, cultural, biochemical and physiological characters.

4) Screening of germ-plasm materials to identify source of resistance which can be utilised for breeding resistant varieties.

5) Control of disease by chemical means. Various systemic compounds including antibiotics, have to be tested.

6) Studies on the phages of the pathogens. They can be used a tool for the identification of the bacteria and can also be tried for their control.

7) Studies on the pathogenicity of bacterial diseases.

E. VIROLOGY

Introduction.

Among various plant diseases, those caused by viruses and mycoplasmas are the most devastating and difficult to control. Seed-borne viruses and virus diseases of vegetatively propagated plants in particular cause considerable annual loss, degeneration of stock and also creats problems in quarantine. Certain complex diseases like citrus dieback and coconut root (wilt) diseases in which a virus component is also involved require intense research to unravel all the aspects.

Virus diseases of crop plants are causing heavy loss to mankind and some have even threatened the livelihood of the people where a single economy is dominating as in West Africa and Java where the main crops are Cacao and sugarcane respectively.

Resume of work done.

In India, a large number of viruses and virus diseases have been studied since Colemans (1917) record of the spike disease of Sandal Wood. A systematic study of virus disease was taken up abour four decades ago. Pal and Tandon (1937) and Pruthi and Samuel (1937) described tobacco leaf cult which is transmitted by whitefly in nature. The potato viruses such as X, Y, A and leaf roll are responsible for heavy losses in yield and for the degeneration of the seed stock (Pal.1943; Vasudeva and Azad, 1952). Since then a number of virus diseases of crop plants have been studied. Varma (1969) has made a review of the white fly transmitted viruses. Similarly, Joh (1957) and Ramakrishnan and Narayana swamy (1965) have published the list of viruses reported from India.

In Kerala also some work has been done on the bunchy top disease of banana, tapioca mosaic and 'katte' disease of cardamom. The results of the studies have shown that the diseases of banana and cardamom can be kept under control and their spread can be checked to a great extent by the regular inspection and systematic rogueing of the infected plants and replanting with disease-free seedlings. As regards tapioca mosaic, it has been found that certain local varieties are tolerant to the disease. The newly released hybrid varieties of tapioca by C.T.C.R.I. are reasonably resistant to the disease. Other major problems are the root (wilt) disease of arecanut. Though several agents have been attributed as the cause of these diseases, their etiology is still unknown. Recently Maramorosch and Kondo (1977) have reported that virus like particles were found in their sections of leaves affected with the root (wilt) disease of coconut. The incidence of tungro (Gopalakrishnan *et al.*, 1973) and grassy stunt (Gopaiakrishnan *et al.*, 1973) of rice have been reported from Kerala. The incidence of yellow dwarf of rice is also prevalent in some localities of this state.

The loss due to virus diseses of individual crops in Kerala will reveal the magnitude of the problem. It is reported that about 12 million palms over 2.5 lakh hectares are affected by the root (wilt) disease causing an annual loss Rs. 300 million to the farmers. The yellow leaf disease of arecanut has spread to several districts of Kerala and the cultivation has been practically/abandoned in these areas. The bunchy-top disease of banana is another serious disease which causes a loss of about Rs. 10 crores annually. The reduction in yield due to 'Katte' disease of cardamom is quite enormous and may range from 35 to 70 percent. By the primary infection by mosaic disease, the loss in yield of tapioca may range from 20-30 per cent. In this case' in addition to the annual reduction in yield, there is degeneration of the planting material also. The extent of damage done by viruses to vegetatable crops like cowpea, bhindi, brinjal, etc. depends on the time of infection. If the infection takes place at an early stage, there will be total loss in yield. Though the viral diseases of rice have not been reported in a serious form so far they are a source of potential danger for the population of our major food crop.

In view of the seriousnes of the diseases caused by viruses and virus like organisms and also mycoplasma, the Kerala Agricultural University have sanctioned a virology unit for initiating studies on the fundamental as well as applied aspects of viral

diseases in Kerala. The results of the studies will throw more light on these baffling problems and based on the findings it will be possible to chalk out proper and effective measures of control for these diseases. The ultimate aim is to make the cultivation more profitable and to increase the crop production which will definitely brighten the economy of the State.

Research gaps identified and future line of work.

The following aspects will be studied:-

1) Study of virus diseases of crop plants with special reference to white-fly transmitted virus.

2) Control of virus diseases by:

(a) Management of agronomic and cultural practices.

(b) Insecticidal control of vector.

(c) Resistant varieties.

F. MYCOLOGY

(a) Taxonomic studies on important plant pathogenic fungi.

The study of modern systematic mycology starts from Carolus Linnaeus., who during the 18th century, adopted the binomial system of naming plants and animals. Today nearly a lakh of fungal species are known to science. In India, the foundation for the systematic study of the fungal flora was laid by the beginning of this century with the formation of the Imperial Agricultural Research Institute. Sir E. J. Butler, as the first Cryptogamic Botanist to Government of India, made serious and systematic efforts to survey, study and name the fungi found in various parts of the country. He is the first scientist to name the fungi causing bud rot of coconut, mahali of arecanut, etc., in Kerala. He along with Bisby, published in 1931, the first monographic work on Indian fungi, in which a few isolated reports about fungi of Kerala aslo appeared. Since then, many Mycologists attempted to make monographic studies of the various groups of fungal flora of India. But the first attempt to make any monographic study of the fungi on a regional basis was made by Rangaswami *et al.*, (1970). They listed out 2019 species of fungi occurring in various parts of South India, with a remark that there are a number of other fungi which the Mycologists have to explore.

Kerala is blessed by its diversity in climate and rich phanerogamic flora. The topography of the State is also peculiar. All this helps to build up a vast variety of different fungal flora natural to the State. No systematic efforts were taken so far to make a Monographic study of the different fungal flora of the State. The knowledge of the fungal flora of any particular region is important since all the mycological programme in that region can be based only on this. Hence, it is highly essential to make a detailed survey of the State for the presence of various fungi, their distribution, the natural hosts on which they colonise, etc. As a preliminary step, the following groups of fungi may be taken up since the important plant pathogenic forms comes under these groups.

1. Rust fungi
2. Coelomycetes
3. Hyphomycetes
4. Pythiaceous fungi

Utilisation of edible mushrooms in Kerala.

From time immemorial people have made use of mushrooms for food. A very conservative estimate shows that there are more than 2000 species of edible mushrooms. Of these nearly 50 species are utilised for human consumption in India itself. The hunt for edible mushrooms is on the increase day by day because of its flavour and its high nutritive and medicinal values.

Utilisation of mushrooms as source of food has increased in many parts of the world, since its artificial culturing has been develped into a sophisticated industry. The artificial cultivation of mushrooms was first started in France, where during 1700 a gardener developed the first method of artificial culturing of the temperate mushrooms, *Agaricus bisporus*. The artificial cultivation techniques have been spread to many parts of Europe and America. Today, *A. bisporus* is the most widely cultivated mushroom of the world. This mushroom is artificially cultivated on special type of compost. The principle of composting was outlined by Lambert (1941). The details of spawn production were also investigated and today the spaen of *Agaricus sp.* is produced mainly on grains following the techniques described by Sinder (1932). Along with the cultivation of *Agaricus*, artificial culturing of paddy straw mushroom also developed in South Eastern countries. In China and Thailand *Volvariella volvacea* and in India, V. *diplasia* become popular. The method of the cultivation of paddy straw mushroom was first described by Thomas *et al.*, (1943) from Coimbatore. Since then its cultivation has been tried by various workers in many parts of India

and abroad. In India, Rangaswami (1956) studied the nutritional repuirements of this fungus in culture. Ramakrishnan *et al* (1968) studied the factors controlling the development of sporophores and reported that the addition of ammonium sulphate and super phosphate increased the size of mushrooms. Sethi and Anand (1972) reported the food value and method of preservation. In India today the cultivation of *Agaricus bisporus* is popular in many states like Himachal Pradesh, Punjab, Maharashtra and *Volvariella* is popular in Tami Nadu.

It is presumed that Linnaeus was the first to identify a few mushrooms in India. Since then many Indian and foreign scientists were attracted by the fungal flora of this country and Kirtikar (1918) was the first Indian to collect and identify some local mushrooms. No serious attempts were made till recently to prepare a monograph on edible mushrooms in India. In 1976, Purkayastha and Chandra published the first Indian Monographic treatise on edible mushrooms, wherein descriptions of 105 species covering 62 genera are given.

In Kerala artificial cultivation of paddy straw mushrooms was tried since 1976 onwards in the Plant pathology Department of the College of Agriculture, Vellayani. From the preliminary trials conducted it was observed that *Volvariella diplasia*, can be cultivated throughout the year in Kerala in places where the temperature will not fall below 25°C. The techniques of spawn production in paddy straw and the cultivation practices to be followed by the farmers for culturing the species were also perfected. Spawns were already produced and distributed to farmers along with instructions of artificial culturing. The results obtained so far are encouraging as evidenced by the increasing demand for spawns.

Kerala is rich in its variety and abundance of naturally occuring mushrooms. Their natural development is encouraged by the luxuriant vegetation and generous rainfall. No systematic efforts were made so far to prepare a monograph on the natural mushroom flora of Kerala and its exploitation for large scale cultivation and utilisation. It is ncessary to initiate and implement projects for mushroom cultivation, especially in view of the following aspects.

1) The cultivation and utilisation and utilisation of mushrooms enable better recycling of the organic wastes. It is claimed that some of the mushrooms can fix up atmospheric nitrogen and thereby increase the manurial quality of the left over straw.

2) It enables more employment opportunities.

3) It helps to develop allied industries like canning, dehydration plants etc.

4) If strains of temperate region mushrooms are isolated and methods prefected for their cultivation in suitable areas of the State, it can be canned and exported to earn foreign exchange.

In order to achieve the above objectives the following lines of research work in this field can be taken up.

1) A detailed survey of the different areas of the state during different periods of the year for the presence of various mushrooms.

2) Identification and preservation of the mushrooms.

3) Standardisation of techniques for spawn production and artificial culturing of suitable mushrooms in various regions of the State.

4) Standardisation of suitable preservation methods for different species.

5) Submerged culturing of various species for biomass production.

FUNGICIDES

Introduction

The use of fungicides and other plant protection chemicals is becoming popular year by year. To meet this demand thousands of chemicals are screened throughout the world for fungicidal activity.

Resume of work done

Mcgrath (1964) stated that there were 280 chemicals marketed for use in plant disease control. These are available in approximately 590 formulations. This number has increased several fold during the past 15 years.

Though extensive work on fungicidal activity, residual toxicity, etc., are being conucted in other countries much attention has not been given to these lines of work in India. Pesticide, when applied to plant/soil must degrade into harmless chemicals once it has controlled the disease. If not, it may

cause several pollution problems. In India, this aspect is being studied at Cuttack and Ludhiana. Another aspect worth consideration is the compatability of pesticides. Dwivedi and Nene (1968) conducted some preliminary study regarding the compatability of different pesticides. Since newer pesticides are added to the old list it is high time to conduct a detailed compatability study.

Apart from laboratory bioassay studeis and some studies on the control of plant diseases using different fungicides much work has not been done along this line in Kerala.

Research gaps identified and future line of work

In order to understand the properties of fungicides the following lines of work are proposed:

1. Compatability studies of different pesticides.

2. Persistence of fungicides on fruits, leaves, grains etc.

3. Degradation of fungicides in soil under different system of cultivation.

4. Studies to find out the proper dosage of fungicides.

H. ALGAL PARASITES

Introduction

Among the various of pathogenic organisms causing plant diseases, algae are only of minor importance. They assume economic importance in the tropics and subtropics and are reported as a troublesome semiparasites on tea, guava, mango and citrus. However, there are no reports of serious loss due to algal parasites except for reports of heavy reduction in pepper export from Sarawak, which is attributed to the algal disease, "black fruit" *Cephaleuros spp.* There are reports of algal parasites from other countries also; red rust of tea from India, die back of cacao in Trindad, premature senscence of oil-palm leaves in Nigeria and "leprosy" of vanila in C. Africa.

Algea, parasitic on land plants, belong to chlorophyta and are included under families, Chlorocaceae, Phyllosiphonasiae and Trentopohiliaceae. Usually algae are harmless to the host in the lichenous forms whereas the fungal components are parasitic. *Rhodochytrium splianthidis* is parasitic and is confined to U. S. A., S. America, C. Africa and Sumatra. Species of *Phyllosiphon* and *Phytophysa* are prevalent in S. Europe, N. Africa and Java. The *Cephaleuros* supp., viz *C. virescens* and *C. parasiticus* infect many plants and causes the disease known as "red rust". Most algal parasites are confined to the regions lying between 35°N and 35°S.

The attack of algal parasites is usually confied to to the leaves fruits and stem of plants.

Resume of work done.

Eventhough, there are a few reports on algal parasites in India, no systematic study has so far been attempted. Practically no work has been conducted on this group of pathogenic organisms in Kerala, but the attack has been noted on many horticultural plants like jack, cashew, mango, trea spices, etc.

Research gap identified and future line of work.

It is necessary to work out in detail the etiology of these parasites, the extent of damage and their control. The work will have to be undertaken on the following lines.

1) Survey of the algal parasites of crops during different seasons in different parts of the State.

2) Assessment of the intensity of the infection and losses due to the disease.

3) Identification of the algae and study of the life cycle.

4) Physology of host parasitic relationship.
5) Control of the parasite.

I. RHIZOSPHERE AND PHYLLOSPHERE MICROFLORA IN RELATION TO DISEASE OF IMPORTANT CROP PLANTS

Introduction.

Nearly 75 years ago, Hiltner noted that the root system of plants exerted considerable influence on the population and types of microorganisms in the soil in close proximity to plant roots. Various organic substances like amino acids, sugars, vitamins, tannins and alkaloids are excreted by plant roots into the soils. Some of these root exudates are known to have either stimulatory/inhibitory effects on certain soil-borne plant pathogens.

Resume of work done

Timonin (1941) observed that roots of flax varieties resistant to wilt caused by *Fusarium lini* excreted hydrocyanic acids which is inhibitory to the

growth of the pathogen. Root exudates of rice variety resistant to foot rot disease caused by *Fusarium Moniliforme* are able to inhibit the spore germination and growth of the fungus (Bhuvaneswari, 1960). Investigations conducted on these fnndamental aspects by various research workers have paved the way for a better understanding of the plant root-microflora relationships and thereby aiding to formulate methods of control of certain soil-borns plant diseases. Apart from the above, there is ample scope for rhizosphere studies on the various aspects related to biological nitrogen fixation. Studies on the various factors responsible for host specificity in strains of *Rhizobia* and correlating the same with the components of root exudates of different legumes will be helpful in enhancing the productivity of these crops. In Kerala, some studies on the rhizophere microflora as influenced by virus infection and also by certain chemicals have been made by Sam Raj and Co-workers.

Akin to the rhizosphere miroflora, the micro-organisms present in close proximity to the aerial parts of plants, viz. phyllosphere microflora, are greatly influenced by the exudates from the shoot system of plants. Certain saprophytic micro-organisms present on leaf surfaces are capable of producing substances inhibitory to the growth and activities of other micro-organisms including phyto-pathogenic fungi. Similarly, certain micro-organisms can induce plant parts to produce phytoalexins, which will inhibit the entry and establishment by pathogenic fungi. The nature of exudates from the aerial parts of plants has an important role in deciding the types, number and activities of micro-organisms in the phyllosphere regions. The presence of higher quantities of sugars present on pods of certain castor varieties has been correlated with their susceptibility to Infection by *Botrytis cinerea* (Orelland and Thomas, 1960). In india, Sinha, Mishra, Bilgram and a few others have conducted studies on phyllosphere micrhflora. In our State, some studies have been conducted on the effect of virus infection as also of different fungicides on the phyllosphere microflora by Wilson and Associates (1967-1972).

Research gaps identified and future line of work

The following lines of work are suggested.

1. Rhizosphere and phyllosphere microflora of important crop plants and their relation to common and destructive diseases.

2. Root and leaf exudates of crop varieties susceptible and resistant to disease.

3. Microorganisms antagonistic to plant pathogens in the rhizosphere and phyllosphere regions.

4. Phytoalexins and their role and utility in combating plant diseases.

3. WEED CONTROL

Introduction

The importance of weeds as one of the agricultural pests has been felt only when the losses caused by them were found to be enormous. Of the four agricultural pests, weed is the most serious one. The losses caused by the weeds to the agricultural products was found to be more than the losses caused by other pests.

Weeds compete with crop plants for nutrients, water and light resulting in the restricted growth of crop plants and thereby low crop yields. Weeds are also responsible for increasing the cost of cultivation; reducing the quality and marketability of agricultural commodities and harbouring insects, fungi and other pathogenic organisms of crops.

Resume of work done

It has been estimated that 350 million acres of crop lands and more than one million acres of ranch and pasture lands in America alone are infested with weeds and the total loss due to weeds was estimated to be more than 11 billion dollars. In India the estimates of loss on crop yields due to weeds were found to be Rs. 4,200 million annually. Varma and Bhardwaj (1963) reported the yield losses due to weeds to be between 70 and 80 percent. Pillai and Rao (1975), estimating the yield reduction in rice due to weeds, found it to be 15 to 20 percent in transplanted rice and more than 50 percent in upland rice. With regard to Kerala, such estimates are not available.

Weeds like *Eupatorium odoratum, Lantana camara, Cyperus retundus, Echinocbola* spp., *Scirpus* spp., *Fimbristylis miliaceas, Eichhornia crassipes* and *Salvinia molesta* are some of the noxious weeds of Kerala found in cropped and non-cropped areas, water ways, etc. For the effective control of these weeds, their life histories and their relationship with the climate, edaphec and biotic factors ate to be studied in detail.

Loranthus is an important parasitic weed affecting the fruit trees like mango, jack, etc, and many important forest trees. Methods for the effective control of this parasite have not been worked out.

Striga (witchweed) is a root parasite of many crops like sugarcane, maize, sorghum and rice. For the control of striga in some of the crops; use of 2, 4-D and MCPA has been found to be effective. Recently use of ethylene gas was found to be effective in inducing the germination of the seeds of this plant in the absence of the host plants. Research work on the control of striga in rice crop is meagre. In Kerala striga has become a very serious problem in the upland rice in Quilon District affecting thousands of acres. The seeds of striga remain viable in the soil for more than 35 years and became a very serious problem in the areas where the infestation appeared.

Many plants which were considered as weeds were later found to be very useful and beneficial. Kolingi, Rauwolfia, Vinca, etc., whose potentialities were not known earlier, are some examples of such weeds. Many weeds are found to be rich in plant nutrients and they can be used as a source of organic matter for enriching the soil.

In the case of introduced weeds some times biological control will be cheaper and more effective than chemical control. Biological control of Lantana has already been found effective. Similarly biological control of introduced weeds like *Eupatorium* and *Salvinia* are to be tried. Work on the Biological control of Salvinia using the exotic insects *Paulinia acuminata*, is carried out at the main campus of the Kerala Agricultural University at Vellanikkara under auspices of the AICRP on Biological control of corp pests.

With the introduction of chemicals for the control of weeds many effective herbicides have appeared in the market but some of these chemicals were capable of controlling particular certain groups of weeds such as grasses or sedges or broad-leaved plants only. Therefore, more than one herbicide is to be used for controlling the entire range of weeds. If combinations of herbicides in the proper ratio are available or prepared and applied they will be economical and will help in the complete control of a large number of weeds. Such herbicide formulations are not available in the market in India at present.

While using the chemicals for the control of weeds in some instances it was found that some pathogenic organisms were also effectively controlled. For example, the herbicides DN (Dimitro) and PCP were found to be effective in controlling pathogenic fungi namely Sclerotium and Cercospora. So investigations in these lines are also to be undertaken when newer herbicides are used.

Research gaps identified and future line of work

Detailed investigations on the following aspects may be undertaken:

1. Ecological studies of the weed flora of Kerala with special reference to noxious weeds.
2. Studies on the control of parasitic weeds.
3. Nutritional studies on weeds.
4. Studies on the use of herbicide combinations
5. Biological control of *Salvinia molesta and Eupatorium oderatum*.
6. Use of herbicides on the control of pest and disease organisms.

18. MISCELLANEOUS CROPS

A. MILLETS

Introduction:

In the order of importance, Ragi and Sorghum are the two main crops coming under this group. Ragi is the most important millet crop af Kerala. It occupies an area of 4967 hectares with an annual production of 4585 tonnes. The average yield is about 1 tonnes per hectare. Ragi is cultivated mainly in Quilon, Trichur, Palghat, Calicut and Cannanore Districts. During the last 20 yeais the area under Ragi remained almost static but production decline due to the continuous decrease in yield per hectare from 1323 kg in 1955–56 to 1039kg. in 1975-76.

Ragi can withstand extreme drought and is one of the crops most suitable to dry land conditions in the State. Area with a rainfall range of 50-90 cm are best suited for its cultivation. Yield can be considerably enhanced with irrigation. The crop is capable of giving steady yield in the plains as well as in the high altitude areas. In plains cultivation of summer crop starts by December.

Since the grains are very small, through land preparation is necessary to obtain fine tilth. Seeds at the rate of 8–10/ha are either sown broadcast or dibbled in furrows. In irrigated areas seedlings are raised in nurseries and transplanted after 20 days at a spacing of 10-15 cm. Compost or cattle manure is applied at 20 tonnes/ha. Fertilizers are rarely applied.

Sorghum or Jower occupies only a limited area of 1443 hectares in Kerala. The entire area is in palghat District. The total production is about 560 tonnes, In the last 20 years the area under sorghum decreased from 1860 hectates in 1955-56 to 1443 hectares in 1975-76. The per hectare productivity was static during this period. Sorghum is comparatively of minor importance as a food crop. It is particularly important as a constituent of animal and poultry feed. It is grown for fodder also.

Tbe crop requires only a coarse tilth and hence only limited tillage operations are recommended. Seeds at the rate of 10–15kg/ha are sown by broadcast. Sorghum being sturdy, is raised as a rainfed crop. No systematic fertilizer recommendations ere available.

Millets other than Ragi and Sorghum grown in Kerala are bajara (pearl millet), tenai (Italian millet), Chami (little millet) and varagu (kodo millet). These are cultivatad in an area of 4583 hectares and the total production is 2832 tonnes per year. The cultivation is mostly confined to palghat District. They are grown as minor food crops and for cattle feed.

2 Resume of work done

No systematic work on the improvement of millets has been done in Kerala.

3. Research gaps identified and future line of work:

1, Ragi is one of the crops most suitable to dryland conditions. High yielding varieties suitable to the different agro-climatic conditions of the state have to be evolved.

2. Developing varieties of Sorghum and maize which can give high yield of grain and fodder.

3. Identification of the best season for cultivating ragi, sorghum and maize in the low rainfall regions of Kerala.

4. Ascertaining the possibility of inter-cropping ragi, sorghum and maize with coconut and tapioca.

5. Management and manurial practices for the different soil types.

6. Investigations on diseases and pests and developing suitable control measures.

7. Sorghum injury noticed on the companion and succeeding crops has to be studied.

8. Exploring the possibility of using sorghum and maize grains as a constituent of cattle and poultry feed and straw as fodder.

B. COTTON

1. Introduction

In Kerala, cotton is cultivated in an area of 7551 hectares with a total production of 9522 bales of cotton. The average yield works out to 230 kg/ha. The entire area is in Palghat district. The area under cotton in the state has been static in the last ten years. It is grown as a rainfed crop.

2. Resume of work done

Some of the earlier trials conducted at Pattambi in the sea Island cotton scheme were centred in the suitability of cottcn as an intercrop in coconut gardens. As most of the varieties tried were found

to be susceptible to Black arm disease in coconut gardens, cotton was tried as a pure crop in uplands where tapioca was normally grown. Varieties Moutserrat and Andrews were proved to be promising. With 3 tons of cattle manure, 30 lb of P_2O_5 and 50 lb of K_2O supplemented by a top dressing with 40 lb of N as Ammonium sulphate per acre, the above varieties recorded an average acre yield of 700 to 1000 lb of kapas. However, these varieties had long fibres and hence they could not be utilised by Indian Mill and consequently marketing of the produce becomes a problem.

Results of preliminary studies conducted recently at Central Rice Research Station, Pattambi, have indicated that cotton can be successfully grown as a second crop after Modan paddy in uplands. Varieties C. P. 15/2 and Riba 8/50 belonging to *Gossypuim hirsutunr* were found to perform well under such conditions.

3. Research gaps identified and future line of work

1. Varieties which can tolerate high rainfall have to be identified for popularising cotton in the state.

2. As the area for monoculture of cotton is limited in our State, the possibility of inter-cropping and mixed-cropping has to be ascertained.

3. Cultural and manurial recommendations are not available for this crop in Kerala. Experiments on the same will have to be conducted.

C. TOBACCO

1. Introduction

Tobacco is grown in a small area of 762 hectares in the state and the production is 1327 tonnes. The entire area is in the Cannanore District. The area under tobacco has been static in the last 15 years. The production per hectare had steadily increased since 1955-56 and reached the highest level of 2162 kg. in 1972-73. Thereafter it decreased to 1741 kg. in 1974-75.

Tobacco is grown as a cold weather crop during October to February. The crop prefers well drained fertile soil. Seeds are sown in nursery and 8 to 10 week old seedings are transplanted. 75 gm. of seed sown in a area of 10 sq. m. will give sufficient seedlings to plant one hectare. Seedlings are planted at a spacing of 85 cm. in well prepared and heavily manured fields. NPK requirement is 50-100 kg. N, 50 kg P_2O_5 and 100 kg K_2O per hectare. The nitrogen requirement varies with the type of tobacco. Intetculture is given at fortnightly intervals. Topping and desuckering are important operations. The harvested leaves are cured for the purpose for which the produce is to be used. The crop is attacked by pests such as stemborer, caterpillar and lice and by diseases such as powdery mildew, damping off and bacterial wilt.

a. Resume of work done

In Kerala, a research scheme on tobacco fully financed by the Central Tobacco Committee was in the Tobacco Research Station, Kanjangad from 1959 to 1968.

As an item of work in the scheme Jaffna chewing type tobacco was introduced from Ceylon. Trials conducted there showed that this was highly suited and adaptable to Kerala conditions.

Ten Beedi Tobacco varieties introduced from Neepani area in Karnataka and Character area of Gujarat came up well under our conditions. However, this did not find market in the State mainly because of the resistance from the big well established Beedi Tobacco Companies.

Spacing cum topping trials conducted there revealed that 3 to 1½ feet spacing and topping at 13 leaf stage were found to he optimum for chewing tubacco under Kerala conditions.

Trials on curing have shown that curing under partial shade was ideal than the same under direct sun.

1. CATTLE

Introduction

India possesses the largest population of cattle. There are about 176 million cattle in India which amounts to 25% of the total cattle population in the world. Though the size of the cattle population is impressive, the poor productivity of the stock is distressing. According to Amble *et al* (1965) the average annual milk production from dairy cattle was 173 kg. One of the important factors for the prevailing low productivity of Indian cattle is their poor genetic potential, through malnutrition is the largest contributing single factor for degeneration of stock. The Indian cattle have not undergone any selection for milk production.

Based on production, the cattle population in India can be advided into two categories: (1) an elite very small stock owned by Government and commercial fairns, and (2) a vast majority of rural stock. The latter category lag behind the former in genetic merit because genetic improvement achieved in Government owned farms through selection rarely affected the rural stock. The first organised attempt to improve the rural cattle was initiated only in 1951 with the introduction of the key village scheme. It was observed that the use of Indian breeds for breeding purpose could not bring out the desired results.

Exotic cattle of the temperate zones which belonged to recognised dairy breeds like Jersey, Holstein-Fresian, Brown Swiss, and Red Dane, were identified as superior in both productive and reproductive performance. Cross-breeding of Indian cattle with exotic breeds to improve milk production began in the late 17th century itself by European Missionaries and tea planters, in the hilly areas of Assam, West Bengal and Tamil Nadu. At the turn of the century, the introduction of exotic germ plasm was adopted as an official policy by Military Dairy Farms of the country. The Imperial Dairy Research Institute, Bangalore, Agricultural institutes in Poona, Patna and Allahabad, and livestock Research Station of Hosur, Tamil Nadu etc, also introduced European breeds in the 1920 s & 30s. But most of cross-breeding efforts were limited to improved Indian dairy breeds such as Red Sindhi. Sahiwal and Hariana. Evidently the majority of rural cattle population are nondescript as well as poor in productive and reproductive performance. Now cross-breedrng Indian cattle with exotic breeds like Jersey, Holstein, Brown-Swiss and Red Dane has been accepted as a national policy for improving the Indian cattle.

In Kerala, where there is emphasis on Agriculture-oriented food and cash crops, the cattle industry is at a subsistance level. According to livestock census in 1972, Kerala had about 2:8 million head of cattle. They belong to *Bos. Indcus* group but has not been differentiated into any definite breed er strain. They are considered as non deseript with all sorts of variation in productive and reproductive performance. Only during the Five year plan period was a certain degree of intensiveness given for cattle improvement activities in the State. With the commissioning of 16 Key Village Blocks, the grading up of the non-descriptt sock with Red Sindhi bulls through large scale artificial insemination was started. Simultaneously two cross-breeding schemes utilising Jersey semen were started at Chalakudy and Neyyattlnkara. The above schemes envisaged evaluation of improvement brought out by cross-breeding with exotic breeds and investigation of other problems associated with cross-breeds. As a joint venture of the Government of India, the Govenment of Swiszerland, and the Government of Kerala, the Indo-Swiss Project was started in 1963 for systematic cattle breeding work with Brown Swiss breed. Now a number of agencies are engaged in cattle breeding programme, like the Animal Husbandry Department, the Dairy Development Department, and the Livestock Development & Milk Marketing Board.

The cow is the productive unit of the dairy Industry. The efficiency of the cow as a producer of milk depends upon the level of managerial skill devoted to good management becomes increasingly important. The present standard of husbandry is not out of line with the present production levels but it is much too low to permit increased efficiency of production. The crossbred has the potential to yield 2000–3000 kg of milk. However, one cannot get away from the fact that to exploit their maximum potential the crossbreds require the most efficient regime of management. While climatic and other environmental factors make it unlikely that milk production levels of typical cattle of the western world will be attained in India there is ample evidence that considerable increases in cow yields are possible through improved management alone. While such improvements are needed in all aspects of dairy husbandry to increase productivity fro its present

low level, significant progress could be made rapidly and easily by concentration on a few of the more important weaknesses. Temperature ranges, long periods of solar radiation, high humidity and rainfall, etc. make the living conditions of the animals not only unconfortable, but also interfere with their feed intake and metabolism. Incidence of disease becomes normal occurrence, making the animal stunted and unproductive. A modern management technology needs to be evolved to suit the requirements of crossbred animals.

Resume of work done

At the national level several reports have appeared, especially during the past quarter century, from the National Dairy Research institute, Institute, of Agricultural Research Statistics, Indian Vererinary Research Institute, etc. on the superior performance of cross-bred cows. The available evidence indicate that cross-bred cows are at least 100% superior to Indian cattle in milk production and reproductive efficiency.

However the superiority has been observed more in the 50% exotic; 50% zebu group, especially where semen from superior merit sires has been used for insemination. Under efficient system of care and managament 75% Exotic; 25% Zebu animals also have been still better or equal to 50% Exotic animals. But the superiority has not been maintained at higher levels, especially under average levels of feeding and management. Differences have also been observed between different exotic breeds used for cross-breeding. Holstein-Friesian being most popular under superior manangement and Jersey under average conditions, of management, breeds like Brown-Swiss, Red-Dane etc. are occupying intermediate position. In Kerala, cross-breeding has made remarkable progress, far ahead of work in other states, but research has not kept pace until recently.

The fundamental aspects of animal feeding including the nutritional requirements of livestock, have been worked out in India by many workers, Dr. K. C. Sen and his associates working on a feeding standard for Indian cattle found that the requirements of Indian cattle are less than those recommended by Morrison. The position of feed supply for the animals has been studied by several workers from time to time. Dr. Sen and associate gave the figures for availability of green fodder, straws and concentrates as 169.0, 135.1 and 4.2 million tonnes respectively. They estimated the deficiency in dry matter as 45% of actual requirements for maintenance alone. The deficiency was more when requirements for production were taken into account. Considering the number of animals, the available feeds did not make any significant contribution towards feeding of animals except for short periods. Since the quality of most of the Indian dry roughages was considered very low, emphasis was laid on cultivated fodder. Moreover the scarcity of the fodder crops in certain provinces was more glaring when the density of cattle population per unit acreage of cultivated fodder crops was worked out. Some attention has already been paid the possibility of improving the scant grazing land now available and also utilising to a greater extent the grazing lands in the forests. A number of suggestions were made by different workers to improve the existing grazing lands by introducing new and better types of grasses as also by reseeding, fencing and bunding.

A great deal of work on the chemical composition of Indian feeds and fodders has been carried out in different laboratories of this country. Seshen (1935) studied on the realiability of usual ether extraction method as well as alkali hydrolysis method for the determination of fat and found that the resistant fractions consisted of fatty acids, in part. He did not apply the water treatment for materials containing large quantities of soluble carbohydrates. Other constituents like pentosans, NPN, oxalic acid, phosphorus, chlorine, calcium, magnesium, Na and K, sulphur were studied by several workers (Krishnan, 1934, Bhagavat and Sreenivasayar, 1936, Talpatra *et al*, 1942, 1948).

Research studies on the digestibility and nutritive values of Indian freeding stuffs were also done by several workers from very early days of animal nutrition research in India. Considerable work has been done in the past on the nutritive value of roughages, chiefly straw. The chemical analysis and digestion trials put the straw as a very poor quality roughage with low protein content, high lignin and oxalate content and poor digestibility. It has been found that when proper amounts of concentrates were added calves relished paddy straw better than wheat straw or dhub hay. Supplementary effect on paddy straw with Napier grass, water hyacinth, linseed cake or mustard cake have been worked out. The digestibility coefficients of organic matter and carbohy-

drates of paddy straw were about the same. Straws of Jowar, ragi and bajra have been studied for their nutritive values. Hay and silage production using different kinds of grasses and legumes have been studied in different parts of the country. Studies were made on dhub, anjan, spear grass, guinea grass, stargrass, berseem, jowar, oats etc. for making hay. Grass hays made in this county were found to contain over ripe materials. Major portion of green fodder available in this country is maize and jowar. Digestibility of green jowar, oats, maize and bajra has been studies by several workers. Guinea grass, Napier grass and Sudan grass have been studied for their proximate principles and digestibility coefficients of nutrients at different stages of maturity.

The concentrates are usually fed to animals in the form of mixtures and their composition may vary depending on several factors. Most of the work on feeding value of concenrrates has been carried out on either cattle or buffaloes and to a lesser extent in poultry. Cakes like groundnut cake, gingilly oil cake, coconut cake, cotton seed cake, linseed cake, etc have been studied for their feeding values for animals and poultry. Oil seed cakes are generally considered to have high protein percentage, having good digestibility. Oil seeds, cereals, cereal by-products, legume seeds and their by-products, animals products like blood meal, fish meal, bone meal etc. have been studied in different classes of animals.

Using 1961 census figures it has been estimated that the annual availability of concentrates is 17.36 million tonnes. But the estimate ot R.O. White and M.L. Mathur was 9.85 million tonnes. The demand for feeds and fodders, the availability and the balance sheet have been worked out for bovines and poultry and the supply of concentrates have been found to be far short of demand. The availability of concentrate feed ingredients cannot be improved rapidly as it is linked with increase in the area and yield of crops. The improvement in the supply position will suffer due to competition with food crops for human consumption. In view of this difficult situation an improvement in the supply position could be brought about by greater utilisation of Agricultural by products and industrial wastes in suitable proportions in feed mixtures.

The study group set up by ICAR in 1967 to investigate the availability of waste materials which could be used as livestock feed found the potentials of agricultural by products and industrial waste materials to augment feed resources. The suggested items were sal seed, mango seed kernel, sugar industry waste, tapioca waste, etc. A coordinated research project was sponsored by the ICAR to take up this work. Products like sugar cane baggasse, molasses, penicillin mycelium residue, distillery spent waste, cassia tora seeds, tomato waste, cocoa bean shells, cabbage leaves, cauliflower leaves, banana leaves and peels were tested in one centre. Cassia pods and 85% wheat bran provided a maintenance ration and in milk ration it can replace 10% of other conventianal feeds and can go upto 20% if heat treated for calves. Tomato waste was found to form 20% of the concentrare mixture in a maintenance ration and mango seed kernel was found to be useful upto 20% for growing calves. As a part of the study, methods to remove the part of lignin by NaOH treatment, maise cobs, wheat straw, paddy straw, jowar kadbi, sugar cane tops etc. were studied. Products like tapioca leaf, rubber seed cake, silk cotton seed, pinapple bran, were analysed and studied for growth and lactation. Tapioca leaf meal showed no adverse effect in lactating animals and 16% tapioca waste did not affect the availability of digestible energy.

Studies on the nutritive value of different kinds of feeds and fodders and on different aspects of cattle nutrition, have been carried out in the Nutrition laboratory/Department of Nutrition, in the college of Veterinary and Animal Sciences. A coordinated project on Agricultural by products and industrial waste materials for evolving economic rations for livestock is functioning in the department. Under the programme of the project several items of agricultural by products and industrial waste materials were screened and tested for their nutritive value. The scheme "Qualitative and quantitative deficiencies of animals in the west cost" started earlier was merged with the by-product scheme. Nearly 40 items of agricultural by products and industrial waste materials available in Kerala were analysed for their proximate composition. The promising ones among them have been subjected to further study. Tapioca leaf meal was studied in cattle to determine its nutritive value and found to have a DCP of 8.3 and TDN of 45.5 and all the animals maintained + ve nitrogen balance. Growth studies and lactation studies carried out indicated that the tapioca leaf meal can be included in the

ration of calves at 0.7% level of the body weight and in dairy cows at 0.4% of the body weight. Tapioca starch waste, silk cotton seed, rubber seed cake, coffee husk, Sal seed meal, Prawn waste, Neem seed cake, Tea waste, Silk cotton seed cake, Cashew bran, Coconut oil residue, Pulippan grass, Jack fruit waste, African payal were subjected to chemical, biological and toxicological studies.

The largest single research project in the Animal Science with which lot of hopes and aspirations are attached is the All India Coordinated Research Project on cattle of the ICAR. The objective of the project is to evolve a new breed of cattle with a productive potential of 3200 litres of milk and a fat content of 3.5% high reproductive efficiency and feed conversion efficiency. It has been pointed out that the programmes of dairy development and rural employment are both tied up with this new cow. Suitable recommendations are made on the basis of the discussions being held in the workshops on this project. The type of cross-breeding work carried out in Kerala is quite different from that in other states since there is no definite Indian breed of cattle available in the state. In the absence of any coordinated research project on cattle there were very few studies undertaken on cross-bred dairy cattle in Kerala, eventhough the cross breeding work has been in progress for quite sometime.

Management practices for calves have been worked out in many of the organized dairy farms located in many parts of the country. The first attempt has been made in Kerala by the publication of the package of practices for cattle. This will need revision at frequent intervals based on new knowledge and technology. Weaning of calves at birth and feeding of fermented colostrum to young calves and there by releasing valuable milk for human consumption have already been put into operation in our farm. The study relating to the use of calf starters has also been completed and more research work needs to be done on the nutrition of calf for better and economic body weight gains.

It has been found that the crossbred animals will have to be treated in such a way to control heat stress particularly during the summer season. The chief principle is to cut off the radiation heat completely. This can be accomplished by providing shade. For comfort it is essential that the animals should not be confined indoors all the times. A common practice in many places is to tie the animals outside in the open during night with arrangement for providing feed and water. Some years ago Scientists were concerned about the adaptation of animals to hot or unfavourable environments and much work was centred in exotic and crossbred animals on this account. Now it has been realised that productivity of the animals in the unfavourable climate is more important. Whereas the Holstein Friesian breed which produces more milk than any other is not particularly adapted to hot environment, it has been shown by American and Israeli workers that these animals can be managed for high production better than those involving crosses with Zebu cattle. Techiques for keeping high producers in peak production in a hot environment include provision of adequate shade, plenty of cool drinking water, provision of sprinkling water on the body surface of the cows during hot and dry weather, feeding more during the cooler part of the day, tempting appetite by providing freshly cut green fodder repeatedly etc. Experience as well as controlled experiments have shown that the reluctance to eat on the part of the cows during hot weather is more a case of deranged appetite rather than productive phenomenon. No harm has been shown to occur as a result of making animals to eat more during hot weather under good management.

Considerable changes have occurred in our thinking regarding the housing of animals under tropical climate. From the point of view of disease control maximum utilization of available land and reducing the heat load, it has been stressed that grazing is not a desirable practice for Indian conditions. While stall feeding can be done with animals in stanchions also, group feeding under loose housing conditions has been shown to induce more forage consumption due to the element of competition involved. This method is found to have less expenditure on construction and less labour for forage distribution but slightly more labour for manure disposal. It has been found as a more efficient system for accommodating changes in the number of animals heat detection, maintenance of animals in good health etc.

In tropical areas the main difficulty is inadequate feed supply which leads to high morbidity incidence and consequent higher mortality among the calves as well as heifers. This in turn leads to high costs of replacement of dairy stock. With growing or fattening animals, the irregular level of feeding at one time or other is not likely to exert a detrimental influence on animals' response at a later

date. In milk production, however, a wrong decision in feeding at one stage in lactation usually results in irreparable damage for the remainder of that lactation. Similarly failure to bring the cow to a good state of body condition at calving time may reduce total milk production in the consequent lactation. Once a lactation curve is permitted to decline it cannot be revived during the lactation in progress. Challenge feeding is merely forcing a cow not only to reach her highest potential peak of production during her lactation but also to achieve it as quickly as possible. Peak milk production under this programme has been found to occur in about 30 days after calving.

Research gaps identified and future line of work

Since large scale cross-breeding programmes are in operation throughout Kerala, and for that matter in whole of India and large number of cross-bred stock with different levels of exotic inheritance are available, it is high time that a detailed study on the performance of the different genetic groups under Kerala conditions be taken up.

The areas in which research work on cattle development may be undertaken are:

Except for the few reports quoted above, no systematic research project has been taken up to evaluate the performance of cross-bred cattle at different regions in Kerala. Jersey cross breds, Brown Swiss cross breds and Holstein Friesian cross breds are reared by the people of Kerala. It is imperative to conduct comparative studies on growth and reproductive and productive performances of these cross-breds, to arrive at a suitable conclusion and to suggest which of the cross-breds will be ideal for a particular area for economic dairy farming.

Cross breds with different levels of exotic inheritance may have to be compared to arrive at a conclusion as to which level will be ideal for the State.

Another important aspect for which studies have to be conducted is with regard to sire evaluation (progeny testing). Most of the improvements realised through selection for increased yield in dairy cattle result from the identification and use of genetically superior dairy sires. For evaluation of the merit of a sire for a character which he himself cannot manifest (eg. milk yield), progeny testing can be made use of. Sires can be studied for their respective transmitting abilities be testing the progenies obtained by each of the sires with random samples of unselected dams. The progenies maintained in a more or less uniform environment constitute ideal materials for the estimation of the breeding value of bulls. Progeny testing of Indian Dairy bulls has not been attempted until recent times.

Large scale progeny testing programme for identification and utilisation of superior sires based on field data is envisaged. Co-operation from Animal Husbandry Department, Dairy Development Department, and Livestock Development and Milk Marketing Board, for collection of up-to-date data on the performance of cross breds at different parts of the state is necessary. The Department of Animal Breeding and Genetics of this faculty will be the centre for progeny testing. As per the recommendation regarding superior sires they can be extensively used for cross-breeding work. Cross bred bulls may also have to be progeny tested as they will be used for either inter se mating or for mating with 75% cross-bred cows. In line with what has been suggested earlier 50% cross-bred bulls can also be selected for breeding based on progeny testing. Establishment of mother farms are also envisaged for ready supply of superior bulls.

Kerala has very few organized dairy farms having 100 or more cows in milk at any given time. On the other hand, the minimum number of cows required for conducting animal breeding experiment will be 300, of which 75% (or 225) are on an average expected to be in milk at any given time. In order to meet this objective, it has been decided to consider all the farms with the University as one single breeding Unit and to have at least 300 cows and 300 buffaloes in these farms taken together. This will form one of the elite herds which will produce progeny tested bulls whose semen will be made available on a large scale for breeding in the State. In the meantime there is need to establish semen freezing facility at the University so that semen of promising bulls could be frozen in sufficent quantity.

At present, several lakhs of inseminations are being carried out all over Kerala. We are justifiably proud of our position as the leading state in India for cross breeding and also for coverage under Artificial Insemination. The first generation crosses invariably show spectacular improvement over their local dams both in production and reproduction. Even in the second generation of crossing to exotic

breeds (75% bred, often incorrrectly called F2) one is likely to get high production but slightly reduced reproductive efficiency which may not be appreciated. But as the exotic inheritance is increased further, we get increasingly 'pure' exotic animals which do not tolerate our climate and this is usually reflected in infertility, poor growth, susceptibility to various diseases and reduced milk production. The ideal percentage of exotic inheritance seems to be close to 62.5% obtained by crossing the 75% with F1 (50%) bulls of the same or other exotic breeds. The NCA has recommended (28-6.2; 28-6.4; 28-11-14; 28-11-15; 28-13-4) that each state Government should set up a panel of experts in animal genetics and farm management and evolve its own procedure for managing, recording and breeding. Since Kerala is ahead of other states, there is urgent need for us to take up this challenging problem immediately. The Veterinary and Animal Science faculty is ready to play its part. But we cannot progress unless the other agencies concerned also join hands with us.

At present almost all activities of the Veterinary and Animal Science faculty are concentrated at Mannuthy. There is urgent need for an animal Husbandry Research station. About 150-200 ha. of good land with facility for irrigation would be the minimum requirement for such a station. We are fortunate in having such a station at Thiruvazhamkunnu. A proposal for developing this station at the cost of about Rs. 50 lakhs has already been submitted. This station will aim at building up an elite breeding herd. This large elite dairy herd would also be a source of substantial income to the University, perhaps equal to all other present sources put together. Apart from a simple breeding station, research on aspects including growth and reproduction will be carried out at this station.

Kerala is one of the States which have been comparatively backward in dairying.

With a large number of cross-bred cattle being produced every year, the chances for substantial increase milk production are very good. This brings up a question, will there be problems in marketing when milk production is increased substantially. Actually, it is not well known that there is already a problem of seasonal surpluses, for about 4–5 months in the year. This is partly because of the large number of poor people who consider milk to be an avoidable luxury. All these facts point to the urgent need for a study on consumer perference and measures for persuading people to consume more milk in Kerala.

There are many milk products of which different products are popular in different parts of the world. Butter and ghee are popular everywhere in India, but money is the main constraint. However, excessive consumption of these products would not be desirable. Ice cream is extremely popular every where, but the cost of ice cream in Kerala Markets appears to be disproportionately high. Curds and buttermilk are popular in Kerala. It appears surprising that very few of the well known fermented milk products are seen in the organized dairies of Kerala. It appears this is a rich ground for research on dairy products. For this the discipline of dairy technology needs to be developed at Kerala Agricultural University.

Kerala dairying is and should be linked to the small and marginal farmers. The climate is such that acidity shoots up and milk gets spoiled very quickly. It should be possible to develop techniques for rapidly testing milk samples for bacteriological and chemical quality in order to pin-point the sites and sources of contamination or adulteration. There is also urgent need for a survey for screening the different kinds of contamination and the particular organisms involved in each case.

Though a great deal of work has been done on different aspects of animal nutrition a great deal more remains to be done. Experiments which will economise the cost of feeding of cattle will have very great practical significance. Studies on the enrichment of cheap roughages, utilisation of unconventional feeds and tree leaves etc. will yield data which may find direct application by the farmers. Some of the studies directed towards that end are in progress in the Department of Animal Nutrition. They include studies on the nutritive value of Agricultural and industrial by products (under the All India Co-ordinated Research Project), utilisation of paddy straw treated with urea and molasses as cattle feed, Poultry litter as cattle feed, and studies on the nutritive value of African payal.

The areas for further research are to be identified and works need to be done. Research studies in the following areas may be worth-while in the context of developing cheap ration and increasing the food resources for the animals in the state.

Survey work to assess the quantitative deficiency of feeds and fodders available in the state to

measure the extent of deficiency of TDN and DCP intake by different classes of livestock, conservation of green leaves suitably processed as silage etc. exploitation of available crop residues as fodder with suitable supplements and/or processing and assessing the digestibility of nutrients of different stages of maturity of forages.

The agricultural scene presented by countries of western world is one of an integrated system where soil, crop, animal and man have been inter woven into highly complex inter dependent and balanced systems leading to continuing high standards of agricultural productivity and of human nutrition. In these systems the dairy cow plays a key role. Europe, North America, Australia etc. have large dairy industries which operate at high standards of efficiency. Apart from the importance of milk in human diets, the reason for this is the need for animal manure to support any continuing system of Agriculture. Taking the above points in to consideration a beginning has been made in Kerala Agricultural Uuniversity for carrying out research on mixed farming in coconut gardens along with rearing of fish and dairy cattle. Also a scheme has been prepared for the utilization of diary farm waste for growing vegetables, fodder and fish.

A calf is the nucleus seed of a productive dairy animal. Good antenatal and post-natal care are inescapable to allow it to fully express its genetical potential. The key to success of a profitable dairy industry is proper management of the calf throughout its stages of development which entails a keen, careful and specialized knowledge. It is, therefore, high time that problem oriented research is intensified and simple, economic and practical methods are evolved for rearing and managing calves under the environment met with in rural parts of the state so that they attain adulthood fast enough with minimum of mortality and are able to express their full genetic potential. The effects of plane of mutrition on growth, age at first calving and on milk yields in the first lactation need to be studied in great detail in the crossbred animals. Sufficient data on these are still lacking in our state for the different types of crossbred animals. The nutrition of the calf from birth to first calving is very important and has significant relevance to the economic life time production. One of the important factors in the overall efficiency in dairying is the economical production of heifers grown at a rate that will allow them to be bred early so that they can begin producing milk in about 24-30 months. In the Indo-Swiss Project, Mattupatti, the crossbred females have shown an earlier maturity than their local mothers. But it does not seem to be advisable to breed them before the age of 20 months. Not only the age alone has to be considered, but also the general condition and body weight of the animal. Only a properly reared and well managed, calf will make a good cow. In the case of Brown Swiss Crossbreds a heifer should reach a body weight of 250 kg before the first insemination. Some of these valuable data are not available for crossbreds of Jerseys and Holsteins. In Mattupatti the average birth weight in the different populations was 37,25,30 and 28 kg for pure Brown swiss and 50%, 75% and 87.5% for Brownswiss crosses. Therefore, an outstanding need is to speed up the rate of development of young cattle. Methods of rearing to permit optimum growth need to be worked out for all crossbred calves and applied in each environment. Delayed sexual maturity and inability to withstand the stress of high milk yields during the first lactation are an inevitable consequence of abnormally slow growth of young animals.

While many recommendations for housing cattle have been made there is considerable need for studying the performance of the animals under the housing conditions that will be most suited for heavy rainfall areas like Kerala. The physiological status of the animals under the hot, humid and heavy rainfall conditions still need detailed studies, since not much has been done in shelter engineering in Kerala.

Practically all the dairy herds in the country are milked by hand. This is particularly due to under developed nature of the industry which depends more on pooling individual production of a large number of producers owing one or two animals each. The new type of dairy cows produced by crossbrecding have smaller teats and more milk (especially in the first lactation) so that it becomes a full time job for one milker to milk a dozen cows a day. However there is scope for the use of milking machine by some of the commercial dairies and progressive farmers who are prepared to make large investments.

The cattle in Asia differ from European state in their response to alternative stimuli and in consequence pose special problem in milking. In practice the problem appears capable of subdivision into two parts. (i) the initiation of let down after calving and (ii) the maintenance of let down during

lactation. In respect of the first one the removal of calf at birth has been suggested as the practical solution. In respect of the second one a regular milking procedure involving vigorous teat and udder massage including washing has been found to be capable of stimulating let down thereafter. In view of the high heritability of easy milking selection and culling of cattle on this basis is important.

Frequency of milking is another management practice worth consideration. It has been shown that increasing the frequency from 2 to 3 times/day production can be increased by 12 to 16% and a further increase of 21 to 23% more by increasing the frequency to 4 times/day. The economics and the production level at which the frequency of milking has to be increased have to be studied in detail.

Pricing of milk without taking into account the composition of milk stands in the way of production of cow milk and therefore of rapid increase in milk production. It is generally accepted that price of milke should be paid on the fat and solids not fat content ot milk.

There is need for revised set of platform tests for use at the collection and processing points to determine the fat and SNF accurately and to carry out the tests most economically. These revised tests should have to be given extensive field trials. Some of the aspects in which research work needs to be initiated and intensified are.

Laboratory techniques (chemical and bacteriological) in the quality control of milk and milk products, Variations in the bacteriological quality of milk and milk products offered for sale, Microbiological aspects of handling, processing and storage of milk and milk products and Applicability of present standards under the prevailing conditions vis-a vis prevention of food Adulteration Rules.

Particular stress needs to be laid on the improvement of quality connected with different methods of production and collection, bacteriological characteristics (harmless and pathogenic organisms), content of undesirable substances (residues or pesticides, antibiotics and mycotoxins) and organoleptic characteristics. The respective influences of the species and the breed of the animals, their feed (grass, silage etc.), the climate, the lactation, the system of production and of the various agricultural practices on the compostion and qualities of milk and the products derived therefrom will need be studied in particular.

Even though attempts have been made to study the compositional, chemical and bacteriological qualities of milk and some dairy products, no systematic survey and analyses on a large scale covering the different parts of the State has been undertaken by any agency.

2. BUFFALOE

Introduction

The buffalo has come to occupy an important place as a milch animal in India since 26.6 million milch buffaloes contribute more than half of the total milk produced as compared to 48.6 million cows contributing about 44% only. India has nearly 50% of the world population of buffaloes. Unlike in the rest of India, cattle are the main dairy animals in Kerala and most of the market milk is cows milk. Buffaloes are used as draught animals in Kerala. Though there is a popular belief that buffaloes do not thrive as well as cattle in Kerala, there is no scientific evidence to this belief. A research project which was started in KAU at Mannuthy during 1976-77 tries to study the climatic adaptation and growth characteristics of buffaloes as compared to cross bred cattle, and it is expected that by the time this project is completed we will have answers to some of the questions of adaptation of buffaloes to this part of Kerala. We are also negotiating with the ICAR for establishing a unit of the AICRP on buffaloes, particularly for studying the potentialities of this species for meat production. The density of population is so high that there is great pressure on the land and area available for pasture and fodder cultivations. Consequently, cattle and buffaloes are maintained on concentrates greatly limits successful rearing of highly productive animals. It is therefore important that we try to evolve an efficient system of mixed farming whereby the by products of the farm are liberally utilised for conversion to milk and meat through the intermediary of ruminants. Thus, the buffaloes play a very vital role in symbiotically integrating man -animal crop soil recycling.

Resume of work done.

Results obtained during the course of another study on the nature and problems of livestock enterprise in Trichur Taluk revealed that more than 50% of the adult buffalo population in the 17 Wards selected at random for the survey consisted of adult males used for work. The ratio between adult females and young stock was found to be 71:29 The mortality rate among calves was also higher (32%). Calvings recorded were also subatantially low, only 30% of average total breedable buffaloes.

A review of literature on the research done on buffaloes, reveals that adequate attention has not been paid for improving the lot of this dairy animal. The productive growth of an animal can be judged from its birth weight and studies on buffalo calves have revealed influences due to sex and breed. An increase in the growth rate from birth to 12th week with the maximum between 8th and 12th week has been observed.

Unlike in the case of cattle, very few rererences are available on the development aud metabolism of the rumen. The weight of the rumen and reticulum reaches approximately adult proportions by the 8th week. Typical microbial activity occurred at the 9th week as evidenced by a decrease in the level of protein nitrogen and increase in the level of NPN in rumen liquor. Feeding calf starter to buffalo calves had a favourable effect on the development of reticulo-rumen mucosa. Buffalo calves raised on calf starters had functionally developed rumer earlier than the control group. The beneficial effects o- feeding 20% higher TDN than the NRC recommended level on buffalo calves have been experimentaiy demonstrated.

The age at first calving has been reported to vary from 40 to 54 months.

Animals kept on a high plane of nutrition for 9½ months gained 1.4 lb/day as compared to 0.88 lb for animals on low plane.

Murrah calves can be reared satisfactorily and economically between the age of 7. 13. 5 months on a ration containing 20.40% low DCP than that of Morrison scale provided TDN requirements are met. Buffaloes can maintain themselves mainly on roughages with comparatively less amount of concentrates and can also retain higher contents of Ca and P. Protein requirements for maintenence during fasting in buffaloes were found to be 28 kg/454 kg body weight.

Significantly higher bacterial count in buffaloe rumen compared with zebu on the same system of management and feeding has been reported.

While studying the concentration of TVFA after feeding equal quantities of wheat straw and berseem, higher levels of TVFA were observed in buffalo than in cow at 2 & 4 h post feeding. The protozoal protein of buffalo had more of proline, tyrosine and phenylalanine while those of zebu were rich in glutamic, valine and leucine.

Buffaloe

The flow rate of saliva was a bit slow in buffaloe. The concentrations of K and Ca were found to be more in rumen liquor of buffaloes than of cattle. The use of uromol, as compared to urea, is beneficial when more than 50% dietary nitrogen is replaced with NPN. Experiments have conclusively shown the superiority of buffalo over zebu in cellulose digestibility. A higher digestibility of crude fat has been reported in buffaloes compared to cattle. The improved coefficient of digestibility of dry matter, crude protein, ether extract and cellulose in buffalose had also been demonstrated. The effect of replacing part of protein with urea nitrogen along the basal roughage of wheat straw on growth of Murrah heifers had been studied. Urea upto 1.5% level of concentrate mixture could be used safely in rations of buffaloes on milk.

As per 1972 census, there were 471,747 buffaloes in Kerala State. Though buffaloe are reared in different parts of Kerala, practically no systematic study has been carried out regarding their production potential, their adaptabillty to the agro-climatic conditions and the economics of their maintenance. The faster an animal grows the earlier will it reach sexual maturity. Having young stock with high genetic potential raised on an adequate and balanced nutritional regime is a must for periodical replacement of animals with undesirable characters in a herd. Currently a research project on the meat potentialities and meat qualities of buffaloes is going on.

Research gaps identified and Future line of work

1. In order to undertake systematic and detailed studies on buffaloes, establishment of a buffalo farm should be taken up on a priority basis. The main objectives of the proposed buffalo farm being-

i) to improve production potential of buffaloes through the assessment of genetic parameters for economic traits,

ii) to supply animals required for conduct of research.

iii) to compare the performance of Murrah and Surti breeds of buffaloe and Murrah local cross-breds and Surti-Local cross breds.

It is suggested that work relating to reproduction (service behaviour and semen studies, semen diluents; deep freezing of semen; studies on patterns of oestrus cycle investigations into reprodutive failures) may be placed before the Animal Reproduction committee for consideration. Similarly, studies on calf-mortality and other infections and non infectious diseases may be referred to the Animal Diseases committee.

3. GOAT

Introduction

India ranks first among the countries in the world in goat population. As per 1972 census there were 68 million goats in the country contributing about 19 percent of world goat population. In Kerala state there were 1.5 million goats. Goats are extensively reared in different areas of the state especially in the northern districts of Kerala. Being a 'poor man's cow' goats are usually reared by small and marginal farmers of the state. Though goats satisfy the milk demands of a household, their status as milch animals are only secondary. Goats are considered as principal meat animals in India contributing approximately 225 million kg of meat which constitutes 35.15% to the total meat produced from livestock except poultry. The position of goats as meat animals in Kerala is in no way different from that prevailing in other parts of India. Goat meat is preferred over beef in most parts of Kerala. Goat skin and hair also fetch income for the state. Goats also contribute reasonable quantity of milk. Goat is usually associated with desertification. Perhaps it is the most mis-understood species of livestock and inspite of the neglect and prejudice, has increased in number. Results of the project on 'A study of the nature and problems of livestock enterprise in Trichur Taluk, showed that in Trichur Taluk goats have proved to be attractive income earners, more for meat than milk production. The goats appeared to be playing an important role in the livestock economy of the households of Trichur with as many as 55% of households with selling goats during the period under study. On the whole, goat population increased by over 10 percent during the period.

Goats, inspite of their economic importance, have been neglected by the scientific world in the past. No systematic attempts have been made in the direction of improving goats in this country and elsewhere. If the economic value of goat is to be fully exploited, improved practices in breeding, feeding and management are imperative. In Kerala State the Department of Animal Husbandry has established certain goat farms, which proved to be a failure.

Resume of work done

With a view to improve the production performance on Indian goats the All India Coordinated Research Product on Goat Breeding was initiated during the fourth five year Plan. There were three separate projects (1) Goats for milk (2) Goats for meat and (3) Goats for Mohair and Pashmina.

The goat for milk project has started functioning in the Kerala Agri. University, Mannuthy from 1974. Goat for milk project aims at developing a new breed(s) of milch goats suitable for Kerala conditions and capable of producing 300 kg of milk during a lactation period of 120 days. Two exotic dairy breeds (Saanen and Alpine) and one local breed (Malabari) would be utilised for breeding.

Though there were certain reports on the Genetics of goats and their breeding there were only very few reports on those aspects in Malabari breed of goats on crossbred goats. The project based research studies on the reproductive performance, adaptability to the agro climatic conditions of Kerala, birth weight and growth rate are in progress.

Comparative Evaluation of conventional and unconventional feeds evolving cheap and economic rations for goats was undertaken utilising unconventional feed ingredients like tapioca chips, tea waste, rubber seed cake and molasses. Conventional feeds were also fed and the animals were maintained on respective rations for a period of 84 days. From the results obtained it could be concluded that incorporation of unconventional feed items in the ration of goats did not influence the physiological well being of the goats.

Another nutritional trial conducted was to assess the suitability of *Leucaena leucocephala* as a fodder for stall fed goats. The leaves were found to be palatable and no deleterious effects were noticed after maintaining goats solely on the leaves of *Leucaena leucocephale* for a period of three months.

Loranthus, a parasitic plant growing usually on fruit bearing trees such as jack and mango trees, is usually a menace to the host tree. This material was found to be palatable to goats. Hence a study was undertaken to estimate the chemical composition and nutritive value of *Loranthus* for stall fed goats.

Nutritive value of banana leaves for stall fed goats was another aspect studied. Jack leaves, poovam, kaine, sapota, mangostein and banana leaves are commonly consumed by goats. Therefore the chemical composition and tannic acid content of those leaves were estimated. It was observed that tree leaves are not only rich in crude protein but also rich in calcium.

A crop-livestock integration (goat rearing and banana cultivation) was initiated to evolve cheap and economic goat ration utilising the various parts of banana after harvesting the fruits and assess the possibilities of utilising goat mannure for growing bananas. It was observed that banana leaves can replace the roughage part of the ration without exerting any influence on feed intake, feed effeciency, growth rate or the physiological well being of the animals. Studies to assess the suitability of banana leaves in pregnant and lactating goats are in progress.

To find out the feasibility of reducing the quantity of milk to be included in the daily ration of kids, experiment was conducted to rear kinds on a protein rich kid-starter ration right from early stage of their growth. The average daily gain obtained for the experimental kids was almost similar to that obtained for kids which received milk in their ration, thereby indicating that kids can be successfully raised on kid starter and roughage without any milk after they are one month old.

Research gaps identified and future line of work

In the All India Coordinated project it is envisaged to study the growth traits, breeding efficiency, production and viability in different genetic groups.

Ancillary studies on nutrition, physiology management, artificial insemination and health aspects are also be taken up. Studies on the adaptability of the newly evolved goat breed (s) in rural conditions of housing and management are another important aspect to be looked into.

The present All India Co-ordinated Research Project on Goats is for milk. But goat for meat is also an important project to be undertaken in Kerala conditions. As sheep husbandry is practically nil in the state it is highly essential that a meat breed of goat should be evolved. A project involving selective breeding of Malabari and crossbreeding with Barbari, Black Bengal and Anglo-Bubian is expected to evolve a meat strain of goat suitable for the agro-climatic condition of Kerala. Estimations of heritability for various meat traits, general and specific combinining ability, genetic and phenotypic correlation between traits and hybrid vigour are to be made. Meat production traits, reproductive traits and production traits are also to be studied.

Immunoglobin level in goats and its association with survivability officials is another area of research to be intensified on goats.

Karyotyping studies are also necessary in order to study the chromosome pattern in goats and to find out chromosomal aberrations, if any associated with sterility and other anomalies in goats.

In the field of goat management very little work has been carried out systematically in India except for the routine observations and conclusions drawn from different farms. It is essential that systematic research projects on various management aspects in goats be taken up for refinement in management of goats,

Comparative studies on the performance of weaned vs unweaned kids in different seasons of the year for different genetic groups is one of the management studies to be taken up. It is also essential to recommend a suitable housing for goats in Kerala.

There is a common belief that goats are be browsers by nature and completely stallfeedig them may not be ideal. Therefore comparative studies on the performance of goats under completely stallfed conditions verses Semibrowsing system is also taken up.

Very little work has been carried out in India and especially in Kerala on the various aspects of nutrition, feeding habits and growth of goats. Goat being a browsing animal is found to eat the leaves of most of the shrubs and trees, the nutritive value of most of which is practically unknown. Also very little is known on the nutritional requirements of these animals, praticularly that of Indian goats

Feeding trials on adult males, growing kids and lactating goats are to be conducted so as to determine the nutrient requirement for the above classes and to fix feeding standards for them. Since feeding standards for preganant goats are not reported so far it is also essential to undertake a detailed study for the establishment of feeding standards for pregnant goats.

4. POULTRY INCLUDING DUCKS

4. (a) POULTRY

Introduction

Poultry farming has grown in India in all aspects during the last decade. With the growing realisation that poultry farming can play an effective role in the socio-economic improvement of small farmers, a new dimension has been added to it. The percapita annual availability of eggs in India is only 15 compared to 200-250 in may developed countries. The current output is less than 10% of the minimal potential demand, which is estimated to be more than 1,00,000 millions a year. Thus, poultry farming has a very vast potential in our country,

Kerala, with a poulation of over 21 million (1971 census) has only 0.18 hectares of land percapita. The total poultry population is just over 12 millions (1972 census) and the estimated egg production during 1975-76 is about 960 million. Because of the very high pressure on the land poultry farming among the livestock sector has the maximum scope in this state. The whole concept of poultry farming has changed with the introduction of modern technology such as deep litter housing system and now the cage system, availability of genetically superior stock, nutritionally balanced mixed poultry feeds, better health coverage and indigenously made modern appliances and equipments. However, these advanced technologies in the poultry farming have not percolated through the farmers in Kerala as have happened in other parts of the country because of the peculiar socio-economic and topographic situations that are prevelant in this part of the country. While a few poultry farmers have taken up large scale commercial poultry farming, a large segment of rural population still consider the back yard poultry keeping as the system of choice for Kerala.

There are quite a few good strains/strain crosses in our country which could be made use of in any commercial venture. Further, the All India Co-ordinated Research Project on Poultry for egg which has been located at the Kerala Agricultural University would also contribute to evolve egg type of chicken with superior genetic make up.

While the strains of birds currently available and those that are being developed would help to boost egg production, the need for a type of bird that could thrive well under the back-yard system of management and at the same time produce egg/meat economically warrents attention. The other major constraint of poultry development in this state is the high cost of poultry feed.

Resume of work done:

A review of literature on the research work done towards bringing down the cost of production of egg reveals that there are two distinct approaches to achieve this objective. One is search for alternate source of feed ingredients and the other is effecting certain changes in the management technology.

Many alternate sources of feed ingredients that may meet the protein need of chicken in place of the conventional items are available in India. Some of the substitutes have been shown to replace groundnut cake in poultry ration either partially or completely without any adverse effects.

Rubber seed meal could be considered as a newer addition as protein alternate at least in areas where it is available. Work carried out in Srilanka has shown that rubber seed meal can replace their traditional protein source, coconut cake, atleast partially. In the preliminary studies conducted at the Department of poultry Science it was found that rubber seed cake could be incorporated in rations meant for laying birds upto 15% without any major disadvantage. However, it had an adverse effect on egg weight. In studies with broilers it was found that rubber seed cake is not suitable at levels of 15% and above.

Recently there has been considerable inquisitiveness among nutritionists on the use of poultry dropping as poultry feed ingredient. Though extensive work has been reported from foreign laboratories, very little information is available in India on this. Studies were taken up at the Department of Poultry Science to evaluate the usefulness of dried mannure (droppings) as an energy source in layer and broiler diets. The results revealed that incorporation of dried poultry manurein layer diet upto 15% level was found to be superior in terms of hen-day egg production, feed efficiency and egg weight. Similarly it was observed that dried poultry manure could be used upto 10% level in broiler rations with advantage.

During the last few years there has been a phenominal change in the housing systems of poultry. Recently poultry men have started to think of raising poultry in cages replacing the deep litter houses. The efficacy of these two systems under the climatic conditions of Kerala was studied

using a strain of white Leghorn at the Department of poultry science. The study revealed that birds reared the cages had performed well in terms of most of the productive traits when compared to birds on deep litter.

There is a growing broiler awareness among the consumers. Preliminary studies conducted at the University Poultry farm has helped to identify two strains of birds as potential broilers. However further studies with newer genetic stock is required to be undertaken for which proposals are under way to established a broiler breeding farm at Kerala Agrl. University.

Research gaps identified and future line of work

The state contributes to more than 10% of the total output of eggs of the country. However, the bulk of layer population is under the back-yard system of management which is quite unique for our State. Taking cognisance of this fact, it is felt that very systematic studies have to be undertaken to suggest improvements in the management of the backyard poultry units. Studies have also been planned to develop a bird that is capable of producing economically and at the same time stand the strain of backyard environment, in short a bird for the backyard. These efforts will also fall in line with the recommendations of the National Commission on Agriculture pertaining to the establishment of 50 bird units in the country.

As a long term project, to study and suggest modifications and improvements relating to poultry farm management, research work on housing, feeding practices and the like are carried out under the project on package of practices for poultry.

In view of the rapid change in the outlook on poultry meat, research projects have either been initiated or contemplated to be taken up shortly on broiler chicken production. Most of the male chicks from hatcheries are destroyed. A study in progress to evaluate the economic feasibility of raising male chicken as a meat bird so that it will bridge the gap of poultry meat demand at least partially.

The egg strain chicken population are under continuous study for effecting scientific selection and testing to make suitable adjustment in the breeding programme so that their high economic productivity could be maintained/improved.

Basic research studies by sister diciplines on the impact of sub clinical vitamin deficiencies in chicken and also on the pathogenicity and treatment of helminths are taken ub with a view to gain additional information which could be later translated to routine management of chicken.

Though it was felt that there is no immediate problems on health cover among chicken, in view of the reported incidence of Raniket disease and fowl pox among vaccinated birds under field conditions this aspect of study is also under progress in the elevant major dicipline.

Taking note of the undue dependance of our state on the neighbouring state for energy and protein feed ingredients, studies on the cultivation of yellow maize, sun flower and saf flower has been suggested.

4 (b) DUCKS

Introduction

Kerala with a coastal stretch of 580 km has 3.6 lacks ducks (1972 census) accounting for about 4% of the total duck population of India. Keralites relish both egg and meat from ducks in contrast to many parts of the country where customs and taboos deter the use of duck products. Thus, there is ample scope for development of duck farming. Duck farming, presently is an unorganised sector. The potentialities of the desi duck on the lines similar to that had been carried out with chicken. There are no nationally accepted standards on the nutrient requirements of either desi or exotic ducks. The other problems confronted by duck farmers are poor hatchability and viability of ducklings posing problems in building replacement flocks. In short the major bottlenecks in the development of duck industry as a whole in India is,the lack of sufficient basic information on management, nutrition, housing, health cover and want of economically viable stock.

As per the recommendations of I.C.A.R. Regional Committee No. 8 (Second meeting held on 19-8-77) the animal production schemes have to be augmented. In order that the duck farming may become quite viable it is imperative that the scientists in the field of study should evolve proper breeding policy, suggest optimum housing system and managemental practices.

Resume of work done.

Preliminary studies conducted at the Kerala Agrl. University have indicated that Desi ducks lack the inherent genetic potentiality for economic production of meat or egg under confined system of rearing. However, the study revealed that for table duck egg production confined system of rearing has an edge over the semi intensive system of rearing.

Research gaps identified and future line of work

Many basic informations on the duck farming are not available. In the light of the information gathered from work carried out at Kerala Agricultural University it is very necessary that suitable breeding programmes are evolved for developing a duck that is capable of producing economically.

In order to bridge these gaps a breeding project is contemplated using desi ducks and Khaki campbell breeds. Studies have also been initiated to establish nutrient requirement of desi ducks which will be later extended to Khaki Campbell as well as breed cross.

Fertility and hatchability being the major constraint in articificial incubation of duck eggs, studies would be taken up to identify the cause and suggest remedies.

In other aspect of study proposed to be taken up is on the aspect of housing.

It is earnestly hoped that the informations obtained from the studies either in progress or that are contemplated would not only bridge the gap in our knowledge on some of the basic aspects but also would help to suggest methodology to poultry and duck farmers for running these sectors effectively and economically.

5. PIG

Introduction

Pig excels all other animals as an economic converter ot feed to highly quality meat. It is the favoured Meat animal in many parts of the world, due to its economical advantages like ability to multiply faster, faster growth, early maturity etc. The contribution of pigs to global meat production is 35.3% against the contribution of 41.0% by beef cattle. In India, pig rearing is still not satisfactory with a hog population of only 68.84 lakhs and is almost entirely in the hands of poor people with little resources who follow primitive methods of rearing. The common Indian Pig is a scrub animal, slow grower, small sized and producer of small liters. Recognising the merits and potentialities of exotic breeds of pigs as a source of animal protein, Government is now paying considerable attention to the development of pig industry. A number of pig production centers have been started and the farmers are being educated on scientific lines of pig rearing. Among the Indian states, Uttar Pradesh is having the maximum number of pigs, about 23.3% of the total hog population in India, Andhra Pradesh stands next to it.

The scope for swine development in Kerala is more when compared to other states on account of several factors. People of Kerala do not show so much averion to pork as those in other parts of India. Kerala has only 1.29 lakhs of pigs (1972 census) and more than 80% of swine population is scattered in Districts of Ernakulam and Kottayam. Besides the non descriptive local pigs, imported breeds like Large White Yorkshire, Middle White Yorkshire and Landrace breeds are also seen in many parts of the state. Imported animals thrive well in Kerala, mortality in the past being only less than6%.

Though considerable work has been done abroad on feeding and managements of pigs, comparatively very little work has been done in India. Attempts have been made by few workers to find out certain carcass changes due to different levels of protein and energy in pig rations. Recent rise in feed cost has affected the pig rearing in Kerala. Production of lean meat has become costly and the demand for pork has been going down. Efforts have been made by workers in the Department of Nutrition to find out how far the feed cost can be brought down by incorporating some of the cheaply available by product feeds. The following paragraphs give a glimpse of what has been done in the College on different aspects of pig rearing.

Resume of work done

Studies on the effect of dietary Calcium and Phosphorus in growth and skeletal development of the baby pig have revealed the following inferences. (i) Ditary levels higher than 0.9% calcium and 0.7% phosphorus do not produce better growth response or bone development in young pigs. (ii) Supplementation of the diets with liver brings about a marked increase in the rate of rowth, skeletal development and haematopoiesis irrespective of calcium and phosphorus levels in the diets. (iii) Neither supplementation with liver nor increased levels of calcium and phosphorus in the diets exerts any influence on the concentration of serum calcium, serum alkaline Phosphatase, blood phosphorus and plasma protein concentration, (iv) 0.9% calcium and 0.7% phosphorus in the diet seem to be quite adequate for optimum skeletal development in baby pigs.

Incorporation of copper at a level of 125 ppm in the basal diet already containing 14p pm of copper and 51 ppm of zinc does not produce any deleterious effect on growth response while doubling the level of zinc brings about a depression in growth rate. Parakeratosis does not seem to develop in pigs maintained on a high calcium-cornsesame oil meal type diet containing 14 ppm of copper and 51 ppm of zinc.

Comparative merits of two systems of rearing piglets, one based on feeding a protein rich creep ration from tenth day of age and the other as per the practice usually followed in the farm, were investigated. It was found that the rate of growth, weaning weight and weight at four months of age on the system of creep feeding were significantly higher than on the usual farm practice.

It was found that the rate of weight gain in piglets at the weaning time on the system of creep feeding with a protein rich ration is significantly higher than that obtained for those maintained on the usual farm practice. Feed conversion efficiency was also found to be greater in animals fed the protein rich creep feed.

Animais receiving 3 Nitro Hoechst together with Aurofac show better gain in body weight and feed efficiency values as compared with those maintained on a basal diet containing either Aurofac or 3-Nitro

Hoechst, both these exerting a synergestic effect in this respect. The comparative feed cost was found to be in favour of the diet containing both 3-Nitro Hoechst and Aurofac.

The digestible nutrients in rubber seed cake were determined using four Yorkshire pigs of 25 kg. body weight on an average and employing pig metabolism cages. The digestble crude protein and total digestible nutrients in rubber seed cake were determined to be 18.2 and 86.3 respectively per 100 kg on dry matter basis. From the results obtained, it was concluded that rubber seed is a potential source of nutrients in pigs

Utilisation of Tapioca starch waste in Swine rations indicated that tapioca starch waste can be profitably incorporated in swine ration replacing either maize or tapioca chips upto a level of 15% without showing any deleterious effect on the nutritional status or physiological well being or carcass characteristics of the animals.

Higher dietary protein level of 18% promoted better weight gains in pigs during the initial period of their growth. Lowering of protein level in the in finishing ration reduced the weight gain and feed efficiency of the animals. A dietary protein level of 16% throughout the feeding period brought about linear increase in overall average daily gain at all body weights studied. Though the protein level does not seem to influence any of the carcass characteristics studied the dressing percentage, carcass length, back fat thickness and muscle area are positively correlated with body weight gain under both the dietary treatments. Fat contents are not affected either by protein levels or by live weights.

Evaluation of the feeding value of Tea waste (*Camellia thea*) as an ingredient in the ration for growing pigs have indicated that tea waste can be effectively and economically incorporated in the ration for growing pigs at 20% level without any significant effect on any of the parameters studied. A fourteen day feeding trial with the Land Snail meat at 7.5% replacing 50% of the fish meal promoted growth rate in pigs as effectively as 15% fishmeal in diet.

Studies on the effect of Vitamin-A deficiency on sexual organs of boars hava shown that the growth rate was not affected in boars maintained on Vitamin-A deficient diet. The deficient animals showed normal appetite and continued to eat the ration throughout the period of experiment. This might have been the reason for not observing a reduced growth rate in the deficient boars. Skin lesions characterised by loss of glossiness and lusture of haircoat was the first symptom noticed in Avitaminosis A in pigs. This was followed by the formation of brownish greasy crust on the skin all over the body. These early symptoms were observed by 165 days of deficient feeding. The level of Vitamin-A in the blood at that time was 100 microgram/100 ml. in advanced stage of deficiency, when the vitamin-A level in the blood dropped below 5 micrograms/ 100 ml the boars appeared lethargic and exhausted and showed recurrent convulsive attacks.

Effect on the growth rate and survival capacity of piglets weaned at 15th, 30th, 45th and 60th day and maintained on creep feed of the same compostion were studied in detail. At 60th day the gain in weight of piglets weaned at 15th, 30th, 45th and 60th dayswas 7.0 + 0.05kg; 9.09 + 0.16 kg; 12.08 + 0.08kg and 10.14 + 0.17 kg respectively. Shortening of lactation was found to reduce the growth rate of piglets. Probably this could be improved by feeding the piglets with more palatable and highly nutritious ration. Post weaning mortality was observed only in the 15th day weaned piglets. However the rate of mortality (4.08%) was well within the permissible limit.

Effect of weaning piglets at 15th, 30th, 45th and 60th day after farrowing, on the subsequent reproductive performance of the sows was also studied. The onset of post weaning oestrus, the conception rate, the litter size and litter weight were not significantly altered by the age of weaning.

There was a significant reduction in the interfarrowing period when the weaning was done during early lactation. Hence it was inferred that weaning of piglets at 15th day of farrowing might improve the overall productivity of sows.

The post mortem examination of 579 pigs of ali ages have shown a high percentage mortality during rainy season but season has little influence on the occurrence of any particular disease.

Research gaps identified and future line of work

a) Carcass qualities of indigenous, exotic and crossbred pigs at various levels of energy and protein.

b) Potentialities of indiganous pigs and comparing it with exotic and cross bred animals.

c) Rearing of pigs entirely on students hostel waste

d) cross breeding for fattener production.

e) studies on the effect of inbreeding on certain economic traits in swine.

6. ANIMAL REPRODUCTION AND ARTIFICIAL INSEMINATION

Introduction

Fertility in domestic animals has of recent years become progressively more important because of the higher values of breeding stock and the necessity for greater food production. There is accumulation of evidence to show that prevention and control of the major disease causing sterility or sub fertility in the livestock will do much to increase the out put and lower the cost of production. There has been in recent years an increased interest to study the reproductive physiology and pathology of domestic animals and a rapidly expanding field of research has grown up with new knowledge being added each year.

Kerala has about 3 million heads of cattle, categorically described as non descript. The average daily yield of the local cattle is very low. In order to improve their production potential, cross breeding with exotic bulls is being implemented on a large scale in the state. The exotic bulls that are used for the programme are Jersey, Brown-Swiss and Holstein-Friesian. There is still dispute on the comparative merits of these crosses from the economic point of view. Data on the influence of climatic variations on the cross bred cattle are also lacking. No study has been made to assay the hormonal or endocrine status of the cross bred cattle. Infertility including delayed maturity, repeat breeding anoestrum etc are common in cross bred cattle.

The buffaloes occupying a pivotal position in the socio-economic frame work of rural India is a neglected species in this part of the country. There is paueity of information on the physiology of reproduction in this species. Whether it is a seasonal or a continous breeder is still disputed. The reason for the high incidence of silent heat observed in buffaloes particularly during certain season is not yet explained. A satisfactory extender for buffalo semen is yet to be evolved. Deep freezing of buffalo semen still remains an infant field for concerted investigation.

Fundamental studies on the endocrinology and physiology of reproduction of goats under the agro-climatic conditions of the state are lacking. Diagnosis of early pregnancy in goats continues to remain as a major problem for the field Veterinarians. The main bottleneck for the wide spread use of artificial insemination in goats is the non availability of suitable extender for preservation of buck semen. The etiology, nature and magnitude of prevalence of infertility in goats have not been well studied in India. In Kerala state, facilities for breeding goats are scanty. In the A. I. C. R. P. on goats of the University, A. I. in goats is practiced exclusively for breeding.

The indigenous pigs of Kerala are notorious for their small size; poor growth rate, low quality pork and small litter size. Adoption of A. I. on a large scale is the answer for bettering the quality of these animals. Lack of a suitable diluent for long term preservation of boar semen remains as a handicap for the large scale introduction of A. I There is no suitable and reliable method available to diagnose early pregnancy in swine.

Resume of work done

The department of Animal Reproduction has been engaged in research on relevant problems of animal reproduction and artificial insemination, since 1958. About 65 research papers have till date been published and these have been widely reviewed in the foremost abstracting journals in and outside India. Keeping in view the importance of infertility amongst the cross-bred cattle, a comprehensive scheme to locate the various factors responsible for producing the condition, has been started. The performance of Brown Swiss crosses at High ranges have been thoroughly investigated at the Indo-Swiss Project. The reproductive performance of Jersey crosses at High ranges (Hill cattle development scheme, Karijirappally) and in the plains (cross breeding programme at Chalakudy, Neyyantinkara and Thumburmuzhi) have also been studied. In the department of Animal Reproduction, a controlled experiment on certain aspects of reproduction of F-1 Jersey-Sindhi calves was conducted (Mathai & Raja, 1971). Studies on repeat breeding (Namboodiripad & Raja, 1975) and pathological conditions of the genitalia of cows (Nair & Raja, 1973) were also undertaken in the department. Research work on the possible etiological factors responsible for delayed onset of post partem heat and anoestum in cross bred cows is being carried out in the department at present.

Preliminary work on the seminal characteristics of buffalo bulls have been done (Reddy & Raja, 1973). Studies to identify a satisfactory extender for buffaloe semen have already been initiated in the department.

Studies on the physical and biochemical properties of goat semen (Kurien & Raja, 1965; Patil and Raja 1970) and preservation of buck semen (John & Raja 1973, Pillai and Neelakantan 1968) were taken up as departmental projects. Attempts to evolve a suitable extender for goat semen is in progress in the Department. An attempt has been made in the department to study the usefulness of the various known biological and chemical tests for the diagnosis of pregnancy in goats (Sudarsanan & Raja, 1970). Though some of these are reliable, elaborate laboratory facilities, are required to carry out the tests. Preliminary work on infertility in goats have been conducted in the department (Achuthankutty and Raja 1971, Nair & Raja 72, Nair & Raja 73, Sudersanan and Raja 73, Joseph Mathew 76). Based on the above, further work on investigation of pathological conditions on genitalia of female goat is in progress in the department.

A study carried out on early weaning of piglets reveals that weaning of piglets at 15th day of farrowing is beneficial for the overall productivity of sows (Madhavan and Raja 77). The major lacunae observed during the course of this study were (i) slight reduction in post partum conception rate of the early weaned sow and ii) comparatively low growth rate of the early weaned piglets. A detailed investigation on the physical and biochemical characteristics of boar semen were carried out (Sreekumar & Raja 76). Research to evolve a suitable extender for boar semen was conducted recently (Neelakantan and Vijayakumar 1977) and 3 extenders, viz, Kiev I, Kiev II and GGE BC, were found suitable for the same. An attempt to correlate the blood picture and pregnancy at different stages in sows were also carried out (Rajagopalan & Raja 73).

Research gaps identified and future line of work

While there are sufficient data available on the physico-pathoiogy of reproduction of cross bred cattle, very little is known about the reproductive performances of the various crossbred reared under identical conditions of feeding and management. Hence a comparative study on the reproductive performance of Brown Swiss and Jersey cross cows of different leves of exotic inheritance is taken up. The results of this study will go a long way in evolving the right breeding policy for the state. Further areas in which research are to be intensified are furnished below. Establishment of a Radioimmuno assay laboratory to study the hormonal status of the various farm animals. The assay of protein hormones and steroid hormones during the various phases of the reproductive cycle will throw more light on the reproductive physiology of these animals. This will also help in the detection and diagnosis of various infertility factors associated with endocrine imbalance in cattle. Early diagnosis of pregnancy is possible using this technique.

Intensifying the research on the fertility problems of crossbred cattle. Data on the percentage of exotic inheritance and hetrerosis, if any, to be included.

Establishment of a deep freezing unit to facilitate study of freezing of semen of farm animals.

Investigation on the reproductive physiology and seminology of cross bred bulls of different categories.

Studies on the fundamental and applied aspects of reproduction in buffaloes under agroclimatic conditions of Kerala.

Evolving an ideal extender for long term preservation of buffaloe semen.

Evolving a suitable extender for preservation of buck semen.

To standardize technique for freezing of goat semen. Introduction of A. I. for goat breeding.

Fundamental studies on the endocrinology of reproduction of goats. To evolve a simple and reliable method for diagnosing early pregnancy in goats. Studies to improve the breeding efficiency of early weaned sows and increase the growth rate of piglets weaned early in lactation. Large scale introduction of A. I for swine breeding. This also include standardisation of techniques of deep freezing of boar semen. Steps to evolve simple and reliable techniques for diagnosing early pregnancy in sows.

7. ANIMAL DISEASES

Introduction

The animal husbandry development programme of the state during the past several years have yielded good dividends with visible changes in the husbandry, breeding and management practices. While it has been recognised that cross breeding with exotic breeds would be the best method for improving the production of cattle, a major limitation is the susceptibility of exotic breeds and cross-breds to the diseases and pests to which the local animals are more resistant. With concerted preventive measures it has been possible to control, to a great extent, many contagious diseases even though sporadic occurrences have been reported from some places.

The most important animal diseases occurring in Kerala are Foot and Mouth Disease, Anthrax Haemorrhagic Septicaemia, Black Quarter, Johne's disease and Tuberculosis. Mastitis has been found to be a disease of importance, causing great economic loss. By efficient vaccination programme and surveillance it has been possible to control Rinderpest. Protozoan diseases like Theileriasis, Babesiosis, Trypanasomiasis and Anapaslmosis have been reported mostly in cross bred and exotic stock. Helminths, including flukes and gastrointestinal worms have been found to be a major cause for the poor performance of animals in addition to causing mortality. Incidence of Rabies has been reported from all over the state. In addition to dogs, cattle, pig and goats have also been found affected. Leptospirosis and Brucellosis are prevalent in the state. Necrosis of extremities has been a real problem in cattle and buffaloes in certain seasons. Tumours of the ethmoid in bovines has been encountered with increasing frequency during the last few years. The disease is prevalent in most of the farms. Apart from these diseases there are many metabolic diseases and hormonal disturbances which bring down production and interfere with reproductive capacity. Diseases like Coli septicaemia, Coccidiosis, Pneumonia and Gastro intestinal parasitism have been found to cause calf mortality.

In swine, Pneumonia, Gastro-enteritis, Atrophic rhinitis, Viral enteritis, Hepatitis, Leptrospirosis, Brucellosis and Gastric ulceration have been some of the diseases more often encountered. The important diseases affecting goats are pneumonia, gastroenteritis in kids, Johne's disease, caseous lymphadenitis, gastro-intestinal parasitism and Mastitis.

The import poultry diseases which require special attention are Ranikhet disease, Marek's disease, Leukosis, Avian mycoplasmosis, Bangkok haemorrhagic disease, Pullorum disease, Aspergillosis, Fowl pox, Fowl cholera, coli infections and Coccidiosis and Aspergillosis. Parasitic conditions are found to be important factors for reduced production in addition to causing mortality. Duck plague infection has caused considerable loss to the duck farmers recently. Because of the limited data available it has not been possible to assess the magnitude of incidence of other duck diseases.

Toxicoses resulting from ingestion of contaminated feed has been definitely shown to reduce productivity and cause mortality in animals and birds. With the introduction of high level technology involving intense use of insecticides and pesticides, the incidence of poisoning due to these chemicals has been found to be increasing.

For the last few years the various departments of the college of Vety. & Animal Sciences in collaboration with the State Animal Husbandry Department have been engaged in identifying the major disease problems affecting livestock and poultry in our state and solving some of these.

Resume of work done

Tuberculosis and Johne's disease are important problems for the state. The latter is a disease of major concern in cattle and goats. Diagnostic tests have been conducted to detect these diseases, and the pathological features were studied in detail. In the studies made on tuberculosis it has been found that the involvement of the udder is common in tuberculous animals. Because of the zoonotic importance, the need to stamp out this disease need not be over emphasised.

Comprehensive studies have been made to study the various aspects of mastitis in animals. The etiological agents have been studied along with the pathological features of the udder in cattle and goats. The sensitivity of the isolated organisms to different antibiotics were also investigated. The suitability of various diagnostic tests has been evaluated.

Pneumonia is one of the common pathological conditions affecting all species of domestic animals. It has been found that goats and pigs show a high incidence. Detailed studies were made in goats and pigs on the etiology, pathogenesis and pathology.

Many species of bacteria and viruses have been found to cause pneumonia. In addition to these micro organisms, stress has also been found to play an important role in the production of the disease. The organisms isolated showed differential sensitivity patterns to different antibiotics and chemotherapeutic agents tested.

Gastro enteritis affects mainly piglings. The etio-pathology of the condition has been completely worked out and suitable curative and remedial measures suggested. The virus causing porcine enteritis has been isolated and detailed investigations are in progress.

The epiemiological studies showed that exotic and cross bred animals are much more susceptible to foot and mouth disease. In the indigenous stock the morbidity due to FMD is high but mortality is low while in the exotic and cross bred animals both morbidity and mortality are high. The nature and development of lesions in cattle have been studied.

Diagnostic results show a high incidence of rabies in dogs. This disease has also been recorded in cats, goats pigs and cattle. The epidemiological features of this disease are under investigation.

The incidence and pathology of Atrophic Rhinitis in pigs was worked out for the first time in India. It was possible to eradicate the disease completely because of the observations made in the study.

Coli infections are seen in all species of livestock and poultry. Detailed microbiologic investigations were done to assess the role of Coli sp. in various diseases and to assess their biological behaviour and drug sensitivity. A through study has also been made to assess the magnitude and prevalence of fungal infections in domestic animals and birds in Kerala. The pathogenesis and pathology were invastigated in detail.

Toxicoses, of fungal and of other plant origin, has been a major hazard for livestock production in Kerala. In depth studies have been conducted on mycotoxicoses especially aflatoxicosis. It is possible now to prevent the disease if suitable precautions as suggested are followed when selecting materials as feed especially in susceptible species like ducks, pigs and buffaloes. Recently it was found that the disease syndrome characterised by necrosis of extremities is caused by the intgestion of fungal contaminated straw. Studies are being conducted to see how these disease syndromes could be prevented and cured. Studies have also been conducted to study plant toxicoses, like tapioca leaf toxicity in animals. A new surgical technique was adopted to treat animals which have ingested rubber latex.

The pathological features of tumoures of ethmoturbinates have been under investigation. Studies are in progress to assess the biological behaviour and to identify the etiological agent.

The incidence of Leptospirosis, Vibriosis and Brucellosis have been recorded in cattle even though their percentage of incidence, was found low. Preventive measures have been formulated.

Quite substantial work has been done to catalogue the various internal parasites, enocuntered in cattle, pigs, goats and poultry including ducks. Studies have been completed on the common nematodes, trematodes and cestodes in chicken and ducks. Similarly studies on the incidence of gastric nematodes of goats and pigs and their treatment have been made. A comprehensive investigation has been conducted on the spirurids of fowl. The pathogencicity of *Tetrameres* and *Acuria* has been elucidated. In these investigations some new species of parasites were described, and life history of some parasites worked out for the first time. Treatment trials were conducted. Because of these studies, now it is possible to prescribe a schedule for the prevention and treatment of many parasites encountered.

One of the important constraints in poultry production in Kerala as elsewhere, is the incidence of Marek's disease. Both the classical form and the acute form are encountered. The pathological features of this disease have been studied.

The etiology of Bangkok haemorrhagic disease was established, the pathological processes were clarified and suitable remedial measures were advocated.

Duck plague infection has caused considerable mortality among ducks in the state. The viral agent was isolated and the pathological causes were worked out. The disease has been controlled with vaccine produced in our state.

Research gaps identified and future line of work.

A comprehensive investigation is required to identify the virus types and subtypes in each outbreak of Foot and Mouth disease in vaccinated and

unvaccinated animals. The incidence of this disease in pigs with reference to prophylactic vaccination needs urgent investigation.

Even though Rinderpest is under control because of the intensive measures adopted, there is scope for study of the epidemiological role of carrier state or of reservoirs in the dissemination of rinderpest nfection. The duration of immunity conferred by the rinderpest tissue culture vaccine in indigenous, crossbred and exotic cattle as well as buffaloes and goats needs to be studied.

Because of the widespread prevalence of rabies in dogs, and because of its grave public health hazard, a comprehensive investigation on the epidemiology and carrier status is urgently required.

Since protozoan diseases have been found to cause mortality, and morbidity, especially in cross bred animals in high altitude regions a study on the incidence, symptomatology, pathology and control measures is required.

An emerging problem of great significance is Mycotoxicoses and other toxic conditions affecting livestock. Work in this area has to be intensified.

One of the constraints for an economical dairy managements is the incidence of various production diseases. Identification of etiologic factors and formulation of preventive measures have to be taken up on priority basis.

Mortality of young Stock has to be reduced. For this the etiological factors have to be identified and suitable remedial measures to be suggested.

Intensive work has to be undertaken on the disease problems of goats, especially on respiratory diseases.

No significant work has been done on diseases of elephants, buffaloes and ducks. Our state is ideally suited to embark detailed studies, especially on the diseases affecting ducks and elephants.

Preliminary studies have shown that there is a great variation in the dosages of different drugs in different species of animals. Dose levels have not been fixed for many drugs especially for goats, elephants etc. So there is an imperative need to standardise the dose regime of common drugs for these animals. The possibility of identifying various indigenous drugs for the treatment of animals diseases has to be given top priority.

APPENDIX

PROJECT CO-ORDINATION COMMITTEES IN THE KERALA AGRICULTURAL UNIVERSITY

A. FACULTY OF AGRICULTURE

1 Project Group: Rice
Co-ordinator: Shri. N. Gopalaln
Members: Sri. N. Rajappan Nair, Dr. U. P. Bhaskaran, Sri. P. J. Tomy, Sri. P. Narayana Pisharody, Dr. C. C. Abraham, Sri. S. N. Shanmugham, Sri. A. E. S. Kurup, Sri. K. M. George.

2 Project Group: Coconut and Arecanut
Co-ordinator: Sri. Kannan
Members: Dr. U. P. Bhaskaran, Dr. P. C. Sivaraman Nair, Dr. C. C. Abraham, Sri. P. K. Satyarajan, Dr. T. S. Venkitesan, Sri. K. P. Padmanabhan Nambiar, Dr. P. K. Narayanan Nambiar.

3 Project Group: Cashew & Spices
Co-ordinator: Sri. V. K. Damodaran
Members: Dr. P. C. Sivaraman Nair, Sri. P. G. Veeraraghavan, Sri. P. K. Venugopalan Nambiar, Dr. Abi Cheeran, Dr. C. C. Abraham, Sri. K. K. Vidyadharan, Dr. S. Balakrishnan.

4 Project Group: Fruit crops
Co-ordinator: Dr. M. Aravindakshan
Members: Sri. K. Kannan, Sri. S. Balakrishnan, Dr. P. C. Sivaraman Nair, Sri. P. C. Jose, Dr. N. Mohandas, Sri. A. Padmanabhan Thampi, Dr. M. N. C. Nair.

5 Project group: Tuber Crops
Co-ordinator: Sri. K. Srinivasan
Members: Dr. P. K. Gopalakrishnan, Dr. N. Mohandas, Sri. P. Sethumadhavan, Sri. P. V. Paily.

6 Project group: Pulses and vegetables.
Co-ordinator: Dr. (Mrs) Mary K. George
Members: Dr. V. G. Nair, Dr. P. K. Gopalakrishnan, Sri. N. Rajappan Nair, Sri. E. V. G. Nair, Dr. C. C. Abraham, Dr. Abi Cheeran, Dr. T. V. Viswanathan, Dr. K. M. Narayanan Namboodiri.

7 Project group: Essential Oils and Medicinal Plants
Co-ordinator: Sri. E. V. G. Nair
Members: Dr. P. C. Sivaraman Nair, Sri. K. Chandrasekharan Nair, Dr. V. Gopinathan Nair, Dr. C. C. Abraham, Dr. Abi Cheeran, Dr. A. I. Jose, Dr. M. K. Rajagopalan, Dr. T. V. Viswanathan,

8 Project group: Cocoa, Coffee and other Beverage crops
Co-ordinator: Dr. P. C. Sivaraman Nair
Members: Sri. S. Balakrishnan, Sri. K. Kannan, Dr. C. C. Abraham, Dr. C. K. Peethambaran.

9 Project group: Sugarcane, Sesamum and other miscellaneous crops
Co-ordinator: Dr. V. Gopinathan Nair
Members: Sri. A. I. Thomas, Sri. V. K. Sasidhar, Dr. R. Vikraman Nair, Dr. P. K. Vijayan, Dr. N. Mohandas, Dr. K. I. Wilson, Sri. P. K. Chellappan Nair, Smt. S. Santhakumari.

10 Project group: Fodder crops
Co-ordinator: Sri. T. F. Kuriakose
Members; Dr. M. S. Nair, Dr. R. Vikraman Nair, Dr. V. Gopinathan Nair, Dr. P. C. James, Sri. P. V. Paily, Sri. B. Thomas, Dr. A. I. Jose, Sri. G. Raghavan Pillai.

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11 Project group: Crop pests, diseases and weeds
Co-ordinator: Dr. M. Ramanatha Menon
Members: Dr. C. C. Abraham, Dr. M. Chandrasekharan Nair, Dr. K. I. Wilson, Dr K. P. Rajaram, Sri. K. P. Madhavan Nair, Sri. P. V. Paily, Dr. Abicheeran, Dr. K. M. Rajan, Dr. S, Balakrishnan, Sri. P. C. Jose, Sri. P. K. Sathyarajan, Dr. C. K. Peethambaran, Dr. James Mathew, Dr. N. Mohandas, Dr. K. V. Mammen, Dr. Abraham Jacob, Dr. P. J. Joy, Dr. P. Rajamma, Sri. K. K. Raveendran Nair, Dr. T. S. Venkitesan, Dr. John Kurian, Dr. R. Vikraman Nair, Sri. Luckins C. Babu.

12 Project group: Soils and Agronomy
Co-ordinator: Dr. M. M. Koshy
Members: Dr. R. S. Iyer, Dr. R. Vikraman Nair, Dr. C. Sreedharan, Dr, U, P, Bhaskaran, Dr. K. P. Rajaram,

13 Project group: Farm Economics, Extension and Nutrition
Co-ordinator: Sri. A. G. G. Menon
Members: Sri. E. J. Thomas, Sri, K. S. Karayalar, Sri. E. R. Narayanan Nair, Dr. L. Prema.

14 Project group: Soil, conservation and Mechanisation
Co-ordinator: Sri. T. P. George
Members: Dr. Jose Samuel, Dr. U. P. Bhaskaran, P. Jacob John, Dr. P. Balakrishna Pillai.

B. FACULTY OF VETERINARY AND ANIMAL SCIENCES

1 Project group: Goat Improvement
Co-ordinator: Dr. B. R. Krishnan Nair
Members: Dr. K. M. Ramachandran, Dr. E. N. Kunjukutty, Dr. K. C. Abraham, Dr. E. Mathai.

2 Project group: Cattle Improvement
Co-ordinator: Dr. M. Subramaniam
Members: Dr. C. K. S. V. Raja, Dr. R. Kalyanasundaram, Dr. B. R. Krishnan Nair, Dr. E. Sivaraman, Dr. M. Krishnan Nair, Dr, G. Nirmalan, Dr. P. C. James.

3 Project Group: Buffaloe Development
Co-ordinator: Dr. G. Nirmalan
Members: Dr. T. G. Rajagopalan, Dr. T. R. B. Namboodhiripad, Dr. K Pavithran, Dr. C. R. Anantha. subramanian, Dr. A. Rajan.

4 Project Group: Poultry and Ducks
Co-ordinator: Dr. A. K. K. Unni
Members: Dr. C. K. Venugopalan, Dr. R. Kalyanasundaram, Dr. Maggie D. Menachery, Dr. A Rajan, Dr. G. Nirmalan, Dr. Sosamma Varkey,

5 Project Group: Piggery & other animals
Co-ordinator: Dr. P. K. Abdulla
Members: Dr. T. G. Rajagopalan, Dr. C. T. Thomas, Dr. M. Krishnan Nair, Dr. Kurian Thomas, Dr. E. Sivaraman,

6 Project Group: Animal Diseases
Co-ordinator: Dr. M. Krishnan Nair
Members: Dr. E. P. Paily, Dr. P. K. Abdulla, Dr. R. Kalyanasundaram, Dr. M. K. Rajagopalan, Dr. K. M. Alikutty, Dr. C. P. Neelakanta Iyer.

7 Project Group: Animal Reproduction and Artificial. Insemination
Co-ordinator: Dr. C. K. S. V. Raja
Members: Dr. C. P. Neelakanta Iyer, Dr. T. R. Bharathan Namboodiri, Dr, K. Prabhakaran Nair, Dr. V. Sudarsan, Dr. E. Mathai, Dr. P. K. Abdulla, Dr. A. Rajan, Dr. C, T, Thomas.