AGRICULTURAL TECHNOLOGY:
A STUDY OF INNOVATION AND DIFFUSION IN KERALA

Dissertation Submitted in partial fulfilment of the requirements for the award of the Degree of Master of Philosophy in Applied Economics of the Jawaharlal Nehru University, New Delhi

SHOBA VARGHESE

CENTRE FOR DEVELOPMENT STUDIES
TRIVANDRUM

1995

TO THE FOND
MEMORY OF DADDY

July 21, 1995

I hereby affirm that the research for this dissertation titled, "Agricultural technology; A study of Innovation and diffusion in Kerala" being submitted to the Jawaharlal Nehru University for the award of the Degree of Master of Philosophy in Applied Economics, was carried out entirely by me at the Centre for Development studies, Thiruvananthapuram.

SHOBA VARGHESE

Certified that this dissertation is the bonafide work of Ms. Shoba Varghese. This has not been considered for the award of any other degree by any other University.

Dr. CHANDAN MUKHERJEE
DIRECTOR

Dr. K.P. KANNAN
FELLOW

Dr. K. PUSHPANGADAN
ASSOCIATE FELLOW

(Supervisors)

Centre for Development Studies,
Thiruvananthapuram - 695 011.

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C O N T E N T S

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1: Introduction

Technology for agriculture takes many forms like biological or genetic, mechanical, chemical and managerial. Biological technology is generally regarded to be the key form of technology for agriculture [Evenson, 1993]. This is because it not only determines the maximum biological performance of plants and animals,but influences the scope and effectiveness of other forms of technology also. For the developing agricultural economies in the world where mechanical and chemical technology[1] is limited, to develop improved biological technology R & D is the most viable option open to achieve productivity growth in agriculture.[2]

Biological technology, is however, subject to geo climate-environment "interactions". Griliches(1964), in his classic study of hybrid corn development, highlighted the location specificity of hybrid corn and pointed out that farmers in different regions of United States obtained access to hybrid corn only after hybrid corn research program `targeted' to their geo - climatic niches were developed. The performance of plant and animals changes, when the soil and climate environment changes.[3] Thus, there is a lag between actual and potential yield of seed technology. The need for proper research to assign priorities for generation of technology arises at this juncture.

Importance of Research Institutes: Modern plant breeding research institutions were developed around the middle of 19th century. They were developed as incentive structures to encourage private farms to engage in plant breeding R & D, which is inadequate in other farms. But, agricultural research was recognized as a "public good", to be generated in publicly supported agricultural experiment stations [Shultze 1991]. Thus, regional niche based systems of plant and animal research emerged.[4]

Since modern public sector agricultural experiment stations were established in Europe and United States a century ago, much has taken place.Darwinian niche location specificity of agricultural technology has continued to guide research system design. Hybrid corn and improved sugar cane varieties were early results of these systems.

After World War II, the building of agricultural research capacity in developing countries was accelerated. The gains achieved in the agricultural practices in developing countries is, by and large, an outcome of the various developed National Agricultural Research Systems(NARS).

A large system of Institutional Agricultural Research Centers (IARC) have been developed to support the regional systems. Private sector R & D has also grown considerably, as agricultural input markets have grown and Intellectual Patent Rights (IPR) have been strengthened. However, private sector R & D is yet to get high importance in developing countries.

1.2 The Case of Kerala: The choice of Kerala as the focal point of study would be more relevant in this context, because the state has achieved a high level of development in terms of social indicators. Yet the stagnation in commodity producing sectors has given rise to economic crisis potent enough to threaten the remarkable benefits of social development. An analysis of its agricultural performance under the past four decades reveal the declining share of the primary sector as a whole, and agriculture sector in particular.

The percentage share of agricultural crop sector and primary sector in the State Domestic Product (SDP) are given in Table 1.1.

Table 1.1 : Contribution of Agriculture sector in SDP of Kerala at Constant prices (1960-61 to 1992-93)

Year	Agriculture (percent)	Primary Sector (percent)	SDP (Rs Crs)
1960-61	53.4	55.95	43222
1965-66	48.07	50.5	48839
1970-71	47.67	50.56	62575
1975-76	44.17	47.19	142323
1980-81	38.14	40.26	157133
1985-86	34.12	37.41	178471
1990-91	31.58	33.47	519280

Source: **Department of Economics and Statistics, Statistics for planning 1977,78,88,93**

The share of primary sector has come down from 55.95 per cent in 1960-61 to 33.47 per cent in 1990-91. The agricultural crop production sector which contributed 53.4 per cent of the State Domestic Product in 1960-61 declined to 31.58 per cent in 1990-91.

1.3 Performance of Agriculture in Kerala

A brief review of performance of the agricultural sector in Kerala is attempted below to highlight trends in the Area,Production and Productivity of different crops.

Agricultural scenario in Kerala: Performance and Problems

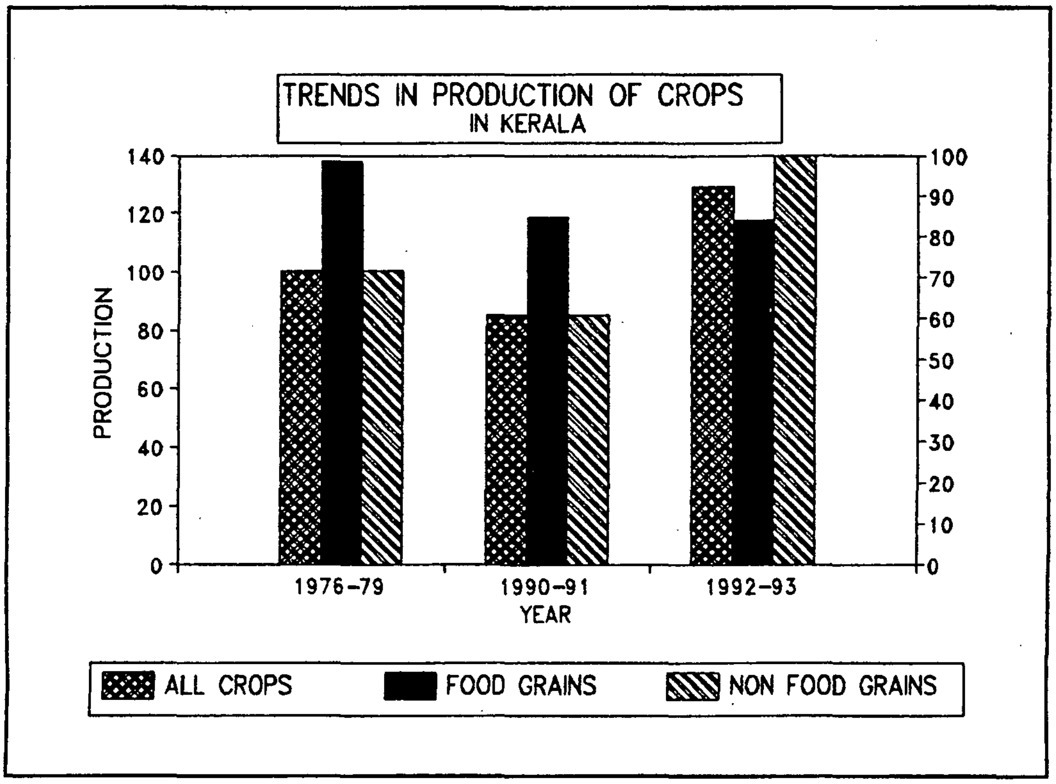
Agriculture in the state has undergone a structural transformation in favour of commercial crops. Food crops in general, unable to withstand the domination of commercial and plantation crops due to their low profitability, naturally lost their pride of place. Consequently there was drastic reduction in the area under food crops especially during the last decade. This transition has adverse consequences particularly from the perspectives of food security, employment support and ecological balance. [Eighth Five Year Plan 1992-97, Mid Term Review, State Planning Board].

Overall trend in the performance of different categories of crops

The indices of area, production and productivity of major categories of crops for the period 1976-77 to 1992-93 with base year as 1979-80 is given in Figure 1.1, 1.2, and 1.3 respectively.

The index of overall production was 100.17 for the triennium ending 1976-79, declined to 85.31 in 1990-91 and increased sharply to 129 in 1992-93. The index number for non-food grains rose from 100.52 in 1976-79 to 139.82 in 1992-93. The indices relating to oilseeds and plantation crops have contributed much to this impressive growth.

Figure 1.1



The overall area index declined to 102.28 in 1992-93 showing a near stagnancy in respect of cultivated area in Kerala. This shows the limited scope for intensive cultivation in the state. There has been considerable fluctuations in the indices relating to the different categories of crops. The most striking feature has been the sharp fall in area under food crops as revealed by the index which declined from 102.55 in 1976-79 to 66.19 in 1992-93. Obviously, the non-food grain category gained substantially in the process with its index climbing up to 118.89 in 1992-93 from 101 in the period 1976-79.

Figure 1.2

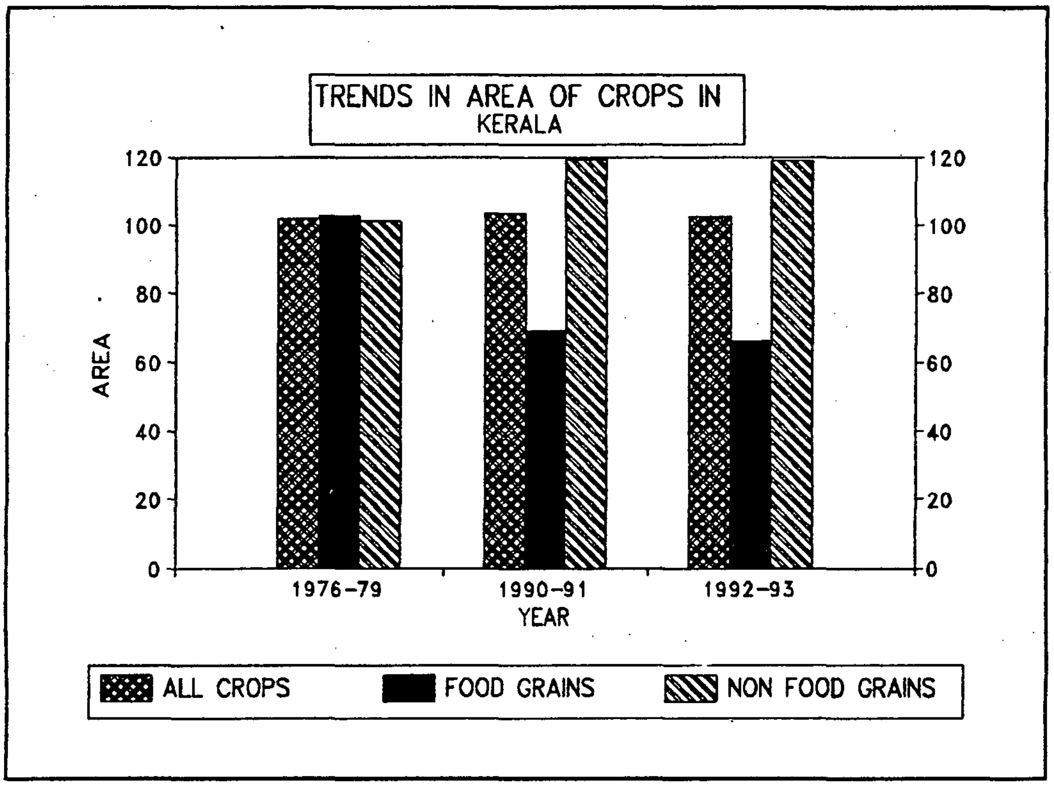
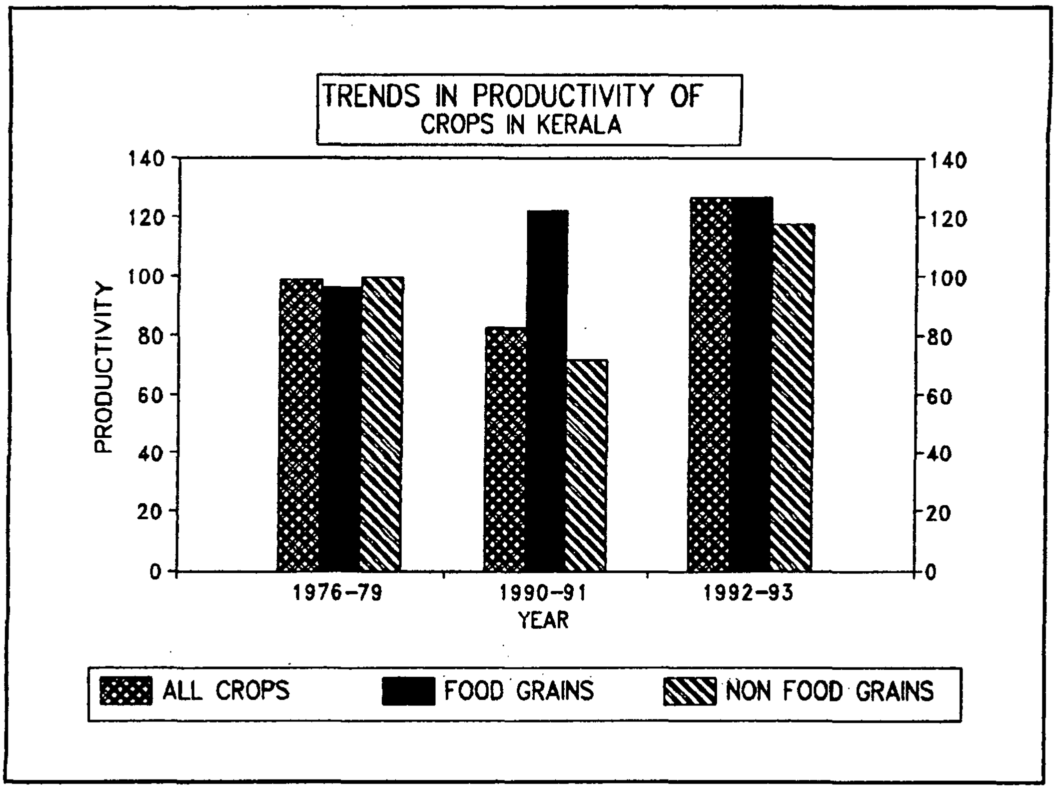


Figure 1.3



The overall productivity index has increased to 126.4 in 1992-93. The productivity index relating to food-grains presents a different picture witnessing spectacular increase from 96.22 for the triennium ending on 1978-79 to 126.77 in 1992-93. It appears that the cultivation of food-grains is getting stabilised in more productive areas. However, the productivity of non-food grains increased from 99.52 in 1976-79 to 117.6 in 1992-93.

Thus, it can be observed that the productivity of some crops (such as plantation crops) have improved. But the decline in the cropping area has contributed heavily to decline in the production of some crops. This can be offset only with the breakthrough in productivity.

1.4 Review of Studies on Agriculture in Kerala:

It is appropriate to look into various studies that have examined the nature and causes of the agricultural performance in Kerala. These studies are classified into macro studies (which deal with the sector as a whole), crop specific studies and studies deal with inputs,prices and wages.

Survey of Studies in Kerala's Agriculture

Table 1.2: Macro Studies

Study	Focus	Conclusions
Pillai (1983, 1991)	General	Declining trend in agricultural production
Sivanandan (1985)	General	"
Kannan & Pushpangadan (1988)	General	"

The declining trend in agricultural production of the state has been brought out by all the above studies. The pattern of agricultural growth in Kerala is generally explained as a fairly positive growth till the mid-seventies and deceleration since then.[Pillai,1983;Sivanandan,1985;Kannan and Pushpangadan,1988]

Table 1.3: Crop Specific Studies

Study	Focus	Conclusions
Panikar (1980)	Paddy	Area and production declined steady yield showed an increasing trend though marginal
Sivanandan (1985)	Paddy	"
George & Mukherjee (1986)	Paddy	"
Kannan & Pushpangadan (1988)	Paddy	"
George (1989)	Tapioca	Declining Growth under Area
Pushpangadan (1988)	Tapioca	"
Kannan(1983)	Cashew	Declining production in cashew.
Narayana & Nair (1989)	Coconut	Decline in Growth Production of Coconut due to real decline in yield
D. Narayana (1990)	Tree crops	Production Cycle Hypothesis

Among the crop specific studies, Pan|kar (1980) who examined the trend in area, production and yield of paddy in Kerala from 1960-61 to 1978-79 observed that the area under paddy and production in Kerala had declined steadily. The yield showed, an increasing trend, through it was marginal. This is confirmed in many other studies.[P.K.Sivanandan (1985), P.S.George and Chandan Mukherjee(1986) and K.P.Kannan and K.Pushpangadan(1988)]

Similarly, declining growth in area is found under tapioca. [George 1989, Pushpangadan 1988].

A study on the trends in area, production and productivity of coconuts in Kerala by Narayana and Nair (1989) concludes that the decline in growth of coconut could be due to a decline in yield.

However, in contrast to the studies noted above, Narayana [1990] rejects the stagnation thesis and argues that crop specificities mark the agricultural growth rate of Kerala. On the contrary, it is argued that any analysis of trends in the growth of agriculture should consider the crop specificities and the consequent production cycle. The study further adds that between the early seventies to the early eighties, area, production and productivity of different crops tended to stagnate or even decline. This should be identified as a down-swing phase of the agricultural production cycle that characterise the tree crop economy.

The point to be noted is that even if the production cycle hypothesis turns out to be true it does not diminish the significance of various other studies which indicate on the constraints of agricultural growth during the decade of 1970-80.

A probe into the factors that explain this pattern of growth is necessary, at least to a certain extent. In this context,it is relevant to look into studies that analyze various dimensions of growth in Kerala.

Table 1.4: Inputs

Study	Focus	Conclusions
Institutional Inputs		
Raj & Tharakan (1983)	Land reforms	Inspite of effective land reforms, there has been no perceptible improvement in productivity.
Kannan & Pushpangadan (1988)	Land reforms	"
Narayana & Nair (1983)	Irrigation	Contribution of irrigation on yield of rice is marginal
Joseph C.J. (1984)	Irrigation	Minor irrigation has helped rice farmers to improve the productivity.
Kannan & Pushpangadan (1984)	Irrigation	No meaningful correlation between irrigation and productivity.
Pillai (1983)	Irrigation	Irrigation has not contributed substantially to productivity improvement.
Technological Inputs		
George (1991)	Fertilizer	Fertilizer use and size of holding were the major determinants of yield.
Pillai (1993)	Fertiliser	agricultural productivity has been subject to wide yearly fluctuations and never significantly influenced by the fairly uniform and high rate of growth in fertiliser consumption.
Panikar(1993)	HYV	Actual yield of HYV is lower than potential yield.

Kerala has the distinction of having introduced effective land reform measures in the country. Although this has removed the major institutional constraints, there has been no perceptible improvement in productivity and growth of different crops.[Kannan and Pushpangadan (1988), Raj and Tharakan (1983)]

The role played by technological progress in the agriculture sector could be examined in terms of the contribution of irrigation, fertilisers or pesticides, HYV, the use of modern agricultural implements like tractors etc.

A study by Joseph C.J (1984) concludes that minor irrigation has helped rice farmers to improve the productivity in rice cultivation. However no other studies are available to prove this conclusion. Narayana and Nair [1983] have analysed the impact of irrigation in establishing and improving the productivity of rice cultivation. They found that the contribution of irrigation in this regard was only marginal. This clearly points to poor water management. Kannan and Pushpangadan (1988) shows that there exists no meaningful correlation between irrigation and productivity in these statistical analysis.

The study by Mary George (1991) suggested that fertiliser use and size of holding were the two major determinants of yield of paddy in state. P.P.Pillai (1993) reports that agricultural productivity has been subject to wide yearly fluctuations and has never been significantly influenced by the fairly uniform and high rate of growth in fertiliser consumption.

Kerala has witnessed a slow growth in mechanisation of agriculture (Pillai, 1990). Wooden ploughs have been replaced by new ploughs and carts have been replaced by tractors. Oil engine and electric pumps have become widespread over the period.

A study by Paniker (1980) shows that the potential yield of HYV's varies notably from the actual yield of HYV's in the States of Palghat and Kuttanad.

Table 1.5: Price Factors

Study	Focus	Conclusions
Pillai (1992)	Agr. Price & Wages	Wages of agricultural labour increased much faster than prices leading to unprofitability of cultivation.
Ramachandran Nair (1992)	Agr.price & Wages	"
Nataraj(1982)	Agri. Prices & Wages	"
Jose (1974)	Agri.prices & Wages	In five states including Kerala,wages rose faster than prices.
Bardhan (1973)	Agri.Wages	Real wages rose faster in Kerala compared to Punjab.
George (1980)	Agri Wages	Growth of wages led to unprofitability in cultivation
Geemol Unni (1983)	Agri.wages	
Panikar (1983)	Agri.Wages	Relatively higher rate of increase in wage rate of labour led to low profitability of paddy.
Kannan & Pushpangadan (1988)	Agri. Wages	Real Wages rose faster than labour productivity

While examining the factors that influence agricultural growth, it is useful to examine the movement of prices and wages. This is particularly useful in the context of Kerala, which had witnessed a transition in respect of crop cultivation.

An analysis of the movements of agricultural prices and wages by P.P.Pillai, (1992) reveals that the wages of agricultural labour increased much faster than the prices of agricultural commodities. This led to unprofitability in cultivation. Other studies also support the view that strong labour movements and unionisation of workers have succeeded in pushing up money wages, and this could have accounted for unprofitability of cultivation (Ramachandran Nair, 1982: Natraj,1982: Paniker,1980: Bardhan,1973: Jose,1974: George,1980:Geemol Unni,1983:Kannan and Pushpangadan,1988).

1.5: Paddy and the Role of HYV

Despite an improvement in yield,paddy production in Kerala has been showing a declining trend since the mid-seventies. [5] Even though the trend towards a shift in area under low value paddy crop to high value commercial crops is justifiable from the profitability angle,it has certainly an adverse impact on employment opportunities, income distribution and per capita consumption of food. As an institutional innovation, group farming was introduced in Kerala in this context. This is expected to avoid the diseconomies of scale arising out of small holdings. It helps in reduction of cost of cultivation due to combined operations and thus increase profitability. It also facilitates technological diffusion into the paddy sector (Govt. of Kerala, 1989).

The following table shows the decline in growth rate of yield of paddy in Kerala compared to all the other states of India.

Table 1.6 : Comparison of Yield of Paddy Among States: 1972-73 to 90-91 (Triennial ended) Kg/hect CARG %

State	70-73	80-83	88-91	70-91
Andra Pradesh	794	1217	1604	3.98
Assam	987	1040	1633	.77
Bihar	882	901	1270	2.05
Gujarat	744	1002	1064	2.01
Haryana	1137	1553	2342	4.1
Himachal Pradesh	1144	1244	1511	1.56
Jammu & Kashmir	1225	1523	1489	1.09
Karnataka	815	893	962	.93
Kerala	**1491**	**1605**	**1784**	**1.00**
Madhya Pradesh	652	703	924	1.96
Maharastra	377	705	844	4.58
Orissa	893	798	1048	1.42
Punjab	1936	2651	3318	3.04
Rajasthan	537	576	811	2.32
Tamil Nadu	1352	1391	1858	1.78
Uttar Pradesh	950	1248	1704	3.3
West Bengal	1203	1167	1803	2.27
All-India	848	1030	1354	2.64

Source: CMIE, 1993.

The table clearly shows that the Compounded Annual Growth Rate (CARG) of the yield of paddy in Kerala is the very low (1.00) compared to the other states and the All- India average.

Thus, the agricultural scenario in the state of Kerala needs to be examined at close quarters. It is also necessary to see the yield of HYV, which produced dramatic increases in the era of green revolution elsewhere. The details for all the three seasons viz.virippu(autumn), mundakan (winter) punja(summer) and total crop are furnished below.

Table 1.7 gives the season wise coverage of area under Hyv in Kerala for the period 1969-70 to 1992-93.

Table 1.7 : Season Wise and Total Coverage of Area under paddy in Kerala (1969-70 to 1992-93)

YEAR	AREA UNDER HYV IN (00ha)			
	VIRRIPU	MUNDAKAN	PUNJA	TOTAL
1969-70	398	492	465	1361
1972-73	942	580	600	2093
1975-76	985	621	693	2301
1979-80	1425	845	5511	2872
1982-83	1130	518	314	1963
1985-86	837	486	388	1632
1989-90	789	369	397	1556
1992-93	780	454	515	1750

Source:Statistics For Planning, various issues
Economic Review, Various issues.

The percentage of area under virippu and mundakan has declined while the area under punja and total area under HYV has increased marginally. This is intriguing in the context of increasing productivity of yield of paddy in Kerala which is shown below(table 1.8).

Table 1.8: Season Wise and Total Yield of Paddy in Kerala (1972-73 to 1992-93)

YEAR	YIELD UNDER HYV IN (kg/ha)			
	VIRRIPU	MUNDAKAN	PUNJA	TOTAL
1969-70	1549	1603	2220	1798
1972-73	1537	2035	2124	1836
1975-76	1872	1593	2039	1817
1979-80	2277	1998	2142	2167
1982-83	2250	2073	2144	2186
1985-86	1877	2054	2638	2102
1989-90	2014	2314	2533	2218

Source:Statistics For Planning, various issues
Economic Review, Various issues.

Thus, sustained agricultural development requires much more than just of physical inputs like seeds, fertilisers, modern implements etc. An effective explanation for agricultural development of any region is in terms of inputs and technology which is endogenous to the process of development itself. This would clearly show why the same technology or input might meet with differential successes in different countries or regions. So, the basic question one has to answer in dealing with the generation and adoption of technological change is how far such changes are consistent with the physical endowment of the given region. However, no single formula can be applied for agricultural growth and development for countries with varying natural resources and other endowments. This realisation formed the basis for induced innovation model developed by Hayami and Ruttan (1971) for agricultural development in which"technological change is treated as endogenous in the development process rather than as exogenous factors that operates independently of other development process".

This model was stimulated by historical evidence that different countries had followed alternative paths of technical change in the process of agricultural development and exists wide productivity differentials among countries [Ruttan 1981]. This could form a basis on which an appropriate technical, organisational and institutional innovation strategy could be designed.

Growth in agricultural production stems mainly from two sources, increased use of inputs such as land, fertiliser and water and productivity growth or growth in product per unit of input

[Bloom and Evenson 1991]. In regions like Kerala where the options for low cost expansion of cropped area have largely been exhausted, output growth mostly comes from the second source- productivity growth. Therefore, what is important is to examine the nature and working of institution that lie behind the generation and management of agricultural technology. Significant contributions have been made in such a theoretical framework which incorporates the mechanism of both technological as well as institutional innovation. (Arndt et.al,1977: Binswanger & Ruttan,1975).

This study attempts to trace the institutional and technological development in Kerala's agriculture and to examine how far this can serve as a satisfactory explanation for the agricultural development of the state. The basic objective of this study is to examine the extent to which agricultural development in Kerala has been affected by the institutional framework for appropriate technology generation and diffusion.

1.7: Objectives of the Study

(i) To evaluate the economic impact due to technical innovations in Kerala's agriculture.

(ii) To examine the dynamics in generation of agricultural innovations in Kerala.

(iii)To study the spatial diffusion of agricultural innovations in Kerala and to examine the variables affecting technology adoption at the local level.

1.8: Limitations of the Study

However, the study is not free of limitations. Much limitations were encountered with the data. This is because, the methodology varied over the period under reference. Since biological technology is an input which needs other complementary inputs in order to be effectively operational, this study must be substantiated with studies in this regard.

1.9: Outline of the Study

The outline of the study is as follows:

Chapter 1 introduces the nature of the study, justification and lays down the objectives and limitations of the study.

Chapter 2 deals with the review of literature along with the methodology and data base of the study. Chapter 3 while attempting a quantitative exercise to measure the technical change in Kerala, brings out the organisation and performance of the agricultural research system in Kerala which is responsible for the generation of technical innovations in the light of its agricultural development. Chapter 4 deals with diffusion of High Yielding Varieties of paddy in Kerala, as a case of biological innovation to test the rate of diffusion and capture the factors that affect the adoption of technology at the local level. Chapter 5 deals with the summary and conclusions.

N O T E S

1. It is to be noted that these forms of technology are not mutually exclusive but complementary to each other.

2. Following Hicks, technical change is neutral if the introduction of new technology does not access the ratio of Marginal Physical Product. Mechanical innovation being a substitute for labour in production, decreases land and labour ratio and increases labour productivity. A change in chemical technology is mainly of land saving nature. On the other hand, biological technology does not affect labour and land ratio. it is per se neutral in land requirement. Thus, the options for productive growth through mechanical technology e.g tractors are limited by the small size of holdings.

3. Charles Darwin make this point forcefully in origin of species by noting that natural process of evolution resulted in numbers of differential types of plants and animals, each with a comparative advantage in an environmental "niche" is discussed in economy.

4. Most countries have developed a system of national and regional experiment stations. Englander is one of the few economists to analyze this element of research system design.

5. We notice, however, a significant change in the trend in area, production and yield after 1989-90. This is attributed to the effect of group farming introduced in 1989. It is possible that this change is also contributed by the developmental efforts of the State as a part of its policy.

CHAPTER II

THEORETICAL FRAMEWORK AND METHODOLOGY

2.1: Introduction

Any attempt to evolve a meaningful perspective on the process of agricultural development must abandon the view of agriculture in pre-modern or traditional societies as essentially static. Historically, the problem of agricultural development is not that of transforming a static agricultural sector into a modern dynamic sector, but of accelerating the rate of agricultural output productivity and technology consistent with the growth of other sectors of a modern economy [Ruttan 1988). So, any theory on agricultural development should provide insight into the dynamics of agricultural growth,that is, into the changing sources of growth.

2.2: Agriculture Models

The studies on agricultural development can be organised in tune with several general models which attempt to explain agricultural growth. But the relevance of these models in the context of the issues of concern raised in Kerala's agriculture is yet to be examined.(as explained in Chapter I)

The emerging agricultural scenario in Kerala is confronted with a number of technological, social and economic problems warranting a critical review of the inter-crop priorities in the allocation of land, water and budgetary resources. Therefore the most important component of any strategy for the agricultural development of Kerala is to make technical change as the main source of growth [Kannan and Pushpangadan, 1988]. Such a strategy can be drawn from the historical experiences of industrialised countries.

Based on a comprehensive survey on agricultural models by Hayami & Ruttan (1971) and Ruttan (1981) a general classification is made and given below.

The **frontier model** has little application in the Kerala context as it emphasises on area expansion as the source of growth, since net area sown is fixed in Kerala. In the **urban-industrial impact model**, higher labour productivity in agriculture is due to the effective factor and product markets as a result of the rapid urban industrial development, as in the case of US and Germany. This is not applicable to regions of less developed countries. The lessons from the **conservation model** is the need to preserve the stock and improve the quality and utilisation of environmental resources such as soil, water and forests. The **diffusion model** is based on the assumption that the productivity differences among the farmers and regions should be narrowed down through effective extension services. This model, however failed to generate the expected modernisation of the traditional agriculture due to the unavailability of appropriate technology adapted to the needs of the developing countries.

In the **high pay-off input model** Schultz (1964) offers significant insight into the role of research in opening up new opportunities of productivity and employment growth.

19

The key to transforming traditional agricultural sector into a productive source of economic growth and employment generation is possible through providing high-pay off inputs to farmers in developing countries where agriculture experiences low return. This model,citing examples from Java, Indonesia and Senapur in India demonstrates the view that the farmers in developing world are inefficient in resource allocation.[Schultz, 1964]

The enthusiasm for high pay off input model to translate into economic doctrine has been partly due to the proliferation of studies reporting high rates of return to public investment in agricultural research [Evenson & Kislev 1975, Scobie and Posada 1978 for Brazil, Ayer & Schultz 1972 for Mexico, Evenson & Flores 1978 for Columbia, Evenson 1975 for Philippines, and Evenson, Jha as well as Mohan, and Bal and Kahlon 1977 for India]. It was also due to the returns associated with modern inputs like seeds, fertilisers, effective soil and water management practices which led to rapid diffusion of these technical inputs and management practices to farmers in Asia, Africa etc.

However, the high-pay off input model remains incomplete as a theory of agricultural development. The mechanism by which resources are allocated among education, research are not fully incorporated into the model. It does not attempt to specify the processes by which input and product relationship induce investment in research in a direction consistent with a nation's particular resource endowments.

The limitations in the high pay off model led to develop a model of agricultural development in which technical change is treated as indigenous to the development process.

The Induced Innovation Model

The induced innovation perspective was stimulated by historical evidences that different countries had followed alternative paths of technical change in the process of agricultural development. Here, technical change is treated as endogenous to the development process, rather than as an exogenous factor that operates independently of development processes.

2.3: Alternative paths of technical development

In agriculture, two kinds of technology can be traced: mechanical technology or `labour saving' and biological technology or `land saving'. The primary effect of the adoption of mechanical technology is to facilitate the substitution of power and machinery for labour. Typically this results in a decline in labour use per unit of land area. The primary effect of the adoption of biological technology is to facilitate the substitution of labour for land. This may occur through high yield crop varieties, chemical fertilisers, husbandry practices, and management systems which permit an optimum yield response. Historically, there has been a close association between advances in output per unit of land area and in biological technology; and between advances in output per worker and in mechanical technology. These historical differences have given rise to the cross-sectional differences in productivity and factor use.

There is clear evidence that technology can be developed to facilitate the substitution of relatively abundant and cheap factors for relatively scarce and expensive factors of production. The constraints imposed on agriculture development by an inelastic supply of land in economies like Japan, Taiwan and China, been offset by the development of high yielding crop varieties designed to facilitate the substitution of fertilisers for land. Similarly, the constraints imposed by an inelastic supply of labour, in countries such as the United States, Canada and Australia, have been offset by technical advances leading to the substitution of animal and mechanical power for labour.

Experience of US And Japan

An examination of the historical experience of the United States and Japan illustrates the theory of induced technical innovation. In the United States it was primarily the progress of mechanisation, first using animal and later tractor motive power, which facilitated the expansion of agricultural production and productivity where as in Japan it was primarily the progress of biological technology such as varietal improvement leading. For example,increased yield response to higher levels of fertiliser application which permitted rapid growth in agricultural output in spite of severe constraints on the supply of land. These contrasting patterns of productivity growth and factor use can best be understood in terms of a process of dynamic adjustment to the changing relative factor prices.

In the United States, the long term rise in wage rates relative to the prices of land and machinery encouraged the substitution of land and power for labour. This substitution generally involved progress in the application of mechanical technology to agricultural production. The process was continued in the early part of this century till the introduction of tractor as the primary source of power. This has continued with the substitution of larger and more highly powered tractors and the development of self-propelled harvesting equipments.

In Japan the supply of land was inelastic and its prices rose relative to wages. Furthermore, due to continuous decline in the price of fertiliser relative to the price of land, advances in biological technology was created. Varietal improvement was directed, for example, towards the selection and breeding of more fertiliser responsive varieties of rice. The enormous changes in fertiliser input per hectare reflect not only the effect of the response by farmers to lower fertiliser prices but the development of rice varieties by the Japanese agricultural research system.

The effect of a rise in the price of fertiliser relative to the price of land or the price of labour relative to the price of machinery has been able to induce advances in biological and mechanical technology.[1]

The high levels of productivity achieved in advanced countries reflects high levels of technical development. The results of this productivity enhancement could be seen in most of the low productivity countries, only if there is investment in agricultural research to develop technologies, appropriate to the natural and institutional environments of the less developed regions [Ruttan 1988].

The history of agricultural innovation in Japan & US is consistent with the proposition that innovative efforts have been directed to save relatively scarce factors of production, to maintain compatibility of modern technology with its factor endowments. It is to be noted that economic policies directed to agricultural development played a major role in the process. The experience of these nations suggested that public sector investment is essential to test and diffuse the indigenous technology and evolve adaptive research. This clearly points to region specific research system along with integrated effects of the national research system.

> "Thus the capacity to develop and manage technology in a manner consistent with a nation's physical, human and cultural endowments is the single most important variable accounting for differences in agricultural productivity among nations" (Ruttan, 1987).

2.4: Importance of Research

In the early twentieth century on realising that technical change was the crucial input for agricultural development, many national governments increased investments in research, education and extension. After the second world war, agricultural research was part of the budget in most countries. The latter half of the twentieth century witnessed rapid growth of government investment in agricultural research (Ruttan, 1987).

The first break through in agricultural technology was the High Yielding Varietie's (HYV) of wheat developed by Centre for Development of Maize and Wheat (CIMMYT) at Mexico in the 1950's. Later, agricultural technology was initiated by institutions like International Rice Research Institute(IRRI),Indian Agriculture Research council (IARC) and Consultative Group on International Agriculture Research (CGIAR). It was realised by the 1970's that the ability to take advantage of new technology generated by international research centers is dependent on the development of national research and extension capacity. Mohan, Evenson and Jha (1977) brought out the importance of indigenous research system in the adaptation of the new varieties of wheat that marked the green revolution. But the case of rice was a failure from the technological point of view, due to the abscence of adequate research system to the cater the crop specificities of rice.

Some studies that prescribe policies for more investment and innovation supportive policies are also to be considered.[Evenson & Jha 1977, Shultze 1964, Hayami & Ruttan 1971, Akimo & Hayami 1974, Ruttan & Mellor 1975].

2.5: Diffusion of Agricultural Innovation

It is necessary to understand the responses of the modern agricultural research institutes to the institutional and physical environment [Blase & Pahlson 1977; de Janvry 1977; Ruttan 1978]. The most important and visible output of an experiment station or a research laboratory is the information - in the form of new knowledge or new technology - that is generated and released.[2]2 In some fields, plant breeding for example, the new technology may be embodied in high yielding or pest resistant crop varieties. In other fields, the knowledge may be embodied in published reports on farm management, cropping practices etc. The result of new technology which led to the green revolution has produced dramatic increases in grain production. At a more fundamental level, there has been a close interaction between institutional and technical change in both the generation and diffusion of this new cereals technology. The theory of induced innovation implies a dynamic and dialectical interaction between technical and institutional change. The green revolution experience is an organising theme to illustrate the interrelated complex nature of institutional and technical changes as implied in the theory of induced innovations (Ruttan & Binswanger).

The estimation of returns in the research investment is based on the fact that investment in research activity, enters into the agricultural production process as technology (in measurable quantity such as seeds) and improves the agricultural productivity. This is pursued in studies like Griliches (1958,1964), Peterson (1964), Ayer and Schuh (1972), Evenson (1967). Evenson & Kisler (1975) measured research output as number of publications and they call for higher investment by the government.

The impact of any new technology cannot be assessed independent of the patterns of the diffusion process.This is because an economy is not affected in any material way by a new technology, until the use of that technology is widespread [Stoneman 1983]. More than that, the nature of the impact will depend upon the pace and pattern of its widespread use. In general, according to the adoption perspective,[3] the important factors determining the rate of diffusion are linked to the relative profitability and the investment- the more profitable the innovation and smaller the investment will lead to high rate of diffusion.

The Economic history perspective[4] emphasises the changes that can be brought out through local adaptation and improvement. The diffusion process is characterised by a continuity in innovation-diffusion interaction in the sense that the diffusion requires the development of the capability to acquire, adapt, improve and produce technology consistent with the local conditions. The time path involved in the diffusion process depends upon the nature of the new technology and its novelty,complexity and profitability. This also highlights the symbiotic relationship between technological change and its institutional context and emphasises the need for considering both together (Rosenberg 1985). Combining some complementary features and constraints in terms of relative profitability and investment cost emphasised in adoption perspective is complement with economic history perspective. Similarly, the emphasis on institutional rather than individual constraint of the market and infrastructure is complement with the economic history perspective. The supply and demand aspects of economic history perspective is complement with the market and infrastructure perspective. In such an integrated approach, following Stoneman one cannot investigate the spread of new technology without considering supply. It is necessary to put emphasis on the supply of technology and identify the institutional constraints as a major factor influencing the diffusion. So the innovation-diffusion is explicitly considered as well as the constraints in local adoptions, modifications and improvements to the technology both in terms of responses of farmer specific characteristics and institutional structure.

2.6: Technology in Agriculture

There exists a substantial body of literature both empirical and theoretical, that attempts to explain adoption of technology which leads to growth in agriculture.

Schultz (1964) contends that the `profitability criterion' is the key to transform traditional agriculture. His hypothesis therefore calls for an assessment of relative profitability of the new HYV technology compared to the traditional technology.

Authors have also advanced `structural' hypotheses to explain lack of technical progress in traditional agriculture. Bhaduri (1973) argues that the tenurial arrangements in semi-feudal mode may impede innovations by tenants.

Mention may also be made of Boserup's (1965) Population - based explanation and Raj's (1970) `dualism' hypothesis. Boserup cites population pressure as the most important factor determining technical change in agriculture. The author concedes, it could only be a `necessary' condition, since the producers may lack the resources or knowledge to carry out the technical change. Raj's dualism hypothesis on the state of technical conditions (especially improper water management) confined the growth of the HYV technology to a few "enclaves".

Risk Hypothesis

Lack of innovation is also sought to be explained by farmer's aversion to risk as in Lipton's (1968) survival logarithm hypothesis or in the safety first types of models formulated by Roumasset (1976) and Bell (1972). The adoption of HYV's may entail a subjective risk (ignorance) and objective risks (weather uncertainty, pest susceptibility). It is thus implied that only with the availability of physical inputs and the producer's receptivity,the institutional framework within which they operate holds a vital consideration in the study of the spatial diffusion of new technology.

2.7: Agricultural Research Institution in India

The Indian agricultural research system developed primarily in response to the commercial and military interests of the colonial government. The agricultural college and research station at Coimbatore started as a model farm in 1868 to develop research and development on sugarcane. These varieties have since become an important genetic resource for many national sugarcane improvement programmes. Later, many research institutes were established in several parts of the country.

The constitutional changes in 1919 made agriculture a provincial subject. The Imperial Council on Agricultural Research was established to coordinate provincial agricultural research. An effort was made to develop a series of central commodity committees to promote research, development, extension and marketing of food crops.

The Indian Agricultural Research System has come a long and varied way since the formal beginning of Indian Council of Agricultural Research (National Commission on Agriculture, 1976). However, when agriculture was given a major thrust in the Five Year Plans during the sixties and various avenues were started to explore the possibilities for promoting agricultural research and education. This was substantiated with introduction of HYV's and thus importance of research was increasingly felt. In 1964, major changes were introduced in agricultural research promotion, coordination and direction through reorganisation of the Indian Council of Agricultural Research (ICAR) in accordance with the report of the Agricultural Research Review.

Objectives of ICAR

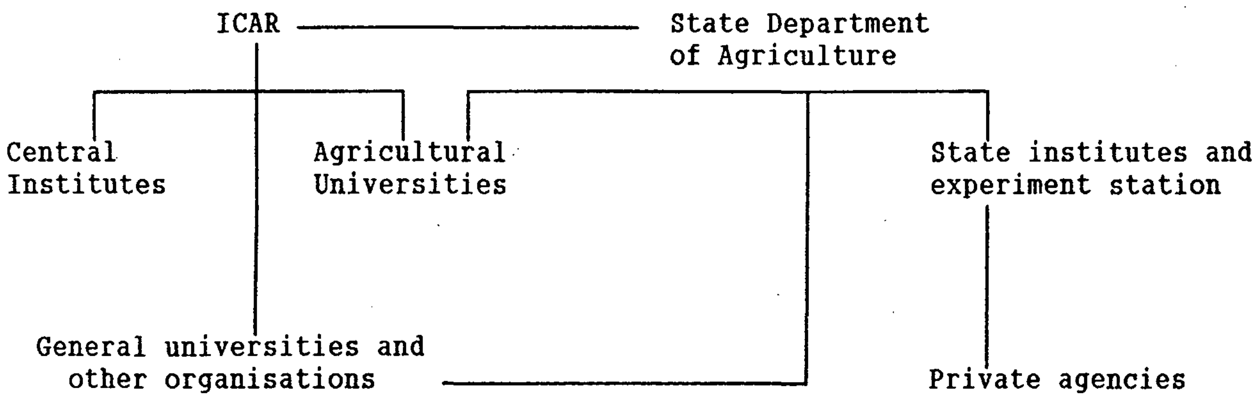
The ICAR has been set as an organisational model for agricultural research. The objectives of ICAR are as follows:

1. "to undertake, aid, promote and coordinate agricultural and animal husbandry education, research and its applications, development and marketing to increase scientific knowledge of the subjects and to secure its adoption in everyday practice".
2. "to act as a clearing house of information not only in regard to research but also in regard to agricultural and veterinary matters generally".
3. "to establish a research reference library with reading and writing rooms and to furnish the same with books, reviews, magazines, newspapers and other publications"; and
4. "to do all other things as the society may consider necessary, incidental or conducive to the attainment of the objectives".

Organisational Structure for Agricultural Research in India

The ICAR conducts its operation in agricultural research in the country through its control and linkages with a big network of research institutes, universities, state departments and other organisations. A schematic presentation of the different organisations engaged in agricultural research in India and how they are linked to each other is given below:

Fig 2·1 : Organisations engaged in agricultural research in India



Central Institutes

At present the ICAR has thirty three research institutions directly under its own control. There are ten institutes for specific crops, thirteen general institutes,three for animal sciences,four for fisheries and three for soils.

Agricultural Universities

The basic objective of the agricultural universities is to undertake state wide responsibility for agricultural education, research and extension, with a focus on needs of location specific agricultural research. There are twenty two universities in India which work under a dual funding system consisting of the ICAR and the state governments.

State Departments

The constitution of India gives to the states the basic responsibility for agricultural education, research and policy. The role of the ICAR, therefore may be considered as a measure of reinforcement of agricultural education and research collateral with the state's efforts.

The state departments of agriculture have traditionally been entrusted with agricultural research in their respective areas. The state departments assist agricultural universities which partly ensures the location specific character of the research. These departments also have research centers and farms under their own control.

Other Organisations

This category consists of some general universities, research institutes, crop specific institutes and centers of local, regional and national importance. These organisations receive support from the ICAR and state government in their research programm ranging from basic and fundamental to the applied and adaptive areas of agricultural research. It is to be noted that private research is yet to gain importance in India, like any other developing country.

All India Coordinated Research Projects (AICRIP)

The All India coordinated Research Projects were introduced to prevent isolated research and duplication or overlapping of research activities. This innovation was introduced in 1957 through the All India coordinated Maize Improvement Project initiated with the collaboration of Rockfeller foundation and the All India Coordinated Rice Improvement Project in 1965. Later, research programmes on rice at more than hundred centers around the country was brought under its purview. The AICRIP, according to National Commission on Agriculture, concentrates on problem oriented applied research.

2.8: Agricultural Research System in Kerala :

Agricultural research system may be viewed as a link between the socio-political and physical resource endowment on the one hand and the technological hand on the other. Institutions generating research tend to interact with technology in order to bring out meaningful change and growth.

In Kerala, agricultural research is largely funded by public sector. This is in tune with the widely acknowledged view of research is a public good [Schultz 1991]. The organisation structure of the agricultural research in the state consists of both national and state research.

State Research in Kerala

The Table 2.1 gives the various agricultural stations and the specific crop wise priorities of research details.

Research by state is undertaken mainly by the Department of Agriculture (DOA) and Kerala Agricultural University (KAU). Till early 70's agricultural research and experiments were undertaken by the Department of Agriculture alone. With the establishment of the Kerala Agricultural University at Thrissur (was set up at Mannuthy in 1971), the State has started its indirect involvement in research through statutory grant. Several stations are located in the various agro-climatic zones of the state for specific crops.

Table:2.1 Organisation and Purpose of Research

Organisation		Purpose
Department of Agriculture	*	Crops : Rice, coconut, pepper, ginger, turmeric, nutmeg, clove, cashes, arecanut, cocoa, fruits, vegetables, pulses, sesamum, groundnut, tubers.
	*	Crop production schemes
	*	Supply of inputs and services
	*	Institutional measures like research, extension.
Kerala Agricultural University		
(a) Coconut Research Station Balaramapuram, Kumarakom, Nileswar and Pilicode		Coconut Mixed Farming
(b) Rice Research Station Vytilla, Kayamkulam, Moncompu & Pattambi.		Rice, Pulses, Mixed farming and Prawn culture
(c) Horticulture Station, Ambalavayal		All horticultural crops viz., Fruits and Vegetables
(d) Pepper Research Station		Pepper
(e) Banana, Pineapple Research Station, Kannara		Banana and Pineapple
(f) Cardamom Research Station, Pampadumpara		Cardamom
(g) Cashew Research Station Anakayam		Cashew
(h) Agroeconomic Station, Karamana, Chalakudy		Soil testing.

Source: Steering Committee Report on Agriculture in Kerala,1988.

Till 1982, the KAU was engaged in crop based research. When the NARP was introduced in the State, the monocrop research stations were reorganised into multi-disciplinary stations for the convenience of system oriented research. Under the NARP, a three tier research setup was established with Regional research stations, special stations and substations, for tackling location specific research.

National Research in Kerala is conducted through various boards viz., Coconut Board, Spices Board, Rubber Board and other ICAR institutes like National Seeds Corporation (NSC), Central Plantation Crop Research Institute (CPCRI), Central Tuber Crop Research Institute (CPCRI) etc.

Examining the organisation structure of agricultural research system in India, it is necessary to note that duplication of efforts and overlapping of activities are certain aspects that needs closer scrutiny. These issues will be taken up in the next chapter.

2.9: Methodology:

Measurement of Technical Change: A direct positive relationship between the productivity change and the rate of growth of output is empirically established in the literature on economic growth (Verdoon 1949, Kaldor 1960). Increased use of inputs, to a certain extent, allows the agricultural sector to move along the production surface. The use of modern inputs may also induce an upward shift in production function to the extent that a technological change is embodied in them. However, it has been long recognised that partial productivity measures, such as output per unit of individual inputs, are of limited use as indicators of real productivity change -- defined by a shift in the production function. The Total factor productivity (TFP) concept, which implies an index of output per unit of total factor inputs, measures these shifts in output, holding all inputs constant. Even though TFP has emerged as an alternative to overcome the limitations of Partial Factor Productivity (PFP) analysis, this is also subject to severe limitations.[5]

Another objection is that it is based on extreme supply side considerations. The analytical framework of TFP is based on the concept of production function which is defined as the technical relation ship between the quantity of output and inputs. A shift in production function is regarded as an increase in technical change. Following Solow's logic,[6] most of the studies used the terms Total Factor Productivity Growth(TFPG) and Technical Growth synonymously.

Various measures of TFPG have been developed, during the 1970's and 1980's by scholars like Kendrick (1961), Domar (1961), Solow (1957), Christensen, Jorgensen and Lau (1971, 1973) and Diwert(1976).

Solow interprets TFPG "as the rate of shift in production function under the assumption of Hicks neutrality of technical change, it is called as disembodied technical change, a short hand expression for any kind of shift in production function. However, Solow (1960) admitted in his paper that the time shift in production function was a confession of ignorance, rather than a claim of knowledge under the restrictive assumption of constant returns to scale, unitary elasticity of substitution and Hicks neutrality of technical change. Solow pioneered the divisia index approach while Diewart was the first to demonstrate the properties of Tornqvist and other index numbers as exact for flexible forms. Christensen, Jorgensen,and Lau (1971,1973) developed a measure of TFP by specifying explicitly the translog production function. This form provides a second order approximation to an arbitrary twice continuously differentiable production function and also accomodates elasticity of substitution varying from 0 - α. In fact, this is a discrete approximation to continuous changes in the divisia index of TFP.

Translog index employs average of previous current period value share and gives weights according to factor inputs in the process of their aggregation, and it has several theoretical and empirical advantages based on more flexible form of production function and enables to decompose TFPG into technical change, scale effects, and other components. The divisia index is used in this study for computing the total output, total input, TFP and input price and quantity indices. The period of analysis is from 1960-92 with 1960 as base year. Inputs included in the input index are land, labour, fertilisers, farm machinery and energy.

Rate of Technical change and TFP

TFP is the ratio of output to an input. Let the index of inputs be denoted as X and output as Y.

Then, TFP = Y/X (2.1)

Differentiating both sides of the equation (1) given above logarithimicaly with repect to time gives,

$\dot{TFP} = \dot{Y} - \dot{X}$ (2.2)

where $\dot{Y} = d\ln Y/dt$, $\dot{TFP} = d\ln TFP/dt$, $\dot{X} = d\ln x/dt$.

To make this equation operational, we must specify a form for the time rate of change of aggregate input ie. $\dot{X}$.

Consider first, the index derived taking the cost share weighted average of the time rates of change of individual inputs,

$$\dot{X} = \Sigma \ (wjxj/c)\dot{x}j \qquad (2.3).$$

This index for $\dot{X}$ is divisia input index that is based on cost shares. Thus, average product measures such as TFP can be meaningfully relate to technical change concept by an appropriate choice of inputs. TFP, thus obtained has three closely related interpretations: the average product of an aggregate input, measure of technical change, and an index of input effectiveness in producing output before and after technical change. But the main problem is that it is based on continuous concepts whereas most data are gathered at discrete intervals.

Operationally, TFPG is same as the difference between logarthimic output index and the logarthimic sum of quantity indices.

Sources of Growth —— A Decomposition Analysis:

The contribution of different factors of land, labour, fertiliser, energy, farm implements and technology to growth in output could be easily understood in an additive decomposition framework.

$$\dot{\text{TFPG}} = \dot{\text{Output}} - \dot{\text{input}}$$

Dividing both sides by output growth, we obtain

$$(\dot{\text{TFPG}}/\dot{\text{Output}}) = 1 - \dot{\text{input}}$$

The Diffusion Model

It appears that the proper specification of the dynamic process of technical change is the key to understanding such sequences in the major phases of growth in agriculture. We have tested a diffusion model in the agriculture, to measure the rate of diffusion.[7]

Technical progress, defined as the upward shifting of the aggregate production function, can be viewed according to the Schumpeterian tradition as the combined effect of two processes: invention and diffusion. We define St as the actual shift that should be realised by year T, if all the producers have accepted and efficiently practised all the best techniques currently available. The best techniques will continue to diffuse among the producers and, with the lapse of time, St will approach Ut.
we may specify the process as:

$$St+1-St = \lambda t\ (Ut-St),\ 0 \leq t \leq 1 \qquad (2.4)$$

where λ is the parameter that determines the rate of diffusion. The above equation implies that the actual shift in the aggregate production function is a certain proportion of the discrepancy between the actual and potential shifts in the previous period. if U and λ are constant, S will approach U. In the actual world however,these values are functions of non-conventional inputs, such as education and research, and will vary as technical,social and institutional conditions vary.
The model is defined as follows:

$$(\dot{Y}/Y)t = \alpha\ (\dot{U}/U)t + \beta\ (\dot{V}/V)t + \tau + \varepsilon 1 \qquad (2.5)$$

where, $(\dot{Y}/Y)t = Yt-(Yt-1)/Yt-1$

$(\dot{U}/U)t = Ut-(Ut-1)/Ut-1$

$(\dot{V}/V)t = Vt-(Vt-1)/Vt-1$

ε = error term; α,β and τ are parameters; Y = Total average HYV yield per unit hectare; U = Average of the highest 3 districts HYV yield per hectare V = Coefficient of variation of total average HYV yields per hectare.

The equation (2.5) is then estimated by Ordinary Lease Squares.

2.10: Data Base

The generation and diffusion of technical innovation in agriculture should be able to be effectively captured only on the basis of micro level results. Unfortunately, the data base of the State is not adequate for this purpose. This poses serious problems in the analysis.

The various Annual Budgets of the State collected from the Legislative library,the Annual Budgets of the Kerala Agricultural University (KAU) collected from the College of Horticulture, Thrissur and College of Agriculture,Vellayani, the various publications of the State Government, Planning board, Department of agriculture (DOA), Department of Economics and Statistics were used. For the diffusion exercise, the publications of the Monitoring and evaluation Department of the Department of Agriculture (DOA) on the block wise data on HYV, in Kerala was used. The zone wise Status report of the National Agricultural research Project (NARP) provided explanations for the diffusion exercise.

N O T E S

1. During the last two decades, as wage rates have risen rapidly in Japan, and land prices have risen in the United States, there has been a tendency for the pattern of technological change to converge. These responses to differences in resource endowments among countries and to changes in resource endowments over time by agricultural research institutions are similar.

2. Hayami and Ruttan distinguish between three phases of technology transfer. First, the phase of raw material transfer of new materials(e.g seeds) without any systematic local adaptation. The process takes place primarily as a result of `trial and error' by farmers. Second, the phase of design transfer during which exotic plant materials (in the form of design of formula) are subject to orderly tests. This phase corresponds to an early stage of publicly supported agricultural research. Third, the final phase of capacity transfer of scientific knowledge and capacity to produce locally adaptable technology.

3. This is dealt in detail by Brown.

4. Brown has made an elaborate analysis on the various perspectives of diffusion.

5. The measurement of TFP is based on the neo-classical theory of production function which rest on certain restrictive assumptions about behaviour of production unit, and properties of input and output variables.(Jorgensen and Griliches,1964)

6. Solow (1957) has conceptualised the shifts in production function or technical change as TFPG.

7. Following Hayami (1975) who tested the diffusion model in the Japanese agriculture.

CHAPTER III

TECHNICAL CHANGE AND RESEARCH IN AGRICULTURE

3.1:Introduction

In this chapter, an attempt has been made to evaluate and measure the rate of technical change in Kerala for the past three decades. It also aims to construct the case of Kerala's agricultural research system, in the context of its organisation and performance. In general,the chapter intends to examine how far the institutional and technological development can serve as a satisfactory explanation for the agricultural development of the state.

Section one deals with the measurement of technical change in Kerala, while section two deals with the trends in growth in research expenditure along with pattern and direction of research in Kerala. Section three deals with the analysis of resources among crops, disciplines, sources of finance,and expenditure pattern. Section four deals with the various innovative support programmes of the state.

SECTION-I

3.2: Agricultural Yield: A Partial Analysis

Based on the survey of the earlier studies (discussed in chapter one) that deal with the performance of Kerala's agriculture sector,we have identified the importance of technical inputs in the agricultural growth process.

Multiple Regression

We have done a multiple regression analysis of yield as the dependant variable and the independent variables as a composite index (FIH) of inputs such as HYV, irrigated area, fertilisers. and other variables such as farm machinery (IMPL) and research expenditure (AREX) and agricultural population (APOP). All the variables are expressed per hectare. We obtained the following results.

The equation is as follows:

$$Y = \alpha + \beta 1FIH + \beta 2REX + \beta 3\ APOP + \beta 4IMPL + \varepsilon \qquad (3.1)$$

where Y is yield per hectare, FIH is composite index, REX is the research expenditure, APOP is the agricultural population, and IMPL is the farm machinery. α and β are the coefficients, and ε is the error term. The results are given below.

Table 3.1: Dependent variable: Yield

Variables	B	SEB	BETA	T
AREX	10.72	7.69	0.18	1.274**
IMPL	0.0048	0.0018	0.04	0.33
FIH	0.0072	0.0021	0.17	2.83*
APOP	0.082	0.042	0.02	1.11**

* - 5% LEVEL OF SIGNIFICANCE
** - 10% LEVEL OF SIGNIFICANCE

R^2 =.61, DW=1.13, F=5.44
R^2 = .73, DW=2.05, F=6.99
[After AR(1)]

Here all the variables except agricultural implements are found to be significant. This shows that all these variables move together as complementary inputs. This insignificance of agricultural implements shows that rate of mechanisation is very low in Kerala. Due to lower R^2 of .61, we have done the regression taking auto regressive unit root one.

We have done an Input matrix of area under HYV, area under irrigation, and fertiliser consumption and farm implements. We have also added total agricultural research expenditure in this exercise.. The matrix is given below.

TABLE 3.2: Input Matrix

	HYVA	IRRA	FERT	IMPL	ARES
HYVA	1	0.13*	0.46*	-0.11	0.63**
IRRA	0.13*	1	0.11	-0.01	0.21
FERT	0.46*	0.11	1	0.24	0.82**
IMPL	-0.11	-0.01	-0.24	1	0.01
ARES	0.63*	0.21	0.82**	0.01	1

Level of significance: * 5 per cent level of significance
** 10 per cent level of significance

From this Input matrix, we have found that area under HYV and area under irrigation and fertiliser are significant at 5 per cent level. Fertiliser is correlated with agriculture research expenditure at 10 per cent level. Agriculture expenditure is correlated with area under HYV and fertiliser at 10 per cent level of significance. However, the values of farm machinery is insignificant. We next proceed on to a total analysis that is, to calculate the Total Factor Productivity to measure the technical change. The period of analysis is from 1960 to 1992.

Rate of Technical Change and TFP:

The estimated values of TFP and TFPG which measure the rate of technical change calculated as per the exercise described in chapter two are given below:

Table 3.3: Estimated Values of TFP and TFPG
Base Year 1980

YEAR	TFP	TFPG
1961	1.03	100.25
1962	0.89	100.37
1963	0.85	100.50
1964	0.92	98.75
1965	0.72	85.51
1966	0.68	70.04
1967	0.59	70.13
1968	0.48	30.12
1969	0.40	28.80
1970	0.50	40.10
1971	0.15	42.15
1972	0.17	40.96
1973	0.14	48.03
1974	0.11	62.06
1975	0.12	60.28
1976	0.12	67.25
1977	0.07	64.54
1978	0.13	60.20
1979	0.14	68.90
1980	0.13	73.71
1981	0.11	71.67
1982	0.13	41.31
1983	0.14	62.86
1984	0.16	78.21
1985	0.09	71.92
1986	0.11	99.81
1987	0.09	99.02
1988	0.08	112.65
1989	0.06	155.28
1990	0.07	166.75
1991	0.07	154.52
1992	0.09	155.88

From the TFPG column, we can see the increase of 55.63 per cent during the period 1961-1992. This shows an average of 1.79 per cent growth in agricultural output of the state. The price and quantity indices of the inputs and output is given in the appendix tables 3.1 and 3.2.

Sources of Growth --- A Decomposition Analysis

The contribution of different factors like land, labour, fertiliser, energy, farm implements and technology to growth in output could be easily understood in an additive decomposition framework described in chapter 2. The results of the exercise is given below.

Table 3.4: Sources of total factor productivity growth in agriculture output and annual growth rate (1961-92)

	Per cent share of TFPG explained	Annual growth rate(%)
LAND	12.05	3.00
LABOUR	16.95	1.51
FERTILISER	40.82	12.32
ENERGY	-1.42	-2.7
IMPLEMENTS	-1.81	-2.43
TECHNOLOGY	33.4	2.18

This table clearly shows the importance of technology in the dynamics of overall agricultural growth in Kerala. Technology and fertiliser (which is a proxy for embodied technology) contributes more than 74.23 per cent of overall agricultural growth. The contribution of land is marginal which shows that the land used for the cultivation is already under exhaustion. The negative contribution of farm implements and energy show the slow mechanisation in Kerala.

Thus, it can be inferred that there is slow rate of technical growth in Kerala which is contributed by fertiliser. So it is necessary to look into the systems in respect of its organisation and resources responsible for generating the agricultural technology in the state. This is done in the next section.

SECTION II

3.3: State wise Expansion of Allocation of Research Expenditure

The rational allocation of research funds among regions is considered a pre-requisite for successful and balanced generation and diffusion of technology in agriculture. A comparative state wise allocation is shown here. As the table shows, the annual growth rate of agriculture during 1960-61 to 1978-79 varied from 1.19 in Orissa to 8.10 in Punjab. It is important to note that the allocation of expenditure on research and education on agriculture during 1979-82 has very little relationship with the percentage contribution of the states to the national output. Out of the 14 states shown, seven have share of agricultural research funds exceeding their share in national agricultural output. Kerala with

Table 3.5: **Allocation of Research Expenditure and Agricultural Growth in States of India**

State	Percentage share of state in all India output [1960-61 to 1978-79)	Growth rate in agriculture output and education (%)	Share percentage of total expenditure on agriculture research
Andhra Pradesh	8.4	1.69	1.86
Bihar	7.7	1.92	3.42
Gujarat	3.3	3.56	8.74
Haryana	3.8	5.33	4.29
Karnataka	6.2	3.4	5.02
Kerala	1.2	1.39	6.82
Madhya Pradesh	10.0	1.67	5.63
Maharashtra	7.4	1.77	6.72
Orissa	4.8	1.19	5.15
Punjab	7.5	8.01	10.21
Rajasthan	6.0	2.97	4.36
Tamil Nadu	5.9	1.83	14.31
Uttar Pradesh	15.8	2.79	11.15
West Bengal	7.1	2.72	6.88

Source: Mukhopadhyay (1988).

the lowest share in the national agricultural output (1.2 per cent) had 6.82 per cent of research funds, while Uttar Pradesh with 15.8 per cent of country's output had only 11.15 per cent of the research funds. Moreover, studies on different states suggest that there is still a relative neglect of extension as compared to other activities (Table 3.6).

Table 3.6: Allocation to funds to Agricultural research, education and extension: selected states
(Millions of Rupees)

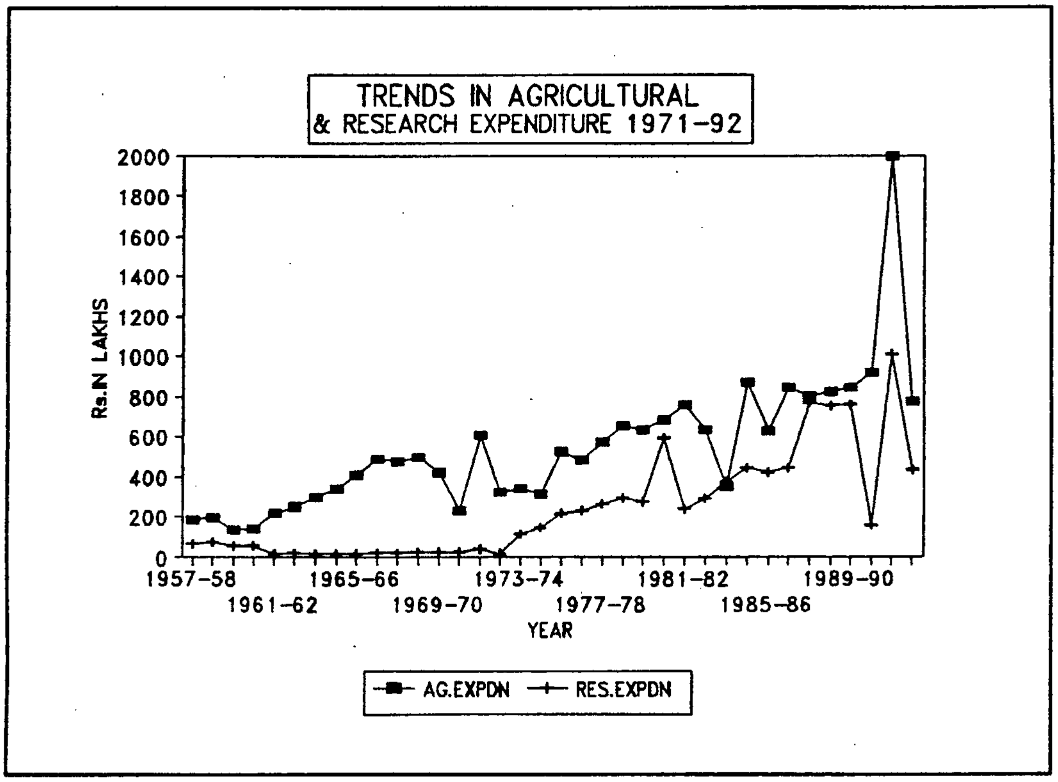
State		Research	Education & Administration	Extension
Gujarat	(1977-78)	36.39 (35.85)	53.92 (53.12)	11.20 (11.03)
Karnataka	(1978-79)	61.06 (21.51)	186.19 (65.59)	36.61 (12.90)
Madhya Pradesh	(1978-79)	25.83 (51.29)	23.71 (47.12)	0.76 (1.59)
Orissa	(1979-80)	17.78 (17.79)	82.16 (79.92)	2.85 (2.78)
Punjab	(1979-80)	45.03 (49.00)	41.82 (43.00)	7.26 (8.00)
Kerala	(1979-80)	39.12 (42.33)	42.01 (46.33)	11.02 (11.56)

Figures in parentheses denote percentages.
Source: 1) Mukhodhapay (1988)
2) Kerala Budget Document 1979-80.

Total Agricultural Expenditure, and Research Expenditure in Kerala:

The total agricultural expenditure has been increasing in Kerala. In 1957-58 the total amount spent on agriculture was Rs 187.8 lakhs which increased to Rs 77.26 lakhs in 1992-93. For the same period, expenditure on agricultural research increased from Rs 64.25 lakhs to Rs 176.75 lakhs. Thus, along with the total expenditure on agriculture, we can see a constant increase in the research expenditure (figure 3.1).

Figure 3.1



The increasing trend of research expenditure in the state, makes it imperative to look into the organisation and performance of the agricultural system in Kerala. This helps to analyse the dynamics behind the generation of Agricultural technology in the state.

3.4: Organisation and Management of the Agricultural Research System in Kerala

The decision making process in publicly funded agricultural research has received very little formal research attention. The actual workings of the decision making process is heavily influenced by organisation and management structures (Pinstrup, 1982).

In Kerala, agricultural research largely funded by public sector. This is because it is widely acknowledged that research is a public good [Schultz 1991]. The organisation structure of the agricultural research in Kerala consists of both national and state research (figure 3.2).

Fig:3.2 Organisation of Research in Kerala

State		National
Department of Agriculture undertakes research and extension in agriculture	KAU research stations [in each zone] Pattambi Kumarakom Ambalavayal Vellayani Pilicode	i)Ministry of commerce a)Coconut board b)Rubber boar c)Spices Board d)Coffee Board ii) ICAR a) Central Plantation Crop Research Institute(CPRI) b) Central Tuber Crop Research Institute(CTRI) c) National Seeds Corporatiom(NSC)

Source:i) Farm Information Bureau, Kerala
ii)KAU Budget Reports

It is evident that research is undertaken by bodies like National institutes (Ministry of Commerce), and ICAR institutions, as well as the Department of Agriculture (DOA) in the state and the Kerala Agricultural University(KAU). Figure 3.2 shows that all the three bodies undertake research on common crops like coconut, pepper, cardomom etc. This shows an overlapping of research activities in organisation and focus of the research institutes.

3.5: Nature and Magnitude of Agricultural Expenditure in Kerala

In order to examine how far the institutional framework has contributed to agricultural development, it is necessary to look into the allocation of budgetary resources into this sector.

Innovation is an investment problem,because it is a resource using activity leading to benefits which occurs over a period of years (Binswanger 1978).

The period under reference is from 1957-58 to 1992-93. To find out the growth rates of total agricultural expenditure, expenditure of state and University we have used an exponential fit growth model. The model is specified as below:

$$\text{Ln } Y = A + bT + \varepsilon_t \qquad (3.1)$$

where Y is the growth in research expenditure,

A is the constant, and

b is the coefficient of time.

Looking at the expenditure of the state on research, it was necessary to examine the further divisions of research, extension and education. The results are summarised in table 3.7.

Table 3.7: Growth Rates of Total Expenditure on Research, Extension & Education

	RES	EXT	EDU
STATE	8.27*	-7.38**	-11.6
KAU	2.96*	15.69	4.8*
TOTAL	11.72**	-9.6*	5.86**

* 5 per cent level of significance
**10 per cent level of significance

For the period 1957-92, the growth in the research expenditure by the State department is 8.27 per cent, while the growth rate in the research expenditure by the KAU is 2.96 per cent. Both the values are significant at 5 per cent level. The state department had accorded a high priority to research (which is discussed below) in this period. However, the number of observations is less for the KAU since it was established in 1971. The total research expenditure growth in the state is as high as 11.72, which is significant at five per cent level.

In the case of extension, the growth rate in the expenditure by the state department is -7.38 which is significant at 10 per cent level. The rate of growth in expenditure by KAU on extension expenditure is 15.69. But this is not significant either at five or ten per cent level. On the whole, the growth rate in extension for the state as a whole shows a dismal -9.6 which is significant at 5 per cent level. Thus, a sheer neglect of extension activities is distinct in the whole three and a half decades of agricultural development in Kerala.

At the education front, the total expenditure growth rate is 5.86 which is significant at 10 per cent level. Out of this, the growth rate of the state department has been -11.6 which,is not significant either at five or ten per cent level and that of KAU is 4.8 per cent significant at 5 per cent level. The, table shows that though the growth rates of research and education are positive,it is high in the case of research and negative in the case of extension. Thus, there is a clear bias in the priorities of the research bodies of the states. In general,the different organisational components of agricultural development viz.,research,extension and education is characterised by strong linkages and complementarities.

3.6: Direction and Pattern of Agriculture Research, Extension and Education in Kerala:

The reference period has three sub periods i.e. Period I from 1957-58 to 1970-71, Period II from 1971-72 to 1983-84 and Period III from 1984-85 to 1992-93. The logic of this classification is purely for two reasons i) to overcome the methodological problems and ii) KAU was established in 1971,so major chunk of research and education was shifted to the university from the state department which was hitherto conducting these activities.

In the first period, the total budgetary expenditure increased from Rs.187.86 lakhs in 1957-58 to Rs.469.33 lakhs in 1970-71. Out of this, agricultural research and experiments which formed the largest proportion that is 35 per cent of total outlay in 1957-58 fell to 5 per cent in 1970-71. The research activities in this period mainly concentrated on paddy, besides coconut and pepper. These activities included schemes for improved paddy, drought resistant paddy, rice research under the five year plan, demonstration of Japanese method of rice cultivation and involvement of rice specialists to look into the paddy cultivation.

Table 3.8: Proportion Of Allocation of Resources in the First Period(1957-71)

HEAD	% of Total Outlay	
	1957-58	1970-71
Agricultural Research and Experiments	34.21	5.11
Agricultural Demonstration and Propaganda	17.84	4.56
Agricultural Education	7.28	4.56

Source: Kerala Budget Documents: Various issues

The proportion of agricultural demonstration and propaganda which formed 17 per cent of total outlay in 1957-58 rose to 24 per cent in 1970-71. The activities under demonstration and propaganda include seed schemes, establishment of seed farm, production and distribution of improved paddy seeds, cultivation of paddy in forest and kayal lands, multiplication and distribution of HYV seeds, training of HYV farmers, and scheme for organising paddy development units. A clear priority to paddy development is shown here. Research activities under the five year plans included ICAR project on research on stack burn in rice, research schemes in rice stations etc.

The proportion of expenditure spent on agricultural education also fell from 7.27 per cent in 1957-58 to 4.5 per cent in 1970-71. Activities under agricultural education include expenditure on Agricultural college and research institute at Vellayani, Agricultural College farm etc.

Under the second period, the plan allocation on agriculture rose from Rs.151.89 lakhs in 1972-73 to Rs.540.87 in 1983-84. Out of this, expenditure on agricultural research formed only 2.7 per cent in 1972-73. This further fell to 1.7 per cent in 1983-84. This drastic fall could be explained in terms of two factors. The first is the shift to the priority to commercial crops. The proportion of expenditure on commercial crops rose from 13.84 per cent in 1972-73 to 69 per cent in 1983-84. Another reason could be that after the establishment of Kerala Agricultural University and other specific crop institutes and ICAR institution research activities were shifted to these institutions.

Table 3.9: Proportion of Resources in the Second Period (1970-71 to 1983-84)

(in per cent)

HEAD	% of total outlay	
	1975-76	1983-84
Research	20.59	1.19
Extension	3.08	1.54
Education	20.67	24.28
High Yielding Variety Program	2.14	1.4
Commercial Crop	13.01	26.16

Source: Same as table 3.5.

A clear shift in priorities in research activities can be seen from a closer examination on the magnitude and nature of research in Kerala during the second period. Research activities was mainly centered on development of coconut, ginger, oil palm, and soil testing. Paddy was totally ignored during this period.

In this period, expenditure on extension also fell from 17.2 per cent to 1.7 per cent on total agricultural outlay in 1983-84. The extension and farmer training activities include National Extension Services (NES) training of farmers in HYV, etc.

From the year 1971-72, statutory grant to KAU and contribution to ICAR, and NARP was allocated in the head under agricultural education, mainly under the non-plan. This rose from 1.39 per cent of total agricultural outlay in 1971-73 to 24.78 per cent in 1983-84.

Under this period, emphasis was given to HYV programme. This formed 15 per cent of total agricultural outlay in 1972-73 and fell to 0.5 per cent in 1983-84. The proportion of allocation on commercial crops was 14.35 per cent in 1972-73 but rose to 26.3 per cent in 1983-84. This indicates a shift in priorities from food crops to cash crops by the state department of agriculture.

In the third period, food grains was given a major thrust under the plan allocation. It formed .61 per cent of the total agricultural outlay, whereas the proportion of allocation on commercial crops fell to 2.4 per cent in 1990-91.

Under the programme of food grains, emphasis was given to activities like intensive rice cultivation, mini-kit establishment of paddy units, intensive rice development programme, intensive programme for paddy, introduction of group farming, development of kole lands and other problem zones, Intensive paddy development units etc. This is strikingly important when compared to the growth in productivity of food grains especially paddy which significantly increased in this period (Fig 1.3).

Table 3.10: Proportion of Resources in the Third period Percentage of total Outlay (in per cent)

HEAD	1987-88	1991-92
Research	5.2	29.6
Extension	0.8	0.8
HYV		
Food Grain	0.61	0.08
Commercial Crops	4.85	1.9

Source: Same as table 3.5.

From the third period onwards, research and education received separate allocation. Total research included research on crop husbandry and forestry. The total allocation on crop husbandry has increased from Rs.181.76 lakhs in 1984-85 to Rs.201 lakhs in 1992-93. But the research activities on coconut, oil palm and soil testing which constituted major part of the expenditure on crop husbandry continued as from the second period. The relevance of the state in undertaking these activities is a further issue of importance because these are the areas of prime importance in the various institutes of KAU, and even in National research institutes like coconut board.

The outlay on extension and farmer training increased marginally by 4 per cent in the second period. These activities included National Agricultural Extension Plan (NAEP), farmers' training etc. The effects of research, extension and education on agricultural development had been accepted in India as the basic principle of the agricultural universities [Mukhopadhyay 1988]. However in practice, stresses have often arises in the importance to these three areas. Agricultural research is found to be complementary with education in agriculture [Ruttan 1980]. So, it would be vital to have a strong educational programme in agricultural research. Similarly, research and technology generation provides the input for extension programmes which is essential for carrying the fruits of research to the community through the farmers.

A brief look at the research, extension and education of the KAU,the main research organisation in the State is significant here.

Table 3.11: Proportion of Expenditure on Research, Extension and Education by KAU (1971-92)

HEAD	Percentage of total outlay		
	1971-72	1981-82	1991-92
Research	32	36	34
Extension	9	9.8	11
Education	41	36	42

Source: KAU budget documents - various issues

The research activities include research on various crops,agricultural engineering,soil studies etc. Those on veterinary,forestry and fisheries are excluded. The various extension activities include training services, communication center, University press,farm advisory service etc. The expenditure on education involves agriculture college at Vellayani, Horticulture college at Vellanikkara.

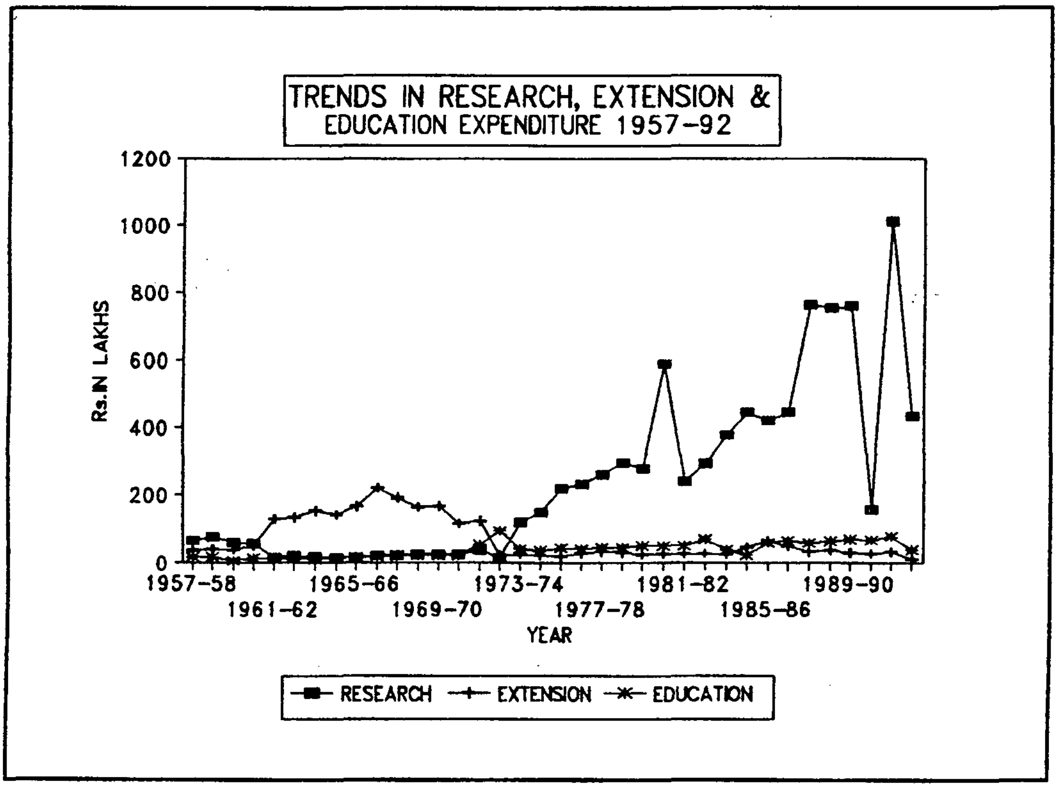
An analysis of the activities of both the State and the KAU shows the duplication of efforts in the case of crops and extension activities. The National Commission on Agriculture noted in 1983 that although there has been an understanding in India of the importance of all these three facets of agricultural development programmes, organisations and agencies often do vie with each other in taking up programmes irrespective of their functional jurisdiction.

Since overlap of functions tends to dissipate organisational responses, the institutes have a very important role to play in conducting adaptive research and undertaking extension programmes.

This must necessary done in close and continuous collaboration with agricultural universities and state departments of agriculture.

The trends in total research,extension and education expenditure in the state (Figure 3.3) shows the bias towards

Figure 3.3



research and neglect of extension. Upto 1973-74, extension expenditure was high which decreased significantly after that. This is a very unhealthy pattern in a developing country like India,because the fruits of research must be passed on to the farmers by a strong extension programe. The lab to land linkage must be effective. Thus, the observed institutional bias must be drawn to attention at the policy level.

SECTION-III

3.7: Analysis of expenditure among various components, crops, and disciplines

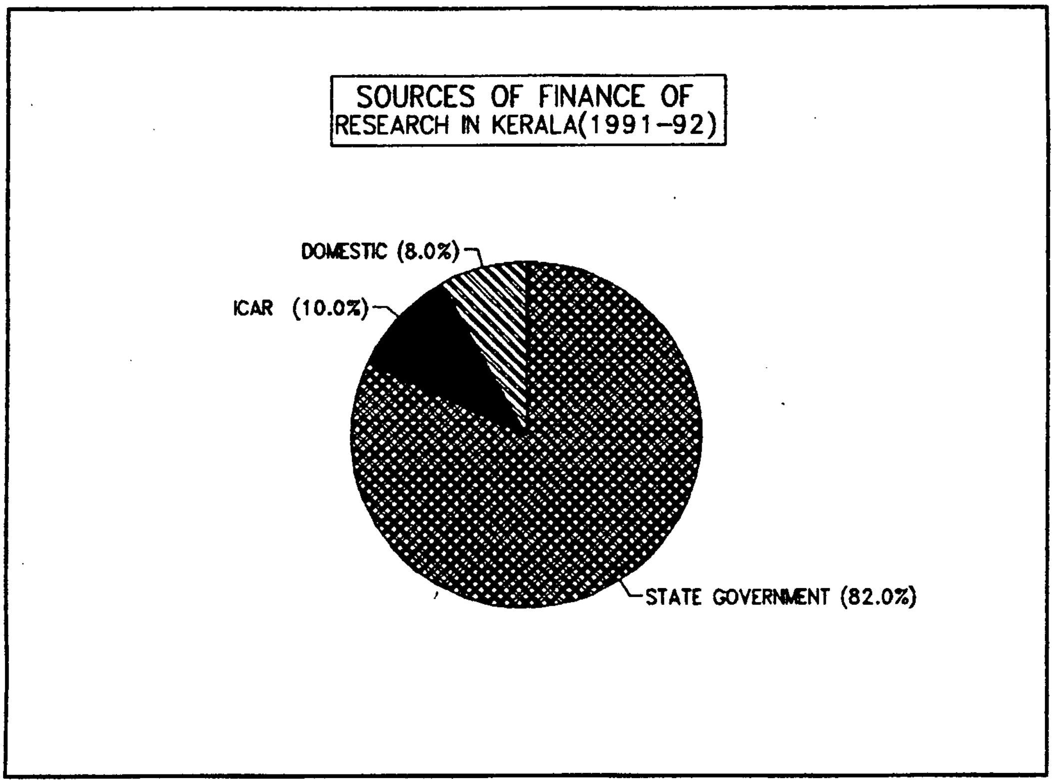
Any attempt to analyse the development of a research system should carefully review the sources and uses of research sources [Ruttan 1988].

Sources of Financing

The source of financing research and development is a very important issue. But it is a rather complex task as the institutions that generate the funds for research are not the same which perform the research. The details of sources of financing research in Kerala is given in fig 3.4.

Thus, the state government budgetary grant forms nearly eighty five per cent of total finance, while ICAR and other external agencies contributes ten per cent of total revenue, the domestic sources like income from fees, income from university property etc constitute eight per cent of total resources. Thus, it is most dependent on the state government for its funds as seen from the figure 3.4.

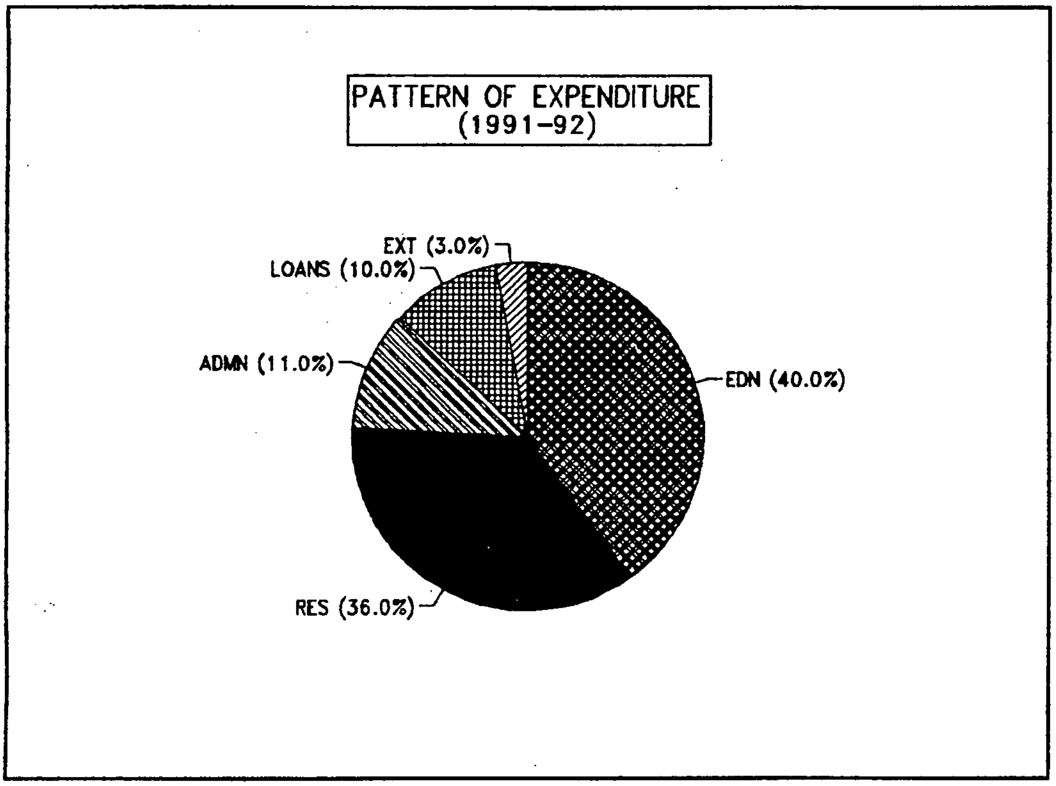
Figure 3.4



Expenditure Pattern

It is also essential to look into the use of the resource for any evaluation of research system. In Kerala, forty percent of the resources is spent on agricultural education, while thirty six per cent is spent on research. Eleven percent of resources is diverted to expenses on management and administration, ten percent on loans suspense, while only three percent is spent on extensions. This is depicted in Fig.3.5.

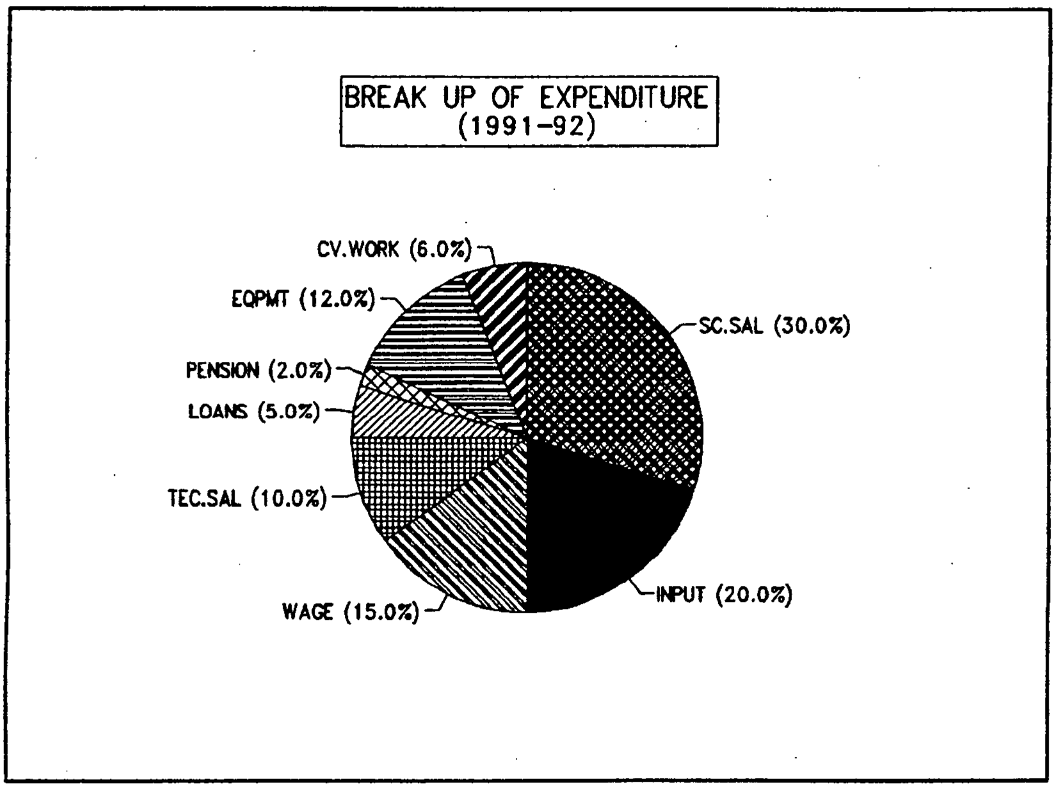
Figure 3.5



Break up of Expenditure

It is necessary to look into the sectoral break up of expenditure on agricultural research in Kerala. This is shown in the figure 3.6. The major proportion of the expenditure is spent on the scientists' salary. This amount works upto thirty per cent of the total expenditure. Next, twenty per cent of expenditure is spent on inputs for the research stations and colleges. This is in the form of seeds, fertilisers, implements, machines etc. Five per cent of the expenditure goes for loans and advances from the research organisation. Labour wages constitute fifteen per cent while civil work and farm development works up to six per cent. The salary of administrative, general staff along work, technical and supervisor's salary amounts to ten per cent each. Pension constitutes two per cent of the expenditure and equipment features working up to twelve per cent each.

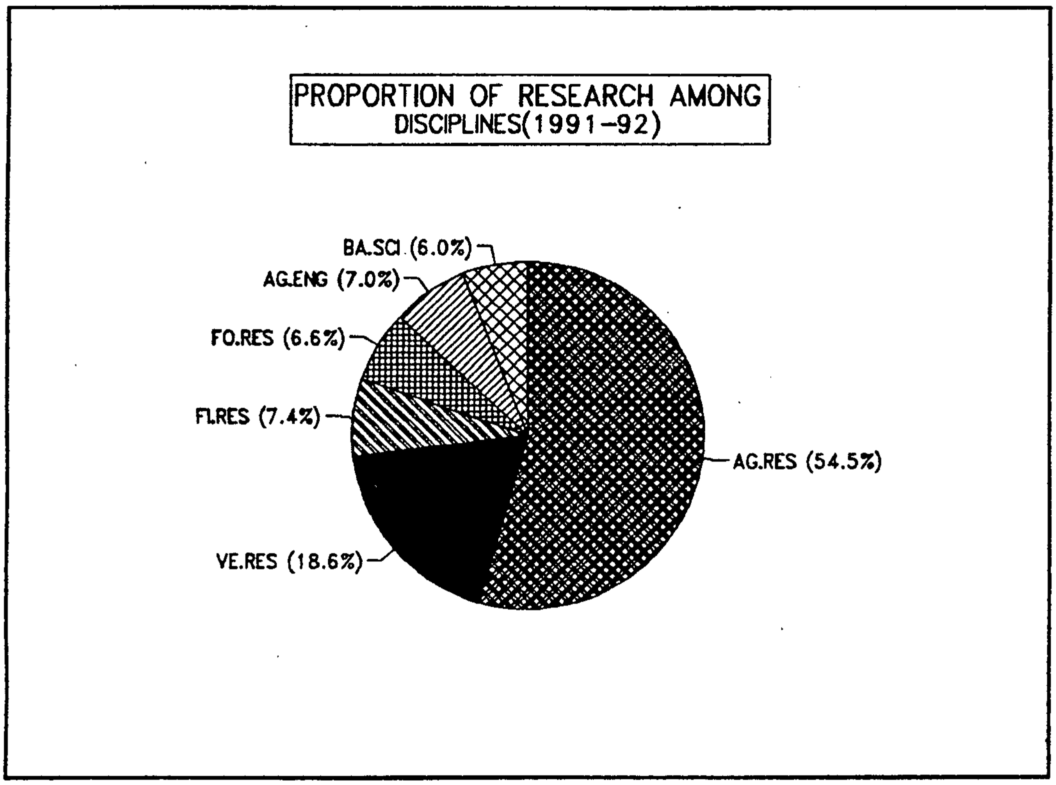
Figure 3.6



Research Allocation among Disciplines

Success in research for technological program in agriculture consistent with a given resource situation and dependent upon how far the pattern of research is optimal with respect to the various disciplines relevant for augmenting the resources of agricultural economy. There should be a consistency between research for technology generation on the one hand and technology diffusion on the other, that is, between soils and manure on land and agricultural engineering. This is seen in fig 3.7.

Figure 3.7

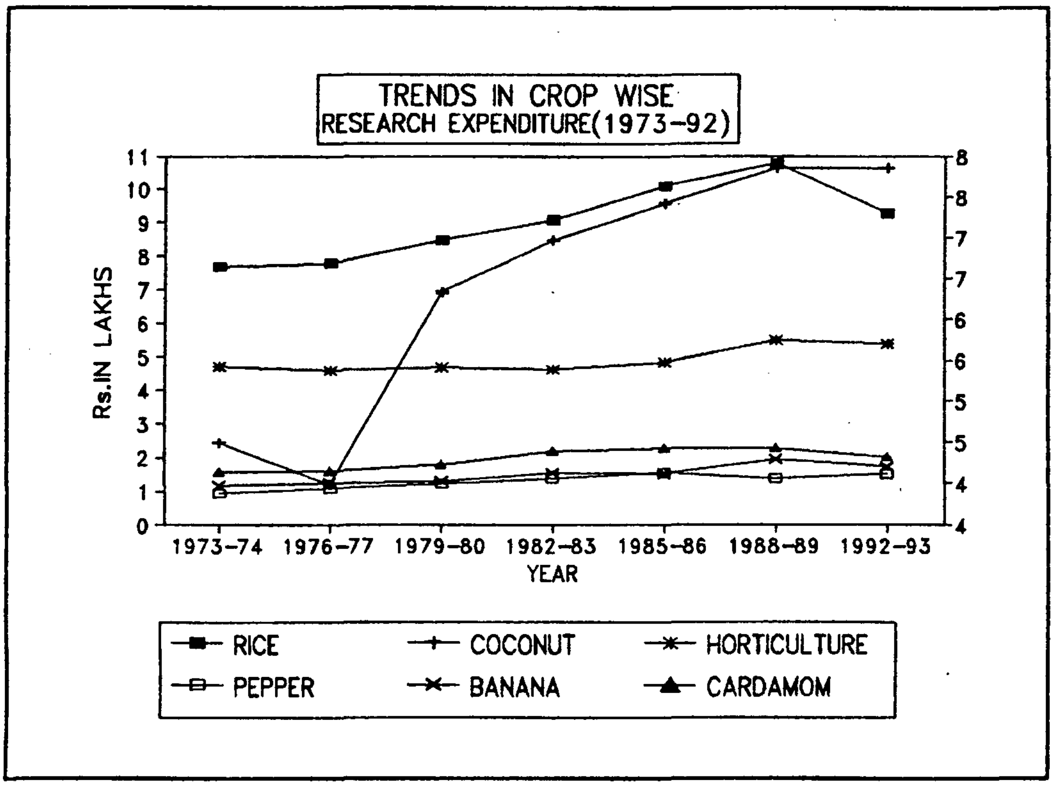


A major chunk of the expenditure is spent on research on agriculture, followed by veteinary, fisheries and forestry. A very low proportion is spent on agricultural engineering and basic sciences.

Research allocation among Crops

It has been observed that volume of agricultural research in Kerala has experienced a substantial increase over time. The volume alone does not speak adequately about the relevance of the type of research. It is necessary to look at crop wise allocation of research expenditure - this would point to the discrepancy between research priority and commodity importance.

Figure 3.8



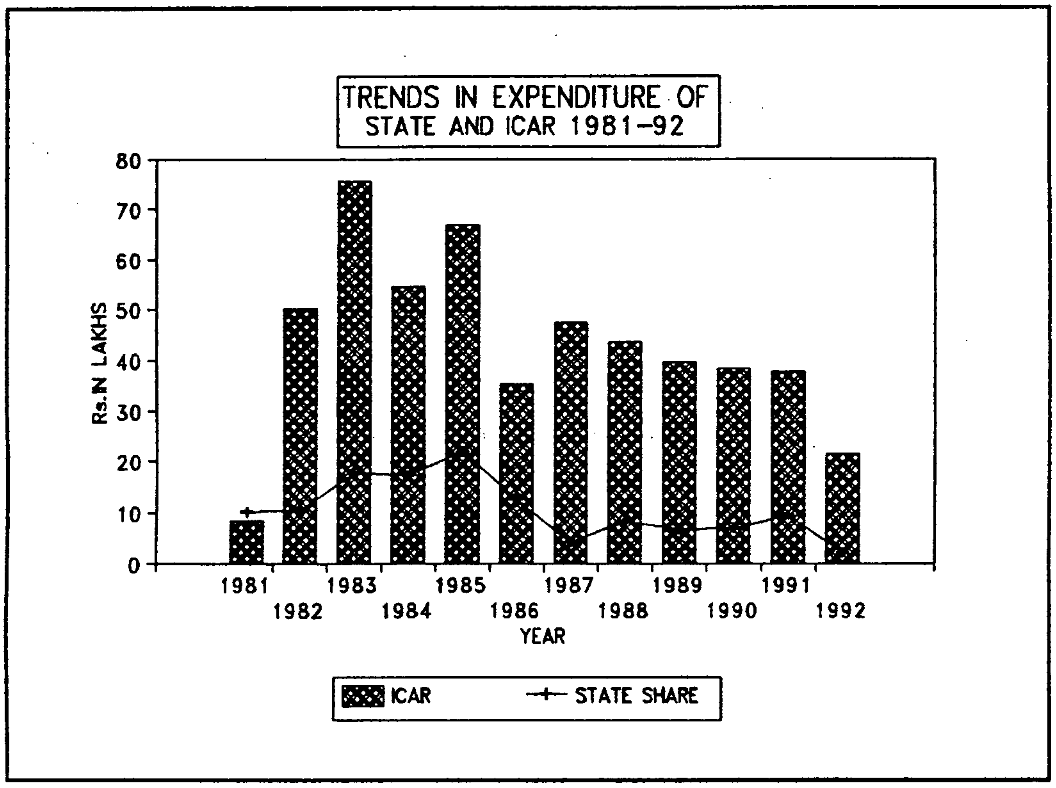
From the graph we understand that paddy had been accorded top priority throughout the entire period(1973-92). It had increased till 1988 and then witnessed a decrease after that. Coconut, which steeply increased after 1976,gained more priority than paddy after 1988. The expenditure on horticulture, pepper, banana and cardamom has more or less increased over the period.

The shift in priorities from food crop to commercial crop is evident.

Trends in ICAR expenditure and state's share on ICAR projects in Kerala:

The figure 3.9 clearly shows the declining share of ICAR in the agricultural research in Kerala. It is also to be noted that the state's share inthese projects is also declining. This is important because major sources of finance of agricultural research in Kerala as seen in figure 3.4 are by state and ICAR.

Figure 3.9



3.8: An Analysis of Support Programs in Kerala 1965-95

This section deals with an analysis of the various programs of the government in terms of allocation of resources for the various agricultural programs.

These include crop production programs, supply of inputs and services etc. The period under consideration is from 1955-56 to 1994-95, which is divided in three periods --- 1955-56 to 1965-66, the second period from 1966-67 to 1974-75 and the third period from

1975-76 to 1994-95. The various support programs encompass the following aspects; biological, chemical, managerial, physical and institutional aspects.

Due to the diversified nature of these programs and their direction over the years, they are classified in the following heads:

A. Supply of various inputs and services,

B. Crop production programs,

C. Institutional programs.

This is presented in the figure 3.10.

Fig:3.10 **SUPPORT PROGRAMS**

A. Supply of inputs & services programs	B. Crop Production Programs	C. Institutional Program
i) Seeds	i) Food grains	i) Extension
ii) Manures and fertilisers	ii) Commercial Crops	ii) Research & education
iii) Agri. Engineering	iii) Tuber Crops	
iv) Crop Insurance	iv) sugarcane	
	v) Pulses	
	vi) Spices	

The corresponding expenditure on these heads under the reference period is given in table 3.12. These are briefly dealt below.

Table 3.12 : Expenditure on Support Programs of State (Rs.Cr) 1955-92

HEAD	PERIOD I (1955-66)	PERIOD II (1966-74)	PERIOD III (1975-92)
SEEDS	89.21	110	590.85
MANURES/ FERTILISERS	163.32	229.32	560.55
AG.ENG	6	200	420
FOOD CROPS	210	6151	3547
COMMERCIAL CROPS	26	680.7	4950
PULSES		320.4	415.1
COCONUT	52	516.7	5675
TUBER CROP		87	4
CASHEW		580	869
SPICES	11	594	75
SUGARCANE	21	52	94
HORTICULTURE	19	52	120
CROP INSURANCE	10		87
EXTENSION	29	98	100
RESEARCH/ EDUCATION	16	73.6	1400

Source: Various Budget documents

Supply of Inputs and Services

Supply of inputs includes programmes like seeds, fertilizers, manures and implements and services includes programmes like crop insurance, improved agricultural practices, agricultural farms, agricultural engineering, soil conservation and other services. The trends over the reference period are briefly described below.

A. Multiplication and Distribution of Seeds

From the initiation of planning in Kerala, emphasis was given to the supply of improved strains of seeds. By the end of 1965-66, 25 per cent of the total area under paddy was covered under improved seeds. Seed testing labs were set up. In the first period under reference, Rs 69.21 lakhs was allotted for the supply of seeds which increased to Rs.110 lakhs in the second period. This included expenses on seed farms. In the third period, an outlay of

Rs 590.85 lakhs was allotted which included the HYV program,the major strategy for increased production especially in paddy. The programs included production and distribution of quality seeds,inspection, certification and establishment of seed testing laboratories,development of existing seed farms,seed multiplication in Kayal lands and distribution of seeds through registered seed growers from National Seeds Corporation (NSC) .

B. Manures and Fertilizers

In the first period, the supply of fertilizers and manures was emphasized in the production of rice. Realizing that intensive cultivation was the only solution to reduce the food deficit in the State, programs on supply of crucial inputs were recognised. An outlay of Rs 163.22 lakhs was spent in this period. Specific targets of NPK suited to the Kerala soil were proposed. Manures like bone digester were taken to meet the internal demand. Fertilizer subsidies were also formulated. Targets for rural and urban compost, green manures, press mud were also set up. In the second period in an effort to boost rice production on Yelah basis, the supply of inputs including fertilizers was emphasized. Measures to popularize green manures was attempted. In the third period, an amount of Rs 560.55 lakhs was allocated which included procurement and distribution of green manure, soil testing service and supply of soil ameliorants at subsidized rates and quality control of fertilizers and pesticides. Other measures emphasized on development of local manurial resources and strengthening of fertiliser control lab. A national project on the development and use of fertilizers in low consumption rainfed areas was also started. The Intensive Package for Rice Development (IPRD) involved substantial development of chemical weedicide. The popularisation of bio fertilisers was also encouraged.

C. Agricultural Implements/Engineering

From the first plan, there were efforts to envisage the provision of agricultural implements as a part of the intensive cultivation. The planners felt that it was important as there existed a serious gap in the agricultural programs since practical action lagged behind. Survey studies were proposed on the extent of utilisation. The outlay was six lakhs in this period which increased to Rs 200 lakhs in the second period. This mechanical measure was in the later plan periods absorbed in other measures mainly in the program for agricultural engineering.

In the second period, as an aim to modernise agricultural implements, a provision was made for mechanisation with an outlay of Rs 100 lakhs. In the third period, an amount of Rs 181 lakhs was allotted. This included maintenance of agricultural engineering services, purchases of tractors which was essentially a centrally sponsored scheme for distribution of improved implements. In Kerala due to the group management techniques, the demand for tractors has increased from the third period. The Kerala agriculture Implements Corporation [KAIC] functions as the hiring centres to the cultivators.

D. Crop Insurance

This scheme was formulated from the first period where an amount of Rs 10 lakhs was allocated which included cattle and crop insurance also. However this scheme was not given adequate importance till the third period which allocated Rs 87 lakhs. This is an important measure that avoids risk to the farmers and provides an incentive to crop cultivation.

Specific Crop Production Programs

1. Paddy
2. Commercial crop production--- cashew, spices, sugarcane, cotton,pulses and oilseeds.
3. Horticulture.

1. Paddy

From the initiation of planning, as a rice producing state, Kerala puts major efforts to increase foodgrain production. In the first period, to fight the food deficit, maximisation of food production was aimed at more than the anticipated production of 10.22 lakh tonnes of rice and 0.17 lakh tonnes of pulses by 1960-61. Realizing the constraints to land, intensive cultivation was aimed in terms of irrigation, soil conservation, supply of fertilizers and manures and better implementation of agricultural practices.

In the second period,development efforts were organised on lines of package programme with shift of emphasis to crops that count. Measures in irrigation front helped in the development of agriculture along with the adoption of HYV. The joint farming in rice cultivation in the Andoorkonam Yelah under the FACT in 1968 was an important step indicated the need for the reorganisation of paddy cultivation. The success of the Kayamkulam Kayal paddy cultivation highlighted the importance of group activities in rice cultivation. An evaluation study of the package program in Palakkad and Allepey by the Bureau of Economics and Statistics in 1966-67 suggested organisation is the missing link in enforcing the breakthrough in agriculture in Kerala. The disadvantages caused due to the small holdings and economic backwardness of the farmers could be overcome through joint operations. The yelah program envisaged in the fourth plan were based upon these findings. The Green Revolution ushered in 1969 by the advent of HYV represents the fruition of the promotional and directional efforts of the State. The increase in production of paddy in this period was due to the increase in area and adoption of modern techniques. However by 1974, though yield increased, several factors contributed to the non-fulfillment of the aspirations due to decline in area under HYV and decreased fertiliser consumption. The former was due to natural factors and later was due to supply and price factors.

In 1973-74 the production of paddy fell due to the incidence of Brown Hopper. In that period the development programmes to combat the crop failure included plant protection measures, farmer camps, Intensive paddy package units, ground water scheme, farm news innovation, training of farmers in HYV, and All India Coordinated Project (AICRIP) on location specific problems like bio control of Salviniae molesta in Kuttanad.

The remarkable recovery in 1975 in the production of paddy showed that despite the weather conditions and stagnant fertiliser consumption, the production could be increased with better pest management and improved water management. The existence of a time lag between accumulation of knowledge with research station on one hand and its transfer to the farmers on the other was recognised and the operational research project was formulated. Moreover the need to take care of the divergence and dilution of research when applied to the fields was acknowledged. This called for adaptive research.

In the third period, there was a stagnation in respect of production of paddy though there was a slow increase in productivity, mainly due to fall in area. This is due to high cost of production and risk in the case of paddy compared to the other crops. The development efforts mainly included more of Intensive Package units, pest management, and supply of HYV seeds. However the group farming which was introduced initially had some good results but the enthusiasm is fading. Therefore, the development efforts should continue in the direction of enthusing the farmers.

II Commercial Crops:

Coconut: In the first period, not much of importance was given to development of coconut as a commercial crop in any of the three plans. In the second period, efforts aimed to expand output of commercial crops through a concerted program for enhancing productivity. An outlay of Rs 366.7 lakhs was allocated for coconut which included the distribution of seedlings, fertilizers, plant protection measures, expansion of area and introduction of malayan semi tall variety and T x D seedlings. It was recognised that for optimum utilisation of land, simultaneous commercial crop development was essential. So coconut based farming systems were encouraged. For the development of coconut, package programs, Intensive Coconut Development units, provision of fertilizers, irrigation, plant protection and seeds were emphasized. In the third period, the coconut development program received an outlay of Rs 3777.2 lakhs. This included centrally sponsored schemes involving production, distribution of seedlings, comprehensive coconut development program and development of oil palm. It also included the preceding measures but emphasized on the group management techniques of cultivation which was a success in the case of rice. It also provided financial assistance for removal of Root wilt, irrigation facility and an integrated project for development of marketing. In the eighth plan, the outlay was increased to Rs 1110 lakhs excluding a rehabilitation project of Rs.870 lakhs with assistance from the EEC for replanting, research and infrastructure.

Spices : In the first period there was not much of emphasis on the development of spices. In the second period, an amount of Rs.584 lakhs was allotted for this purpose. It included schemes on pepper development and distribution of fertilizer mixture, pepper nursery, organisation of demonstration plot, and the multiplication and distribution of improved ginger. This also included schemes like rehabilitation of pepper gardens, package programs, control of root wilt, demonstration, maintenance of central nursery, multiplication of Panniyur-1 production of tree spices etc.

In the third period, 330 lakhs was allocated for spices which dealt with spices nursery, pepper development program, and the development of ginger, turmeric and garlic. It had comprehensive schemes like the intensive program of development of spices. The major schemes were; rapid multiplication of hybrid pepper, and local variety, development of tree spices, and package program for rejuvenation of pepper gardens along with experimenting group farming. Though adequate importance is given to spices in the State, more attention is required in plant protection measures to enhance productivity.

Pulses : In the first period, there were no specific program for the development of pulses. In the second period, an amount of Rs 320.4 lakhs was spent on pulses that included package program that is subsidy for rhizobium culture,plant protection chemicals,micro-biology laboratories, expansion of additional area etc.

In the third period,Rs.14.64 lakhs was spent which include the pulses development program. The main component was the National Pulses Development Project with an outlay of Rs.8.46 lks.

Sugarcane : From the first period itself, attention was paid to the development of sugarcane. An amount of Rs 11 lakhs was allotted which included the supply of seeds, plant protection, manurial and cultural demonstration, crop competition etc and publicity. In the second period,the major activities involved the production and distribution of quality seeds, improvement of communication in factory areas,training etc. An amount of Rs 52 lakhs was allocated that dealt with intensive sugarcane development units, nurseries etc. In the third period, Rs 94 lakhs was allotted for this crop.

Cashew : Though this is an important crop of the state, attention was paid only in the second period. An amount of Rs 87 lakhs was allocated that included expenditure on the expansion of area, control of stem borers etc.

Under the third period, some diversified measures were adopted that had an outlay of Rs 217 lakhs including, scheme for cashew cultivation in the private sector,adoption of plant protection measure and multi state cashew development project. These schemes were continued in the eighth plan along with schemes for area expansion and improved cashew by insitu vegetative propagation technique.

Tuber Crops : Though tuber crops like tapioca, yam and cassava are some of the main crops of Kerala, it was in the second period that some attention was paid to tapioca in the form of manure loans, and popularisation of HYV, with an outlay of Rs 75 lks. An amount of Rs 875 lks was set for tapioca that involved a package program and demonstration. Next, yam received Rs. 8.27 lks. In the third period, the development of tuber crops received only Rs 3 lks. Though the state sponsored programs are meagre, much work is done by the Central Tuber Crops Research Institute (CTCRI), an ICAR institution in Kerala.

Horticulture : From the first period itself, horticulture development was given importance. In this period, an amount of Rs 19.06 lakhs was allotted and for banana development alone, an amount of Rs 15 lakhs was allotted which included control of bunchy top disease, and raising of disease free suckers. In the second period,the programs for the horticulture development included development of orchards, financial assistance to the agri-horticulture societies, vegetable cultivation, fruit preservation units etc. The programs for horticulture were diversified to include plant protection, chemicals and equipments, package practices, area expansion etc.

In the third period, an amount of Rs 120 lks was allotted which included development of horticulture crops, societies, etc. Additional programs like National Horticulture Board scheme which arranges for the production and supply of quality planting material were taken up.

Institutional Measures

Extension: When agricultural research was at its infancy in Kerala, a total of Rs 29.09 lakhs was spent for agricultural extension and training in Kerala during the first period. In the second period, an amount of Rs 91 lakhs was spent in this head which included training of agricultural personnel, multi-crop demonstration, mobile soil testing lab, and soil testing in private colleges. In the third period, this amount was Rs 27 lks which included farmers training centres, training to demonstrators and junior agricultural officers etc. This is mentioned in the second section of this chapter.

Agricultural Research and Education

Realizing the importance of agricultural research in Kerala, from the third plan onwards, specific amounts were allocated to research and education, in order to held fundamental applied research following the package program recommended by the Ford foundation. In the second period, am amount of Rs 98 lakhs was allotted for this purpose. Expenditure on education included studies on pathology, statistics and economics division, parasitology etc. The expenditure on research included research on horticulture, wastelands, ICAR projects etc. There is a need for adaptive research in Kerala and the KAU was established in 1971 to pursue research on significant disciplines. In the third period, an amount of Rs 1400 lakhs was spent on this head which includes development grant to the KAU, and contribution to ICAR projects in the State. The research activities are mentioned earlier in this chapter.

So this study prescribes policies for more investment and innovation supportive policies in the right direction. This is supported by many other studies. (Evenson and Jha,1977: Shultze,1964: Hayami and Ruttan, 1971: Akimo and Hayami,1974: Ruttan and Mellor1976)

Thus, from the above analysis we can safely conclude that much efforts have been put in terms of resources for the generation of research activities in Kerala. However, we see a clear neglect of extension activties over the four decades. Also, from the section I of this chapter we arrive at the conclusion that the technical change achieved in Kerala in the past three decades is due to fertiliser. It is also necessary to see if the innovations are diffused at the local level. The case of the HYV of paddy is taken in this context in the next chapter.

APPENDIX 3.1: Price Indices of Inputs in Agriculture and Output Indices 1960-92 (base year 1960)

YEAR	FERTILISER	WAGES	LAND	ENERGY	MACH	OUTPUT
1960	100.00	100.00	100.00	100.00	100.00	100.00
1961	98.42	114.21	106.07	133.33	103.13	105.03
1962	103.03	108.61	107.14	75.00	104.55	98.69
1963	102.00	92.95	111.30	66.67	102.90	103.09
1964	99.78	101.90	103.03	150.00	104.23	118.05
1965	100.61	99.07	103.87	133.33	104.51	106.38
1966	97.61	107.98	102.12	75.00	106.41	104.72
1967	131.27	112.61	109.69	66.67	104.82	105.67
1968	103.03	93.82	109.01	200.00	101.15	99.85
1970	104.97	100.01	108.74	103.00	102.27	97.99
1971	101.35	97.94	99.88	231.07	115.56	105.35
1972	100.01	108.40	96.89	125.11	105.77	87.44
1973	112.96	101.55	118.63	100.76	110.91	113.21
1974	130.09	92.37	143.20	101.17	127.87	109.50
1975	163.99	103.31	136.03	97.12	110.90	87.42
1976	98.40	108.00	79.60	85.67	98.27	98.45
1977	128.49	100.00	85.86	117.72	101.18	90.47
1978	90.71	104.07	100.12	122.54	105.81	93.78
1979	100.20	100.36	122.16	179.82	115.93	109.33
1980	86.63	92.91	103.23	58.05	109.48	96.8
1981	124.68	95.42	127.96	98.62	109.46	99.98
1982	116.58	104.80	115.07	51.33	105.12	82.01
1983	99.56	107.63	111.74	178.18	105.99	98.85
1984	95.54	82.98	132.52	129.88	104.59	107.13
1985	100.1	144.87	108.59	80.92	110.14	130.47
1986	100.5	97.94	102.85	100.02	105.52	89.61
1987	126.64	102.41	114.37	98.47	103.20	109.49
1988	100.6	102.94	103.98	100.06	110.98	103.60
1989	100.4	70.86	104.51	100.93	102.03	97.72
1990	100.3	180.65	97.94	100.77	106.97	97.88
1991	109.08	138.39	109.23	98.59	100.47	100.65
1992	108.93	109.68	117.32	88.71	102.08	136.20

Source: i) Fertiliser Statistics, Various Issues
ii) Economic Review, Various Issues
iii) Census of India, 1961,1971,1981,1991
iv) Statistics For Planning, Various Issues

APPENDIX 3.2 : Quantity Indices of Inputs in Agriculture (1960-92) base year 1960

YEAR	FERTILISER	LABOUR	LAND	ENERGY	MACH
1960	100.00	100.00	100.00	100.00	100.00
1961	140.89	100.00	99.21	75.00	96.67
1962	209.80	100.31	105.57	50.00	91.24
1963	236.17	100.61	107.21	75.00	90.78
1964	283.95	111.55	107.50	50.00	89.38
1965	326.81	131.80	109.79	80.00	89.13
1966	377.00	137.12	111.50	57.50	87.51
1967	445.57	159.41	114.79	95.00	85.58
1968	574.54	171.06	123.36	97.50	83.53
1969	588.27	182.21	125.43	238.50	82.22
1970	462.85	184.15	126.57	207.50	80.34
1971	530.77	192.94	129.79	300.56	71.05
1972	623.05	193.05	129.50	221.90	82.74
1973	635.94	192.94	129.79	191.72	83.13
1974	550.30	193.15	130.79	303.80	74.35
1975	511.16	194.38	127.29	305.60	76.06
1976	567.00	192.54	125.50	285.90	77.37
1977	763.47	195.71	123.21	289.76	78.03
1978	889.12	195.5	119.50	305.60	52.39
1979	844.23	195.81	119.29	218.50	52.58
1980	796.76	195.91	120.64	262.50	53.89
1981	774.13	196.01	122.86	242.10	63.58
1982	896.93	196.42	122.21	265.50	65.17
1983	1057.32	196.83	122.57	230.60	64.00
1984	1044.40	196.32	123.36	252.50	66.15
1985	1154.56	210.84	122.29	327.50	66.43
1986	1236.44	212.07	122.57	342.90	67.35
1987	1490.87	212.58	124.07	365.77	68.35
1988	1339.16	212.07	125.64	465.99	68.66
1989	1727.42	212.58	127.93	478.99	79.09
1990	2123.81	213.80	129.07	480.66	72.51
1991	1256.26	214.11	122.64	487.33	69.17
1992	2115.04	214.26	126.50	490.77	70.10

Source: Same as Appendix 3.1

CHAPTER IV

DIFFUSION OF HIGH YIELDING VARIETIES OF PADDY

4.1: Introduction

This chapter deals with the diffusion of High yielding varieties of paddy as a biological innovation in Kerala. The case of paddy is chosen purely for two reasons i) Paddy is the only crop where much varietal improvement has taken place for a long period, and ii) Inspite of much stress on paddy and HYV's only marginal increase in yield has taken place and more distressing is that the area under HYV's is declining drastically.

Section I describes the various types of HYV's released in Kerala zone wise, Section II deals with the diffusion model which tests the rate of diffusion of HYV's in Kerala, Section III deals with spatial diffusion among all the blocks of Kerala.

Varietal Improvement of Paddy in Kerala:

Rice is the major crop that has the largest number of varieties. The varietal improvement work in rice was started from the time it came into cultivation. Conscious or unconscious selection of better plant types and adaptability of different situation, from the primitive stage of cultivation onwards was resulted in the vast number of rice varieties suited to the different agro-climatic regions. Attempts to transfer and combine the widely dispersed locally indigenous varieties by planned breeding work was started in the 1930's with the establishment of rice research station at Pattambi (1927). Many of local varieties have national and international importance as donors for pest and disease resistance. Some of the varieties released from the

Pattambi research station are widely used in resistance breeding programmes and donor parents too one or more pests and diseases. Local types like Vellathil Cheera, Velutha Cheera are also being used in multiple resistance breeding programme. All these suggest the diversity of plant types available in Kerala and their importance in the world rice breeding programmes.

The identification of the `dwarf gene' in "dee-gee-woo-gen", a semi-dwarf variety from Taiwan has paved the way for a break through in rice in Kerala. Varietal improvement through hybridisation and selection started with the introduction of T(N)I and IR8 during the 1960s. Annapoorna - The first short duration red rice high yielding variety from Asia was released from Pattambi during 1968.

All these varieties were evolved in suit the different agro-climatic situation of the state. The State is divided into five agro-climatic zones taking into consideration of its physiography, climate, soil characteristics, sea water intrusion, irrigation facilities, land use pattern and the recommendations on the Committee on Agro-climatic regions and cropping patterns constituted by the Government of Kerala in 1974. The zones are (i) Northern (ii) Central (iii) Southern (iv) High Range and (v) Problem Areas.

Type of HYVs in Kerala

Broadly, the HYV's are grouped into traditional varieties and modern varieties.

(a) Traditional varieties

In general the traditional varieties are tall and have duration from medium to long period. Some of these are extremely long in duration like Aryan (Ptb 1) of the Virippu season with the duration 150-155 days and Vellari (Ptb 4), 1025, Cheradi etc. of the mundakan season which come to harvest in 175-180 days. Heavy foliage production, wide grain-straw ratio and low effective response to fertiliser levels are some of the general features of these varieties.

(b) Modern Varieties

Though most of these are dwarf or semi dwarf in stature, there are some varieties like Mahsuri with tall plant structure. These are of either short or medium duration. Erect leaves, non-lodging nature, narrow grain-straw ratio and good effective response to fertiliser levels and high grain yield potentials are some of the general features of these varieties. Tables 4.1,4.2, and 4.3 show the various international,national and zonal wise release of HYV's in Kerala.

Table 4.1: International and National Release of HYV'S In Kerala

Name of Variety	Duration	Stature	Season	Suitable Regions	Features: Resistance to pest/ diseases	Others
1	2	3	4	5	6	7
INTERNATIONAL						
<u>Malaysia</u>						
IR 5 (Pankaj)	115-140 (med.)	Tall	-	Flood prone	tolerant to bacterial leaf blight	Non-lodging
IR 20	120-125	Tall	-	Stem borer area	Resistant to stem borer	
IR 8	125-135	semi-dwarf	-	well drained soils		wide adaptability
<u>Ceylon</u>						
H-4	125-145	Tall	-	Flood & ill drained soil	'	Non-lodging
<u>Malaysia</u>						
Mashoori	125-145	Very tall	-	deep soils with poor drainage (problem soil)	-	Bad shedding of grains on maturity
NATIONAL (AICRIP)						
<u>Hyderabad</u>						
Jaya	120-125	-	-	-	-	Yield stable

Source: Farm Guide,1991-92

Thus there are several varieties of HYV that are transferred from international and national research institutes. However, it is important that these varieties adapt to the geo-climatic variations in Kerala especially in the problem zones. They must suit for all the three seasons of virippu, mundakan and punja which is marked by the vagaries of weather. The most important requirements are the stature,lodging capacity, susceptibility to pests and disease, straw content and duration of the varieties.

Out of the above, only H4 is red variety. Red rice is preferred in Kerala,especially in the southern zone. Rice plants in Kerala are susceptible to lodging during the rains. Moreover, only IR 20 has resistance to diseases like stem borer, tungro virus and resistance to bacterial leaf blight. The HYV strains are more prone to pests and diseases inspite of its high yield. All these types are medium duration varieties. IR 8 does well only in well drained soils while IR5, H4 and Mashoori performs well in poor soils.

Table 4.2 shows the varieties released by the central and northern zone. It is also to be noted that no variety has been released in the northern zone. The varieties released by the Kayamkulam station should suit all the regions of the southern zone while the releases from the Pattambi station should suit all the regions of the central zone. The varieties of Lekshmi and Onam, are released to suit the southern zone. These are tall, and non-lodging in nature and are red in quality. However, `Lekshmi' is not tolerant to leaf roller.

There are numerous varieties released in the Central zone research station of Pattambi. Varieties like Annapoorna, Rohini, Aswathi,Thriveni, Jyothi,Sabari,Bharathi,Suvarna Modan have resistance to the pests and diseases. But none of the varieties have multiple resistance to pests and diseases.They are resistant to either one or two diseases or pests only. These vary in their duration and stature to suit the various regions and seasons. Nearly five of them are varieties of red rice. The latest release of `Rasmi' is tall and highly season bound suited only for mundakan.

Table 4.2 : Varieties Released in the Southern and Northern Zones:

Name of Variety	Duration	Stature	Season	Suitable Regions	Features: Resistance to pest/ diseases	Features: Others
1	2	3	4	5	6	7
Southern Zone						
Onam Kayamkulam-3	95 (short)	Medium tall	Virippu			early drought resistance
GOA Vellayani ACV 1 [Arathy Jaya]	120-137 (med.)		Virippu	Sheath Blight Rot & BPH		
Central Zone						
Annapoorna Pth 35	95-100 (short)				Moderate resistance to diseases	good seedling vigour. Lodging resistance
Rohini (Pth 36)	75-110 (shortest)		Punja	Kole & Kuttanad [multiple cropping]	low susceptibility of pest/diseases	
Aswathy (Pth 37)	120-125 (medium)	semi-dwarf			less susceptibility	Best for local condition
Thriveni (Pth 38)	95-100 (short)				less susceptible to stem borer	More grain & straw
Jyothi (Pth 39)	110-125 (med.)				Resistant to BPH	High seedling vigour
Sabari (Pth 40)	100-125 (Med.)	Medium	Virippu & Mundakan			
Bharathi (Pth 41)	115-125 (med.)		All		Non-lodging	
Suvarna Modan (Pth 42)	115-125 (med.)	Tall	Virippu	Modan lands	—	—
Suvarna Prabha (Pth 43)	100-110 (Medium)	Medium tall	All Virippu	Wetland modan		
Rasmi	150-180 (long)	Tall	Mundakan only			

Source: Same as Table 4.1

Table 4.3 : Varieties released in the High Range and Problem Zone:

Name of Variety	Duration	Stature	Season	Suitable Regions	Features	
					Resistance to pest/ diseases	Others
1	2	3	4	5	6	7
High Range						
WND 1	140 (long)		Virippu	High Range		
WND 2	140 (long)		"	"		
PROBLEM ZONE						
Bhadra (Mo-4)	125-130 (med.)	Dwarf	Priya	Kuttanad		
Asha (Mo-5)	115-118 (med.)		Virippu	"	Resistance to BPH	
Pavizham (Mo-6)	115-118 (med)				Fairly resistant to pests	Moderate grains
Karthika (Mo-7)	110-115 (med.)				Moderate resistance to pests	long grains
Lakshmi Kayamkulam-1	175-180 (long)		Mundakan	Onattukara	Moderate resistant to Sheath Blight, Fair tolerance to stem borer, not tolerant to leaf roller	
Bhagya Kayamkulam-2	95-100 (long)	Med.tall	Virippu	"	Moderate to BPH	Drought resistance
Vgt 2	125-130 (med.)		Virippu	Saline areas of Erk. & Alp. (Pokkali)		
Vgt-3	115-130 (med.)		"	"		

Source: Same as table 4.1

There are only two varieties for the high ranges, released by the research station at Ambalavayal. There are several varieties to suit the various problem soils released by the Moncompu and Kayamkulam research stations. Bhadra, Asha etc are evolved to suit Kuttanad and Bhagya for Onattukara while Vytilla 2 and 3 are evolved for the saline areas of Ernakulam (pokkali) and Alapuzha.

Thus, there are several varieties with characteristics in regard to stature, duration, seasons, soils,quality (red or white) and straw content. We can safely arrive at the conclusion that as according to Hayami and Ruttan(1971), Kerala has nearly passed the second stage (see chapter II). But it is necessary to see whether these new HYV's are adopted by the farmers and suit to location specific requirements of Kerala. This is done in the following sections.

SECTION II

4.3:The Diffusion Model

The diffusion model set out in chapter 2 is tested and the results are provided.

Table 4.4: Estimated Results

TYPE OF CROP	α	β	τ	SE	R^2	F
VIRIPPU	0.97 (10.47)*	-.54 (-5.41)*	.07	1.11	.85	56.9*
MUNDAKAN	.84 (7.31)*	-.10 (-8.99)	-.23	1.55	.75	28.92*
PUNJA	.46 (2.02)**	-.24 (-1.07)	1.22	3.27	.17	2.07*
TOTAL	.99 (13.5)*	-.15 (-2.1)	.36	.86	.90	95.7*

* Significant at 5 per cent level
** Significant at 10 per cent level

The results do support the diffusion model. It can be clearly seen that the estimates of α, the coefficient of the advanced levels of HYV and ß, the coefficient of variation, have signs consistent with theoey and are significant at 5 per cent level in all the seasons of the virippu (autumn) and mundakan (winter) and for the total crop at 5 per cent level. The punja crop also ratified this result at 10 per cent level. The negative sign of ß shows that yields are getting stabilised in all the districts ie. according to our hypothesis S approaches U. In the Virippu season,the stabilisation is the highest, followed by Punja and then Mundakan. The districts of Pathanamthitta, Wayanad and Kasargode are ommitted for the reason that these were formed only after 1983. For the virippu season, the average of advanced yields of the districts of Kottayam, Idukki and Palakkad were calculated. For the mundakan, the average of the yields of Alapuzha, Kottayam and Palakad were calculated. For punja, the average of the advanced yields of the districts of Alapuzha, Kottayam and Malappuram were calculated. For the total crop, the advanced yields of Alapuzha, Kottayam and Palakkad were calculated.

The results are presented in figure 4.1, 4.2, and 4.3.

Figure 4.1

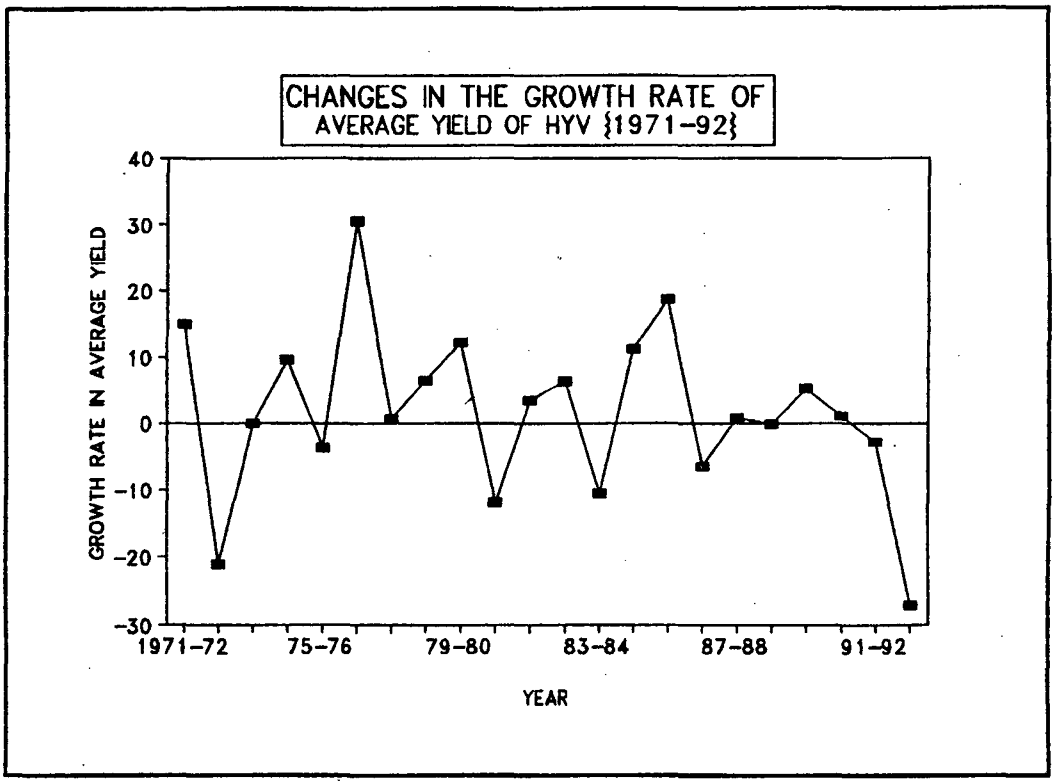
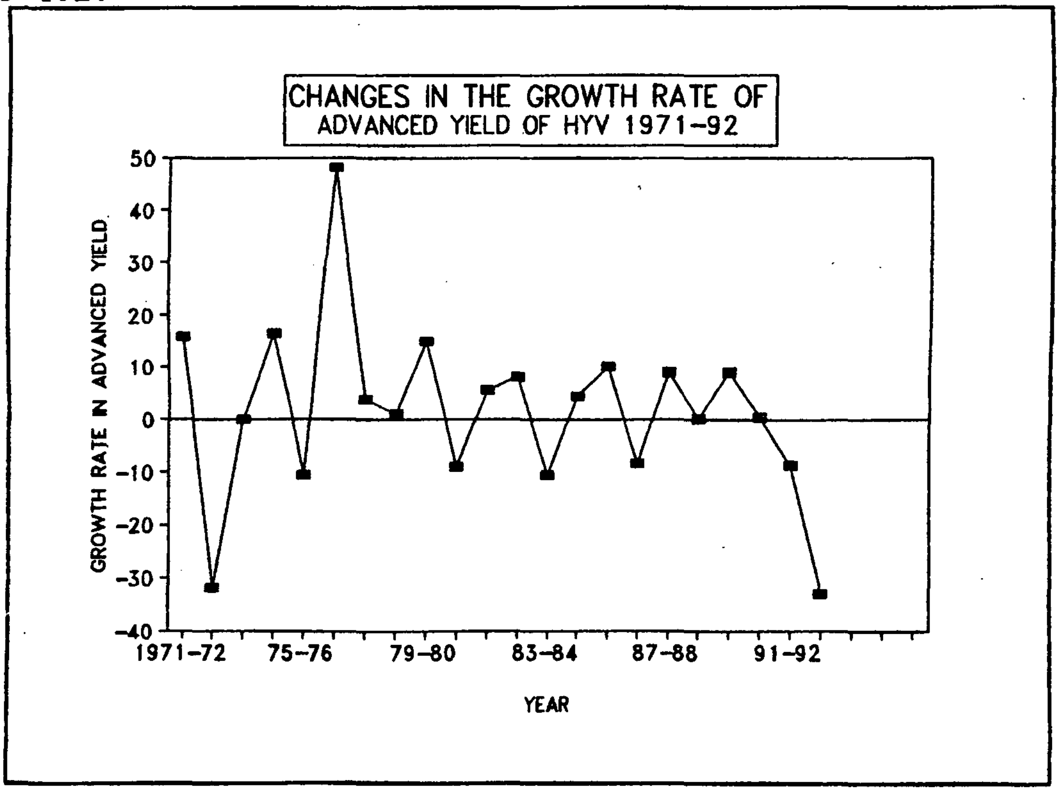
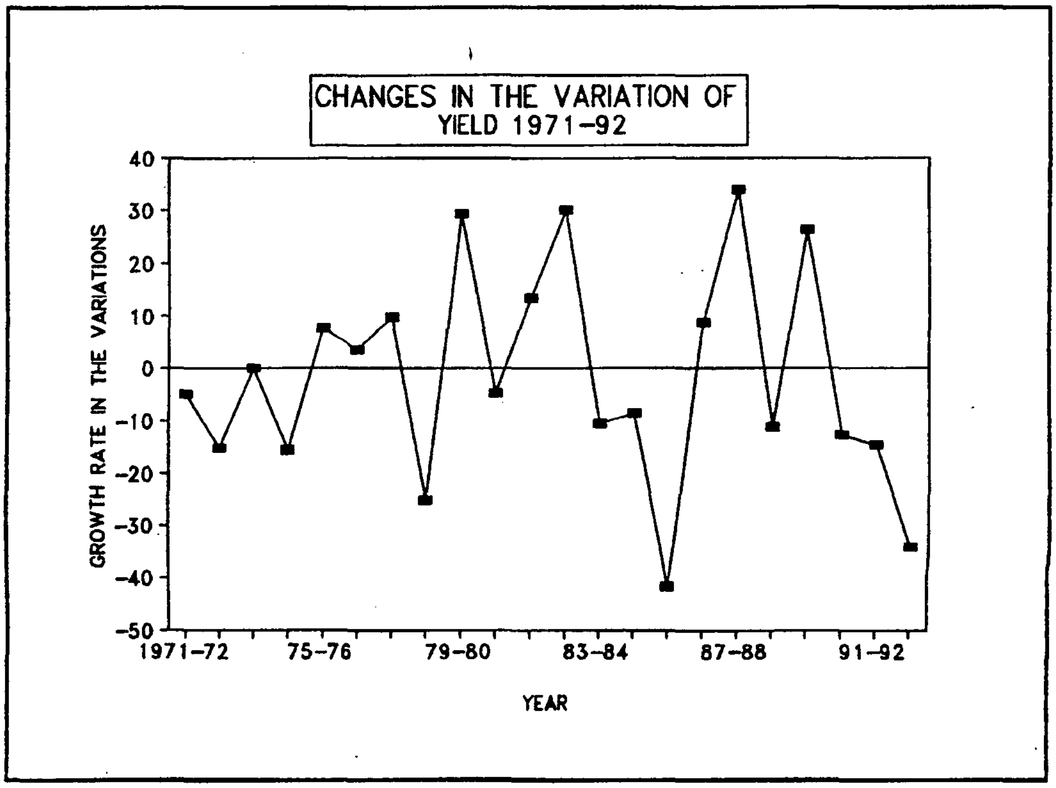


Figure 4.2:



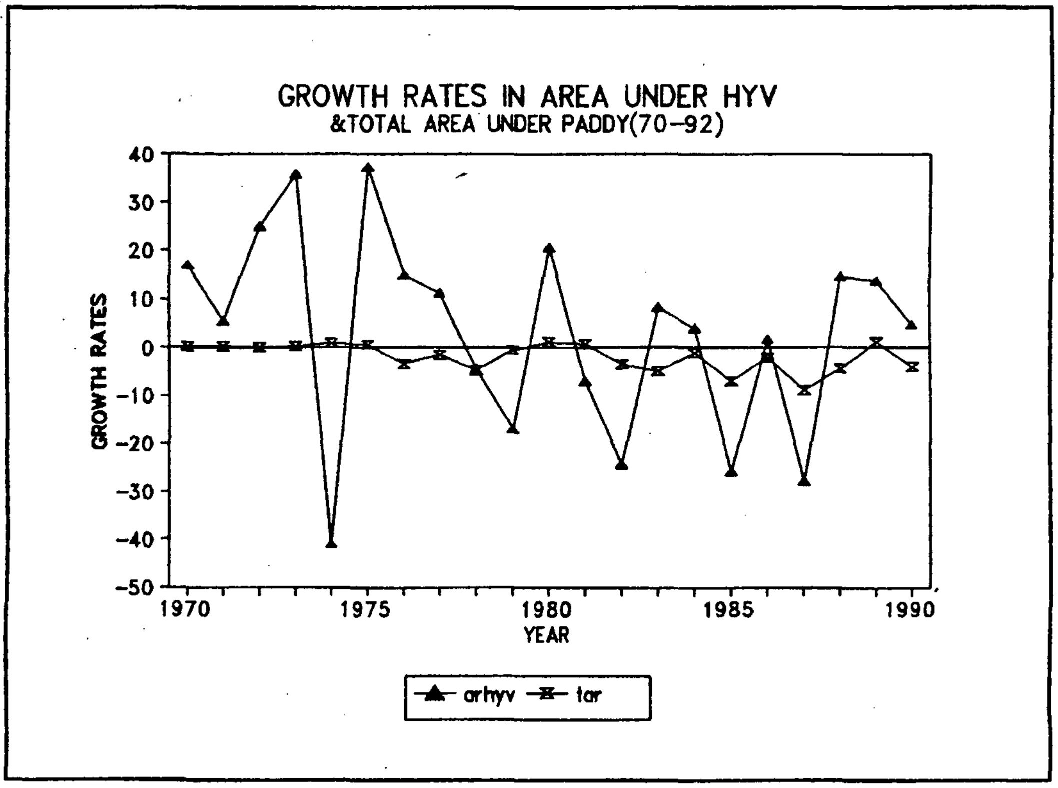
Figures 4.1 and 4.2 show that advanced levels of yields are getting stabilised in all the other districts. However, both the graphs show that the declining trend after late 80's. This perhaps, shows that the agriculture in Kerala has been recently moving toward the exhaustion of technological potential.

Figure 4.3:



The figure 4.3 shows the changes in variations in the yields which is decreasing. But this result has to be examined in the light of the production statistics.The plethora of studies on paddy (see chapter 1) point to the decreasing area under HYV. Thus, though, there is a diffusion of yield, the area under HYV the result of biological technology in Kerala is falling drastically (fig 4.4). This is shown in the graph below. The growth rate is area under paddy for the State is falling moderately but the fall in the area under HYV is falling drastically throughout, especially for some years. This due to incidence of pests and diseases, droughts and floods. Therefore, the farmers prefer the local varieties inspite of the their low yield.

Figure 4.4



The area under HYV and local varieties of paddy are shown in table 4.5:

Table 4.5: Estimated yield under local and modern varieties of paddy in all districts and all season 1990-91

	VIRIPPU		MUNDAKAN		PUNJA	
DISTRICT	LOCAL	HYV	LOCAL	HYV	LOCAL	HYV
TVM	2849	3314	2657	2774	2313	1911
KLM	2490	3193	2791	3126	1818	1691
PTA	2595	2611	2968	3346	4143	5271
ALP	2807	3085	2694	4481	4139	4348
KTM	2918	2997	2788	3857	6393	4628
IDK	3280	3549	3532	3778	6209	0
ENK	2406	2922	2739	2627	2359	2526
TSR	2246	2588	2457	3327	2353	3276
PKD	3696	3646	3139	2170	2927	2645
MLP	2291	2826	2298	2451	2948	3331
KZD	1555	2181	1809	2269	1634	2390
WYD	0	0	3041	43482	5524	3376
KNR	2420	2872	2211	2773	1591	2673
KSD	2619	3374	2380	3280	2414	3098
STATE	2954	3066	2751	3573	2796	3855

Source: Farm Guide,1991-92

In the virippu season, in all the districts and for the State as a whole, the yield of HYV is higher than the local varieties except Palakkad. In the mundakan, except in the districts of Ernakulam and Palakad, the yield of HYV is higher than the local varieties. In the punja, except in the districts of Thiruvanantha puram, Kollam, Idukki and Palakkad the yield of HYV is higher than the local varieties. It is interesting to note that in Palakad, which is the rice bowl of the State in all the three seasons, the yield of local varieties is higher than the HYV's. For the State as a whole, the HYV is higher than the local varieties. But the results are just the opposite in the case of area statistics. This is shown in table 4.6.

Table 4.6: **Estimated area under local and modern varieties of paddy in all districts and all season:1990-91**

	VIRIPPU		MUNDAKAN		PUNJA	
DISTRICT	LOCAL	HYV	LOCAL	HYV	1OCAL	HYV
TVM	6361	13868	8948	1472	229	43
KLM	4190	10424	15434	981	36	9
PTA	2249	2180	4232	1375	647	3266
ALP	12112	14804	13401	7873	5803	10541
KTM	1808	10608	1279	8111	25	7237
IDK	1814	181	2464	218	237	0
ENK	14259	10713	26144	2666	11643	4376
TSR	21629	3946	29358	5442	6040	8036
PKD	66053	8617	68600	1478	1248	710
MLP	17371	4512	25915	1754	1293	2559
KZD	2472	1009	7880	607	914	1122
WYD	0	0	16000	1509	2236	1287
KNR	6918	6060	5942	1650	289	123
KSD	7377	2075	5057	774	82	114
STATE	164614	78997	31689	26910	31461	29718

Source: Farm Guide 1991-92

In the virippu, except for the districts of Kollam and Alappuzha all the districts have more area under local varieties. In the mundakan, only Kottayam has more area under HYV. In the punja, only the districts of Pathanamthitta, Alapuzha, Thrissur, Malappuram, Kozhikode have more area under HYV. These observations show that the spread effect of the the biological innovation - HYV is very thin. Thus, except in the Punja season, most of the districts have more area under local varieties. The coefficient of variation is calculated for the yield between the blocks that have high adoption of HYV and the blocks with adoption below twenty five per cent. This exercise is also carried out for between the districts and varieties of paddy. The results are given below. This is further examined in the next section.

The table 4.7 shows the coefficient of variation of yield between the blocks that have low adoption of HYv and the blocks that have high adoption. It can be seen that blocks with high adoption has less variance.

Table 4.7: Coefficient of variation among Blocks:

Season	0-25% of HYV adoption	75-100% of HYV adoption
Virippu	35.45	23.05
Mundakan	27.98	26.35
Punja	35.2	31.68

The coefficient of variation among the yields between districts of high and low levels of adoption also show (table 4.8) there is less variance in the high levels of adoption.

Table 4.8: Coefficient of variation among Districts

Season	0-40% of HYV adoption	75-100% of HYV adoption
Virippu	25.45	20.11
Mundakan	13.32	10.60
Punja	29.30	14.60

Similarly the table 4.9 also shows that the variance among the HYV's is more than that of the local varieties. Thus, adoption of HYV is lower when the variance is high.

Table 4.9: Coefficient of variation among local and modern varieties

Variety	Virippu	Mundakan	Punja
Local	13.9	12.8	15.6
HYV	25.1	47.1	22.2

SECTION III

This section attempts to study the spatial diffusion of adoption of HYV in 149 blocks of Kerala. The details of all blocks in Kerala are provided in appendix figure 4.1. Three blocks are eliminated for the reason that data was not available. The year 1990-91 was chosen due to the reason that group farming as an institutional innovation in Kerala was started in 1989. The adoption of HYV in group farming area is important in the case of Kerala where the size of holding is small. Table 4.10 gives the number of blocks which have adopted HYV in paddy cultivation at various levels in different districts and the different seasons viz, virippu (autumn), mundakan (winter) and Punja (summer).

The level of adoption of HYV among blocks differs over various levels from 0-25 per cent to 75-100 per cent. As seen from the table, the districts of Alapuzha, Malappuram and Kozhikode have three blocks each in the 0-25 per cent range of adoption in the virippu season. The districts of Thiruvanathapuram and Idukki have one block each and Ernakulam has two blocks in this season. The districts of Palakkad, Thrissur, Malapuram, Kozhikode and Kasargode have nearly 3-7 blocks in the 25-50 per cent adoption level, while Thiruvanathapuram, Idukki, Ernakulam and Kannur has one each in the same level. Again in the 50-75 per cent level, Kannur, Ernakulam, Thrissur, Malappuram, Kozhikode,Alapuzha, Kollam and Thiruvanathapuram have 2-9 blocks, while Idukki and Kasargode have one block each. In the 75-100 per cent level of adoption, the districts of Kollam, Pathanamthittaa, Alapuzha, Kottayam, Idukki, Ernakulam,Malapuram, and Kozhikode have blocks between 3-9, and Thiruvanathapuram and Kannur with one block each.

Table 4.10: No of blocks which have adopted HYV in paddy cultivation at various levels at different districts and seasons

District	No. of Blocks	Virippu				Mundakan				Punja			
		0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-70	75-100
TVM	12	1	1	9	1	1	5	6	0	1	2	1	0
KLM	14	0	0	6	7	4	6	3	0	0	1	0	0
PTA	9	0	0	0	9	1	0	3	6	0	0	0	6
APA	12	3	0	2	7	2	1	0	5	0	0	0	7
KTM	10	0	0	0	9	0	1	0	9	0	1	0	8
IDK	8	1	1	1	5	0	0	0	3	0	0	0	0
EKM	16	2	1	4	3	4	2	5	0	0	0	2	8
TSR	14	0	5	3	5	1	5	4	2	0	0	0	14
PKD	12	0	5	0	6	0	4	2	6	0	1	4	0
MPM	14	3	8	3	0	4	5	5	0	1	2	0	9
KZD	12	3	7	2	0	7	5	1	0	1	3	1	5
WYD	3	0	0	0	0	0	2	0	0	0	0	0	2
KNR	9	0	1	7	1	0	1	6	0	0	1	2	1
KSD	4	3	3	1	0	0	1	3	0	0	0	0	0
STATE	149	13	32	38	53	24	38	38	31	3	11	10	60

Source: Calculated from various publications of Evaluation and Monitoring Unit(DOA)

In the Mundakan season, in the 0-25 per cent level of adoption, the districts of Kollam, Alapuzha, Ernakulam, Malapuram and Kozhikode have 2-7 blocks and the districts of Thiruvanathapuram, Pathanamthitta and Thrissur have one block each. In the 25-50 per cent level of adoption, Thiruvanathapuram, Kollam Ernakulam,Thrissur, Palakkad, Malapuram, Wayanad and Kozhikode have 2-6 blocks. The districts of Kasargode, Kannur Kottayam,and Alapuzha have one block each. In the 50-75 per cent adoption level,Thiruvanathapuram,Kollam, Pathanamthitta, Ernakulam, Thrissur,Palakkad, Malappuram, Kannur, and Kasargode have 2-6 blocks and Kozikode has one block. In the 75- 100 per cent level of adoption, the districts of Pathanamthitta,Alapuzha, Kottayam, Idukki, Thrissur and Palakkad have blocks from 2-9.

In the punja season, Thiruvanathapuram, Malapuram and

Kozhikode have only one block each in the 0-25 per cent level of adoption. In the 25-50 per cent level of adoption, Thiruvanathapuram, Kollam,Kottayam, Palakkad, Malappuram,Kozhikode and Kannur,have 1-3 blocks. In the 50-75 per cent level of adoption, Thiruvanathapuram, Ernakulam, Palakad, Kozhikode, and Kannur have 1-4 blocks and in the 70-100 per cent range of adoption, all the districts except Thiruvanathapuram, Kollam, Kottayam, Palakad, and Kasargode have blocks from 1-14.

Thus, it is interesting to note that the HYV adoption varies from season to season and from district to district. To understand this further, we have classified the HYV adoption levels according to the agroclimatic zones . The details are furnished in Table 4.11.

Table: 4:11: Number of Blocks Which Have Adopted HYV at Different Levels at Different Zones

ZONES	TOTAL NO OF BLOCKS	VIRIPPU				MUNDAKAN				PUNJA			
		0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
SOUTHERN	38	6	19	12	1	12	12	14	0	2	6	3	14
CENTRAL	34	1	10	7	11	4	10	11	6	0	1	6	18
SOUTHERN	44	4	1	15	22	6	13	12	12	1	4	1	12
HIGH RANGE ZONE	11	1	1	1	5	0	2	0	3	0	0	0	2
PROBLEM ZONE	22	1	1	3	14	2	1	1	10	0	0	0	14
TOTAL	149	13	32	38	53	24	38	38	31	3	11	10	60

Source:Same as Table 4.10

Northern Zone:

In the virippu season, in the 0-25 per cent range of adoption there are 25 blocks. Out of these seven have adoption below 25 per cent which are mostly blocks of the Malappuram and Kozhikode sub-divisions. The blocks of Tirur,Thaliparambu, Badagara, Kozhikode, Thalassery, Kannur and Kasagrode which falls under the coastal, alluvial, rainfed tract, a unique system of rice cultivation known as the `kaipad' cultivation is practises where only one crop is sown in virippu. The rice cultivation is unique as the crop is raised in the fields adjoining river mouths which are subjected to salt water intrusion. There are mounds to wash of the salinity. Since there are no HYV's suitable for this sort of cultivation, only tall local varieties are preferred. Hence adoption of HYV,s is low in Virippu in these blocks. After the crop is harvested, prawn culture is done and so no plant protection measures is followed for fear of chemical pollution. So local varieties are preferred which do not require much of fertilisers and insecticides.

In the virippu, the weed competition is severe. The virippu in the northern zone is affected by early drought and floods in the later stages. Since majority of the virippu crop is sown under semi-dry conditions, it is affected by intermittent floods during the vegetative and reproductive phases. Therefore, varieties which are lodging resistant, semitall with more straw are required. Moreover, in the deep laterite areas of Malappuram, Perinthalmanna, Kozhikode, Badagara the problem of iron toxicity is severe. Therefore, varieties resistant to iron toxicity is required.

In the 50-100 per cent range there are 13 blocks.Out of these Kuthuparambu,Irikkur, Iritty and Kannur have 100 per cent adoption. These blocks of Nilambur, Koduvally, Kunnumangalam, Thaliparambu, Thalassery, Kuthuparambu, Peravoor, Idakkad, Kannur etc fall in the shadow high level, low plateau, non-saline and rainfed tract. It is an agriculturally important tract with 46 per cent area under the zone. The laterite but organically deficient soils are well drained and respond to good manurial practices. Thus, there is high adoption of HYV in line with the recommended practices. Water resources are also in plenty.

The HYV's are highly prone to pests like Brown Pest Hopper and diseases like the sheath blight and blast. The varieties should have multiple resistance. In the Mundakan season, in the 0-50 per cent range of adoption there are twenty blocks and twelve fall below the twenty five per cent range. These mainly belong to Malappuram, Badagara and Kozhikode blocks. The deep laterite areas of Kannur Kasargode Badagara are subject to saline intrusion.The mundakan crop is affected by drought in the reproductive phases. It is also subject to pests like stem borer, Brown pest Hopper, Blast, sheath blight etc. The agriculture potent is low in the soils due to intensive laterisation and deficiency in organic matter of the alluvial,non-saline irrigated tract. The rice crop is not irrigated due to the porous nature of the soil. Semi-tall local varieties with more straw are preferred. Mostly prawn culture is taken after virippu.

Some blocks of face scarcity of water and mundakan crop is not cultivated. There is direct sowing in some areas. Tall local varieties are preferred, as the HYV's are susceptible to maladies like iron toxicity, flood, drought, pests and diseases. Thus the vagaries of weather prevent balanced manuring. The dry spell in these months cause less adoption of HYV as there is no supplementary irrigation.

In the 50-100 per cent range there are ten blocks. Four of them have 100 per cent adoption due to availability of water like those in the irrigated tract with rivers and canal irrigation. In the Punja, eight blocks fall in the 0-50 per cent adoption.mostly in Manjeri and Nilambur blocks This is due to the dry spell in November to May with no supplementary adoption. In the 50 -100 range, there are sixteen blocks and four have 100 per cent adoption. These blocks fall in the alluvial, non-saline irrigated tract which has lift and basin irrigation.

Southern Zone:

The southern zone comprise the districts of Trivandrum, Pathanamthitta, parts of Kollam, Allapuzha and Kottayam. In the 0-50 per cent range of adoption, there are five blocks and four blocks fall below 0-25 percent. This is because in the block of Parasala, Nemom and other parts of Kollam and Alapuzha which fall under the coastal wetland, the salt intrusion is high and the water holding capacity of the soil is low.

In the 50 -100 per cent range of adoption, there are thirty seven blocks and four blocks have 100 per cent adoption in Pathanamthitta and Kottayam. Thirty two blocks of the midland, wet medium elevation hydromorphic soils and irrigated tract have high adoption in HYV especially in Virippu. These are the low lying areas of the zone and covers sixty five per cent of the zone. The soils are poor in nutrients but respond well to management practices like blocks of Panthalam, Elanthoor, Lalam etc. Some blocks in the district of Kollam have low adoption due to floods in virippu. Moreover, preference for red rice and high straw content is still prevalent. There are no varieties to replace the local cheradi which is used here. This is because the HYV to fight the flood and the drought conditions are unavailable. The soils are acidic and interlogging with restricted drainage and dependent on irrigation especially in Trivandrum. So the blocks of Adoor, Neyatinkara, Kotarakara and Attingal adopted Kootumundakan where both the crops seeds are sown to fight the dry as well as flood conditions. Since there are no suitable varieties local varieties are used. These blocks fall under the medium elevation, low lands salinity and rainfed tract. They face endemic occurrence of sheath blight and sheath rot leading to low filling of the grain. It is also prone to the rice bug attack at the seed setting stage. Hence, HYV adoption is affected in Neyatinkara and Ithikara, Chitumala, Perumkadavila etc. Lack of irrigation makes rice based cultivation fallow. Thus there is no availability of drought resistant variety. There is lack of short duration varieties,suitable varieties suited to saline kayal lands for kootumundakan,.

In mundakan, in the 0-50 per range,there are 19 blocks and 6 fall below 25 per cent adoption.The blocks of Neyatinkara, Nemom, Athiyanoor and Parasala have low water holding capacity of the soil and fear of washing of fertilisers leads to low adoption of HYV. Since, these are rainfed tracts, washing of basal fertilisers is common. The kutticheradi and japan cheradi is preferred where there is no water. The blocks of Kottarakkara, Konny and Paracode are susceptible to sheath blight. There is saline intrusion in the low land coastal areas especially in Shertallai, Parasala and the there is risk of floods so resistant varieties are needed though the south west monsoon provides much water.

There are twenty four blocks in 50-100 per cent and five from Kottayam and Pathanmthittaa have 100 per cent,in the punja five blocks fall in the 0-50 because of lack of water like in Eratupetta and Ithikara,and thirteen in the 50-100, nine have 100 per cent adoption. This is because areas in Kottayam and Pathanamthitta are well irrigated and though the soils are poor and acidic they respond to good water management practices.

Central Zone:

The central zone comprises of the districts of Palakkad, parts of Ernakulam and Thrissur excluding the Kole and the Pokkali lands. This zone is a well irrigated area and accounts for 61 per cent of the total irrigated area in the state. Apart from the heavy monsoons, supplementary irrigation is available especially in summer through lift irrigation, ponds and wells. In the virippu, eleven blocks which fall under the 0-50 per cent range. Only Parur block falls below 25 per cent. Virippu is dry sown and subsequently maintained under water logged conditions. The blocks of Manarkad, Sreekrishnapuram, Thrithala, Pattambi,Ottapalam,fall in medium elevation and high rainfall and is subject to floods. The practice of Kootumundakan is getting popular. It is dependent on rain. Application of basal fertilisers and top dressing is difficult due to heavy down pour after the onset of the south west monsoon. The rains in the maturity problem create problems hence adoption is low as there is no varieties that is flood resistant. In the 50 -100 per cent range, there are eighteen blocks, The blocks of

Chalakudy, Vellangallur, Pazhayannor fall in the high elevation and high rainfall. Though the adoption is high adoption of fertilisers is a problem the blocks of Mulamthuruthy, Alangad, and Parakadavu fall under the medium elevation and high rainfall. These are subject to flood risk.

In the mundakan, in the 0-50 per cent range, there are fourteen blocks,and onlt the block of Angamali falls below 25 per cent. The blocks of Angamali, Sreekrishnapuram, Ottapalam, Thrithala and Pattambi in the medium elevation and high rainfall run the risk of floods. The blocks of Kothamangalam, Chalakudy, Chavakkad and Chovanur in the high elevation and high rain run the risk of washing of fertilisers.

In the 50-00 per cent there are seventeen blocks. The blocks of Alathur, Coyalman, Palakkad and Nenmara fall in high elevation, This is called the Palakkad gap tract and the rice bowl of Kerala. Nenmara has 100 per cent adoption. The blocks of Kollengode fall in High elevation and low rainfall and Chittur which fall in the medium elevation black soils have no proper varieties. The blocks of Moovatupuzha Kodakara and Ollukara fall in the high elevation and high rainfall.

In the punja, there is no block in 0-50 per cent range as supplementary irrigation is available. All the blocks have higher adoption of HYV in the 50-100 per cent range, there are twenty blocks blocks and three has 100 per cent adoption. However the varieties are subject to Brown Hopper, Leaf roller, stem borer, and diseases like bacterial blight and sheath. Varieties with resistance in early virippu and late mundakan is needed.

Problem soils:

In the 0-50 per cent range of adoption, there are two blocks. Vypeen of the pokali has below 25 percent where the soils are clay and acidic. Edapally and Vypeen are pokali soils where rice based prawn culture is done. Since no plant protection is followed due to fear of chemical pollution local varieties that are tall are used. A tall variety with short duration crop tolerant to water logging and acidity is to be evolved. The newly evolved vytilla 3 does not satisfy these requirements and moreover the HYVs are not available which affects adoption. In the 50-100 per cent range, there are seventeen blocks in the Onattukara Kole Kayal and Kuttanad areas.However eight blocks in Kuttanad area fall in 100 per cent adoption. Mavelikara, Haripad, Muthukulam in Alapuzha district Karunagapally and Oachira in Kollam fall in the Onattukara tract (Onam-ootum-kara means ushering in plenty) which was once a high yielding area has become a problem tract. These blocks covers 11.3 per cent of these two districts. Rice is raised in the lowlands in Virippu and Mundakan. The soil has moderate permeability HYV is virippu is high, however the water shortage in early virippu and flood in later period is a problem. The frequent floods and the impeded drainage make it difficult for the application of inorganic fertilisers to the virippu crop. Application of the organic manure to these soils are indispensable to improve the soil texture and nutrient status. Pest and diseases like earhead caterpillar and sheath blight are common. The blocks of Champakulam, Velianad, Pallom, Vaikom, Etumanur and Kaduthuruthy fall in Kuttanad region.

The crop is risky in virippu due to floods, poor nutrient status and toxicity affects the crop acidity and salinity affect the crops. The crop is harvested before the floods and short duration varieties are required. Karunagapally falls in kootumundakan areas where the kootumundakan is a system of cultivation which is a system of insurance against the crop loss. There is mixed sowing of virippu and mundakan crop in virippu in the proportion of 3:1 in April or May. The virippu crop is harvested in August and the stubbles of Mundakan is allowed to grow and harvested in December. The yield is more in virippu. There is lack of flood and salt resistant varieties. So the local chettivirippu is grown. There is also need to develop the genetic improvement in the orumundakan variety because plant protection measures is difficult to be applied as it grows tall. Varieties are prone to pests like leaf roller, Brown Hopper, rice stem bore, thrips, and gall midge and diseases like sheath blight, blast rot, and stack burn.

In the mundakan, there are three blocks in the 0-50 per cent of adoption. The blocks of Karunagapally, Aryad and Edapally fall below 25 per cent. Aryad and Karunagappaly fall in the kootumundakan area and hence the adoption of HYV is low. The block of Puzkakhal comes under the Kole which has flood in mundakan. It is subject to Brown Pest Hopper. In the 50-100 per cent range, there are eleven blocks and seven falls below 25 percent. The areas belong to the kole lands,and Kuttanad areas. The Kole lands of Anthicad, Cherpu , Mullasery and Ponnani have floods in mundakan.The other blocks of Kuttanad, like Ambalapuzha,,Haripad, Muthukulam are poorly drained with slow permeability . It is prone to salt water intrusion. The weeds like salviniae molesta is a problem. In the punja, there are no blocks with 0-50 per cent adoption. In the 50-100 range, all the fourteen blocks have 100 per cent adoption. Erratic monsoons cause water scarcity in punja in the blocks of Mavelikara.The coverage of blocks in Kottayam like Etumanoor, Vaikom, Kaduthuruthy,Pallom in Kayal lands have high coverage in Punja. However, there is salinity and acidity HYV's are adopted though it is not salt resistant. The Kole lands of Anthicad, Cherpu, Puzhakal, Mullasery, Ponnani have salinity in summer.

High Ranges:

In the virippu, there are two blocks in the 0-50 per cent range ie. Kattapana and Nedumkandom , while in the 50-100 per cent range there are six blocks and four have 100 per cent adoption. the adoption is high as the soils are good and respond to the recommended practices. In mundakan, Kattapana and Manathavady fall in the 0-50 per cent range while Thodupuzha, Elamdesom and Idukki have 100 per cent adoption. In the punja the blocks of Kalpetta and Mananthavady have adoption in the 50-100 per cent adoption.

A Disaggregate Analysis:

The levels of HYV adoption is studied among group farming(an institutional innovation introduced to avoid the diseconomies of scale due to small holdings) and the non-group farming areas as well as irrigated and unirrigated areas. The level of adoption is classified into of 0-25 per cent, 25-50 per cent, 50-75 per cent and 75-100 per cent. The details are given in table 4.12 and 4.13. and appendix tables 4.1, 4.2, 4.3, and 4.4.

Table 4.12: Number of blocks HYV adopted in each zone un er group Farming and on-groupfarming and non group farming

HYV adopted		Virippu G	Virippu NG	Mundakan G	Mundakan NG	Punja G	Punja NG
	I	2	16	5	16	4	3
	II	1	7	6	14	2	0
0-25%	III	0	3	5	3	0	0
	IV	0	0	0	1	2	0
	V	1	1	2	1	0	0
	I	14	16	11	15	5	6
	II	5	3	11	9	2	0
25-50%	III	6	7	9	5	1	0
	IV	0	1	0	0	0	0
	V	0	4	0	1	0	2
	I	12	3	14	1	1	6
	II	11	11	10	3	2	2
50-75%	III	11	0	10	1	5	2
	IV	1	0	3	0	0	1
	V	1	2	2	0	0	1
	I	10	0	3	1	14	8
	II	24	13	17	8	9	11
75-100%	III	11	8	7	3	17	3
	IV	5	5	4	3	3	2
	V	18	7	11	4	10	7

GF _ Group Farming; NG - Non Group Farming;
I - Northern Zone; II - Southern Zone; III - Central Zone;
IV - High Range; V - Problem Zone

Source: Same as Table 4.10

In the virippu season,the adoption of HYV in group farming areas is quite high(135 blocks). In the 0-25 range of adoption, out of four blocks two belongs to the northern zone. Patanakad in Alapuzha and Vpeen in Pokkali are the others. In the mundakan, five blocks are from southern zone, six from central zone five from northern zone and three from problem zone. In the punja season, out of eight blocks, four belong to northern zone and two belong to the high range. In the 25-50 per cent range of adoption, twenty six blocks belong to northern zone. In the mundakan season out of thirty one blocks, most of the blocks belong to southern northern and central zones.In the punja season, out of eight blocks, all belong to the northern zone. In the 50 - 75 per cent range, out of thirty seven blocks in virippu, the blocks are spread in all zones. In the mundakan season, out of thirty eight blocks, the blocks are spread in all zones, but in the punja, out of nine blocks most of them are in the central zone. In the 75 -100 per cent range, out of sixty eight blocks in virippu, most of the blocks belong to southern and central zone and in the mundakan season, out of fourty one blocks the blocks are spread in all zones In the punja season, out of fifty seven blocks most of them belong to the central zone.

HYV in the Non-Group farming areas:

In the 0-25 per cent range of adoption, virippu has twenty eight blocks, in the punja there are three blocks both with more blocks in the northern zone. In the mundakan, there are thirty six blocks with more in both south and north zones. In the 25-50 per cent range of adoption,virippu has thirty one blocks, mundakan has twenty nine blocks and punja has eight blocks all with maximum blocks in the northern zone. In the 50 to 75 range, sixteen blocks belong to virippu,five in mundakan and eleven in punja with more blocks under southern zone.

In the 75-100 per cent level of adoption, there are thirty two blocks in virippu, with more in the high range central and southern zone. In the mundakan, there are nineteen blocks with more blocks of problem zone and high range. In the punja,there are thirty one blocks, with blocks of southern,high range and problem zone.

Table 4.13 : HYV In Irrigated Areas: Number Of Blocks That Have Adopted HYV In Each Zone Under Irrigated And Unirrigated Areas

LEVEL OF ADOPTION (%)	VIRIPPU		MUNDAKAN		PUNJA	
	I	UI	I	UI	I	UI
0-25						
I	11		9	3	1	1
II	10		10		1	3
III	6	5	4	5	4	4
IV			1			1
V	3		1	3		
25-50						
I	1		2	5	2	3
II	5		2	2		3
III	7		12	2		2
IV	2		1			
V	1	2	1	1		
50-75						
I		1	4	4	4	8
II	1	3	6	4	2	2
III	3	7		8	1	
IV		2		1	1	
V		2				1
75-100						
I		36	8	20	14	2
II	2	29	8	22	7	7
III	6	14	12	14	17	6
IV		6		5	2	
V	5	12	2	8	7	10

Source: Same as table 4.10

In the 0-25 range, there thirty blocks under virippu all in the southern,central and northern blocks. In the mundakan, there are twenty five blocks all in the northern zone and in the punja all the blocks are in central zone.

In the 25-50 per cent range, out of sixteen blocks most of them belong to the central, high range and southern zone. In mundakan, there are eighteen blocks, mostly in the central zone. In punja, the two blocks belong to northern zone. In the 50-75 per cent range, there are four blocks in virippu mostly in the central zone, in the mundakan out of the ten blocks, these belong to both the southern and northern zone. In the punja, out of eight blocks these belong to the northern and high range zone. In the 75-100 per cent adoption, out of thirteen blocks,these belong to the southern and central zones and in mundakan there are eighty three blocks which mostly belong to the central and northern zone. In the punja, there are forty nine blocks mostly belonging all the zones excluding high range.

In the unirrigated areas, in the 0-25 per cent range of adoption, there are five blocks in virippu with most blocks under the central zone. In the mundakan, there are twelve blocks, in both the central and northern zone, and in punja out of the blocks belong to the central and the high range. In the 25-50 per cent range, the four blocks belong to all zones,and in mundakan the ten blocks belong mostly to the northern and central zone In the in the punja, there are eight blocks, in the northern and southern zone. In the 50-75 per cent range, the fifteen blocks in the virippu belong to the southern, central and high range. In the seventeen blocks under mundakan, these belong to the southern,northern and central zone.In the punja out of eleven blocks, more blocks are in the northern zone apart from the southern zone.

In the 75-100 per cent range, out of ninety seven blocks, in the virippu, most blocks are from central, northern and high range. In the mundakan, out of sixty nine blocks, the blocks belong to all zones except the problem zone. in the punja, out of twenty five blocks, there are twenty five blocks mostly in the Kuttanad region and the central zone.

TABLE 4.14: Percentage of HYV adoption in different seasons and districts

Districts	Virippu	Mundakan	Punja	Total
TVM	57.45	43.21	49.89	50.35
KLM	80.62	32.71	24.13	55.78
PTA	51.3	93.32	99.43	80.59
ALP	81.05	74.46	99.61	88.43
KTM	98.49	97.05	54.85	82.09
IDK	78.04	100	0	85.68
ENK	71.71	34.01	79.83	59.66
TSR	62.34	50.7	90.75	58.43
PKD	89.28	80.24	55.38	79.1
MLP	43.81	40.74	87.89	45.99
KZH	46.57	29.91	75.45	45.82
WND	0	55.83	92.83	63.11
KNR	57.34	55.12	59.91	56.55
KSD	41.76	51.46	0	45.51
Tot.	74.54	58.45	44.2	44.52

Source: Same as 4.10

On the whole there is 44.52 per cent of HYV adoption in the State. In virippu, it is 74.54 per cenr while it is as low as 44.2 in the Punja. Comapring it with table 4.6, we find that the yield is highest for punja. This observation needs attention as the factor that affects the adoption of this biological technology - HYV- is not yield, but other factors like minimum risk as seen in our analysis. This may be the prme factor respensible for the transition in food crops to commercial crops witnessed in our State for the past one decade.

Need for location specific research

(1) Varieties for Mundakan

Most of the HYV's presently recommended in Kerala are dwarf and period bound. These varieties are capable of exhibiting during Virippu and Punja seasons. But these varieties are quite unreliable during mundakan season. It has been now well recognised that specific varieties are required for mundakan season in Kerala.

Therefore, it is aimed to breed varieties with tall structure assuring good straw yield and with bulk in photosensitivity maintaining good grain yield. Such varieties are expected to tolerate seedling ageing. The VIIIth Plan has launched a major thrust in this area of breeding. The hybridisation programmes are cantered around improving the traditional varieties like CO25 and Ptb 20.

(2) Drought tolerant varieties for rainfed Uplands or modan lands

There are lands where one rice crop is taken during the virippu season as a purely rainfed dry sown crop. The uncertainty of moisture conditions and the heavy weed growth are the most important features of these lands. The important characteristics needed for successful varieties for these are:

* Good initial seedling vigour to compete with weed growth;
* Resistance/tolerance to drought;
* Moderate resistance to diseases especially rice blast
* Short duration not exceeding 115 days
* Tolerance to logging
* Good yield at moderate level of manuring.

Local varieties suited to these conditions are Pth 28, Pth 29 and Pth 30. Among the HYV's released `Suvarnmadan' and `Swarnaprabha' are suited to these conditions.

(3) Varieties for dry sown virippu crop

Areas with initial drought followed by flooding of fields require suitable varieties. Such varieties should be able to withstand initial drought, should have the initial vigour to compete with the excessive weed growth, and resistance to lodging such varieties are yet to be identified.

(4) Varieties with broad Spectrum of Pest and Disease Tolerance

Susceptibility of HYV's to pests and disease increases the cost of cultivation. Sometimes this will lead to complete crop loss. Therefore, varieties having a broad spectrum of pest and disease tolerance is the only solution to such maladies. Evolution of such varieties have been attempted and promising varieties were identified. KAU 1727 (Pth 46), the variety released from Pattambi combine in its resistance to all the three biotype of brown plant hopper, green leaf hopper, sheath blight and bacterial leaf stream.

(5) Varieties with high yielding potentials for Kole and Kuttanad

Kole and Kuttanad are organic rich soils where even the ordinary HYV's can express high yield potential of 8-10 t/ha. There is a need to evolve varieties with very high yield potentials so that production can be increased significantly.

(6) Varieties suited for problems prone areas.

They are:

(a) Varieties suited for special soil situation

(b) Varieties for high altitude areas

(c) Varieties for flood prone areas

(d) Better varieties for special systems of cultivation like `Koottumundakan' and `Kaipad'.

(e) Varieties with good yield for areas suffering from water scarcity during mundakan.

APPENDIX 4.1

HYV IN IRRIGATED AREAS

	VIRIPPU	MUNDAKAN	PUNCHA
0-25	Nemom (S 18.1), Vellanad (S 12.5) Vamanapuram (S 24.14), Ithikkara (S 7.15) Chittumala (S 9.2), Pathanapuram (S 16.69) Sasthamkotta (S 14.38), Parakode (S 9.7) Elanthoor (S 17.24), Lalam (S 2.7) Pampakuda (C 13.41), Cherppu (P 2.2) Kodakara (C 22.1), Puzhakkal (P 16.27) Koyalman (C 10.16), Mannarkkadu (C 17.4) Ottappalam (C 17.89), Thrithala (C 6.4) Ponnani (P 19.3), Valancherry (N 15.5) Tanur (N 1.32), Nilambur (N 19.74) Wandoor (N 6.2), Kondotty (N 22.6) Manjeri (N 1.08), Malappuram (N 7.06) Mankada (N 11.5), Vengara (N 2.4) Thaliparambu (N 0.26), Iritti (N 0.72)	Chirayinkil (S 0.9), Varkala (S 0.57) Nedumangadu (S 19.18), Vellanad (S 11.78) Ithikkara (S 8.2), Pathanapuram (S 21.4) Kulanada (S 14.5), Mallappally (S 6.4) Lalam (S 5.9), Uzhavoor (S 16.98) Puzhakkal (P 18.43), Chovannur (C 2.1) Pazhayannur (C 11.6), Wakakkancherry (C 19.8) Coyalman (C 0.02), Andathodu (N 21.5) Valancherry (N 24.71), Thanur (N 22.03) Nilamboor (N 22.28), Kondotti (N 10.8) Mylady (N 3.6), Perambra (N 4.6) Mananthavady (H 21.96), S.Bettery (H 20.23) Thalassery (N 0.27)	Athiyannoor (S 18.03), Mulanthuruthy (C 12.93) Chalakudy (C 14.33), Irinjalakuda (C 7.38) Mala (C 24.84), Pandalayani (N 2.6)
25-50	Athiyannoor(S 39.27), Perumkadavila (S50) Chirayinkil (S 43.36), Nedumangad(S 34.9) Koippuram (S 37.03), Vaikom (P 28) Moovatupuzha(C 27.5), Kotamangalam(C 48.5) Mulanthuruthy(C 25.63), Ollukara (C 28.6) Vellangallur(C 35.8), Irinjalakuda(C 15.4) Nedumkandom (H 14.21)	Paracode (S37.19), Elanthuoor (S 36.97) Moovatupuzha (C 50), Kotamangalam (C 33.8) Pambakuda (C 37.4), Mulathuruthy (C 46.9) Kodakara (C 34.03), Vellangallur (C 32.6) Irinjalakuda (C 45.3), Mannakadu (C 43.2) Sreekrishnapuram (C 30.66) Ottappalam (C 50), Patambi (C 44.8) Thrithala (C 47.3), Ponnani (P 32.2) Kalpatta (H 26.4), Thaliparambu (N 31.7) Edakkadu (N 33.6), Irikkur (N 34.96)	Tirur (N 40.6), Koduvalli (N 34)
50-75	Chengannur (S 62.95), Alangadu (C73.07) Parakadau (C 70.23), Mala (C 75)	Athiyannor (S 57.79), Nemom (S 68.7) Perumkadavila (S 52.43), Vamanapuram (S 72.51) Sasthamkotta (S 70.01), Koipuram (S 58.43) Tirur (N 69.73), Perunthalmanna (N 69.5) Payyannur (N 1.13), Iritty (N 64.75)	Parassala (S 68.75), Koippuram (S 72.18) Kothamangalam (C 60), Valancherry (N 55.69) Kozhikode (N 56.42), Balussery (N 54) Melady (N 72), S.Batheri (H 71)

VIRIPPU	MUNDAKAN	PUNCHA
75-100 Aryad (S 99.87), Ambalapuzha (S 100) Thaikkattusseri (S 100), Kanjikuzhi (S 100), Chambakula (S 100) Velianad (S 100), Irinjalakuda (S 76.45) Chalakkudy (S 87.24), Pazhayannur (S 76.41), Nenmara (S 100) Chittoor (S 82.67), Kollengode (S 90.04) Palakkad (S 90.34)	Parassala (S 100), Parakode (S 100) Pandalam (S 100), Kulanada (S 100) Kanjikuzhi (S 100), Thaikattusseri (S 100) Pattanakkadu (S 100), Bharanikkavu (S 100) Parakkadavu (C 87.9), Alangadu (C 100) Angamali (C 100), Vazhakkula (C 82.01) Vaduvancode (C 100), Koovappady (C 100) Anthikkadu (P 100), Cherppu (P 87.02) Ollurkkara (C 85.8), Chalakkudy (C 82.36) Nenmara (C 100), Chittoor (C 100) Kollengode (C 100), Palakkad (C 99.35) Manjerry (N 100), Malappuram (N 100) Mankada (N 95.3), Vengara (N 90.78) Manjeswaram (N 98.32), Kasargode (N93.58) Kanjangad (N 100), Nileswar (N 100)	Elanthoor (S 100), Panthalam (S 78.8) Kulanada (S 100), Nelliampathy (S 78.04) Pulikeezh(S 91.040, Aryad (P 100) Ambalapuzha (P 100), Chengannur (S 90.81) Mavelikkara (P 100), Bharanikavu (S 100) Champakulam(P 100), Alangadu (C 100) Parakkadavu (C 96.46), Angamali (C 100) Vazhakulam (C 100), Vaduvacode (C 100) Koovapady (C 100), Anthikad (P 100) Cherppu (P 100), Kodakara (C 100) Ollukara (C 100), Puzakkal (P 100) Vellangallur (C 80.79),Chalakkudy (C 93.47) Irinjalakuda (C 91.39), Mala (C 93.43) Mannarkkadu (C 100), Sreekrishnapuram (C 98.95) Ottappalam (C 100), Pattambi (C 100) Erattupettah (S 100), Andathodu (N 100) Nilambur (N 87.08), Vandoor (N 100) Kondotti (N 100), Manjeri (N 100) Malappuram (N 100), Mankada (N 100), Vengara (N 100), Cholannur (N 91.42) Kalpatta (H 100), Mananthavady (H 98) Payyannur (N 100), Kuthuparambu (N 79.8) Idakkadu (N 100), Irikkoor (N 100) Iritti (N 100)

Source: Same as 4.10

APPENDIX 4.2

UNIRRIGATED AREA UNDER HYV

VIRIPPU	MUNDAKAN	PUNCHA
0-25		
Chalakkudy (C 12.75), Mala (C 24.54)	Uzhavannur (S 20.36), Parakadavu (C 9.8)	Elanthur(S 21.42), Pandalam (S 15.3)
Chittur (C 5.08), Kollengode (C 9.9)	Cherppu (P 8.9), Ollurkkara (C 14.19)	Koippuram (S 25), Vellangallur (C 18.86)
Palakkad (C 23.9)	Puzhakkal (P 23.84), Chalakkudy (C 16.22)	Chalakkudi (C 6.5), Mala (C 8.6)
	Mala (C 26.04), Palakkad (N 0.64)	Sreekrishnapuram (C 1.04),
	Ponnani (P 23.17), Wandoor (N 13.3)	Tirurangadi (N 12.9), Sultanbathery (H 17.44)
	Mankada (N 4.6), Kasargode (N 6.4)	
25-50		
Perumkadavila (S 49.34),	Athiyannur (S 42.2), Perunkadavila (S 47.5)	Parassala (S 31.25), Koippuram (S 22.8)
Irinjalakuda (C 49.57), Ponnani(P 39.49)	Muvattupuzha (C 47.26), Mullassery (P 33.27)	Mallappally (S 33.26),
Tirur (N 37.48)	Ottappalam (C 44.31), Perinthalmanna (N 30.48)	Valancherry (N 44.3),
	Balusserry (N 29.62), Payyannur (N 38.86)	Cholannur (N 26.43), Kozhikode (N 38.8)
	Kadakkal (N 48.71), Iritti (N 35.1)	Kunnamangalam (N 43.62), Irikkur (N 48)
50-75		
Athiyannur (S 60.68), Ithikara (S 92.42)	Nemom (S 73.5), Chittumala (S 59.7)	Athiyannur (S 81.96), Nemom (S 100)
Chengannur(S 68.58), Champakkulam(P 55.9)	Parakodu (S 62.81), Elanthur (S 62.8)	Ponnani (P 59.33), Pandalayani (N 73.2)
Veliayanadu (P 55.3), Alangadu (C 61.53)	Kothamangalam (C. 66.15),	Balusseri (N 62.3), Perambra (N 70)
Muvattupuzha (C 72.34),	Mulanthuruthy (C 53.07), Kodakara (C 65.9)	Melady (N 59.1), Payyannur (N 55.5)
Kothamangalam (C 54.49)	Velangallur (C 67.3),	Kuthuparambu (N 69.25), Edakkadu (N 71.4)
Mulanthuruthy (C 67.46), Ollukara (C71.3)	Irinjalakuda (C 50.27), Mannarkadu (C 56.76)	Iritti (N 51. 68)
Velangallur (C 64.1)	Pattambi (C 55.27), Thrithala (C 63.8)	
Thrithala (C 53.7),	Tirur (N 73.27), Vengara (N 9.2)	
Tirurangadi (N 73.9) Kattappana (H 61.5)	Taliparambu (N 68), Irikkur (N 56.8)	
Nedungandam(H 65.83)	Kalpatta (H 73.5)	

VIRIPPU	MUNDAKAN	PUNCHA
75-100		
Nemom (S 81.89), Parassala (S 100),	Ithikara (S 91.8), Mukhathala (S 100)	Ithikkara (P 100), Chavara (S 100)
Mukhathala (S 100), Anjalmudu (S 100)	Anchalmoodu (S 100), Karunagappally (P 100)	Elanthur (S 76.1), Aryad (P 100)
Chavara (S 100), Karunagappalli (P 100)	Kulasekharapuram (S 100)	Ambalapuzha (P 92.8), Chengannur (S 81.4)
Oachira (P 100), Chittumala (S 100)	Kottarakkara (S 100), Vettikavala (S 100)	Chambakulam (P 97), Velianadu (P 99)
Kottarakkar(S 100), Vettikavala (S 100)	Chadayamangalam (S 100), Anchal (S 100)	Mavelikkara (P 100), Bharanikkavu (S 100)
Chadayamangalam (S 100), Anjal (S 100)	Pathanapuram (S 78.5), Sasthamkotta (S 91.1)	Harippadu (P 100), Uzhavur (S 100)
Pathanapuram (S 82), Sasthamkotta (S 9.19)	Konni (S 100), Pandalam (S 100)	Vaikkom (P 100), Kaduthuruthi (P 100)
Konni (S 100), Parakode (S 90.2)	Kulanada (S 100), Pulikizhu (S 100)	Ettumanoor (P 100), Pallom (P 100)
Elanthur (S 76.4), Pandalam (S 100)	Mallappally (S 93.5), Ranni (S 100)	Madappalli (S 100), Mulanthuruthy (C 79.4)
Kulanada (S 100), Koippuram (S 100)	Aryad (P 100), Ambalapuzha (P 100)	Angamali (C 100), Vazhakulam (C 100)
Mallapplly (S 100), Ranni (S 100)	Thikkattusseri (S 100), Chengannur (S 91)	Vaduvakkodu (C 100), Koovapadi (C 100)
Pattanakkadu(S 100), Thaikkattusseri(S 86)	Lalam (S 94), Vaikkom (P 100)	Attapadi (C 100), Thondannur (N 100),
Kanjikuzhi (S 100), Lalam (S 97.2)	Kaduthuruthi (P 100), Ettumanoor (P 100)	Koduvalli (N 79.59)
Uzhavur (S 100), Erattupetta (S 100)	Pallom (P 100), Madappali (S 100),	
Vaikkom (P 96.4), Kaduthuruthi (P 98.5)	Pambadi (S 100), Vazhoor (S 100),	
Ettumanoor (P 97.1), Pallam (P 100)	Edappalli (P 100), Pambakuda (C 86.5)	
Madappalli (S 100), Pampady (S 100)	Angamali (C 100), Vazhakulam (C 100)	
Vazhadi (S 100), Edappalli (P 100)	Vaduvakkodu (C 100), Koovapadi (C 100)	
N.Parur (C 100), Vpyeen(P 100)	Chavakkadu (C 100), Chovannur (C 100)	
Anthikadu (P 100), Cherppu (P 100)	Pazhayannur (C 88.26), Vadakkancherry (C81.1)	
Kodakara (C 77.21), Puzhakkal (P 83.7)	Alathur (C 97), Koyalman (C 98.20	
Irinjakakuda (C 86), Chavakkadu (C 100)	Nenmara (C 92), Attappadi (C 100)	
Chovannur (C 100), Mullasseri (P 100)	Sreekrishnapuram (C 98.2)	
Pazhayannur (89.3), Vadakkancherry (C100)	Andathod (N 78.5), Valancherry (N 75)	
Alathur (C 100), Koyalman (C 95.2)	Tirurangadin(N 77.9), Thanur (N 79.8)	
Nenmara (C 100), Mannarkad (C 82.5)	Nilambur (N 77.7), Kondotti (N 100)	
Sreekrishnapuram (C 100)	Kozhikode (N 100), Cholannur (N 100)	
Ottappalam (C 82.11), Pattambi (C 85.6)	Pandalayani (N 100), Kunnamangalam (N 100)	
Andathodu (N 100), Valancherry (N 84.4)	Vadakara (N 100), Thunneri (N 100)	
Thanur (N 98.6), Nilambur (N 80.2)	Kunnummal (N 100), Thondannur (N 100)	
Wandoor(N 93.7), Kondotty (N 77.3)	Koduvalli (N 100), Meladi (N 100)	
Manjeri (N 98.1), Malappuram (N 92.9)	Perambra (N 100), Talasseri (N 89)	
Mankada (N 86.4), Perunthalmanna (N 100)	Peravur (N 91), Kannur (N 89.3)	
Vengara (N 97.5), Kozhikode (N 100)	Mananthavadi (H 76.3), S.Batheri (H 80.8)	
Cholannur (N 100), Pandalayani (N 100)	Thodupuzha (H 100), Elamdesam (H 100)	
Kunnamangalam (N 100), Vadakekar(N 100)	Idukki (H 100)	
Thuneri (N 100), Kunnummal (N 100)		
Thondannur (N 100), Koduvally (N 100)		
Perambra (N 100), Balusseri (N 100)		
Melady (N 100), Payyannur (N 99.8)		
Taliparambu (N 100), Talasseri (N 100)		
Koothuparambu (N 100), Peravur (N 100)		
Kannur (N 98), Edakkadu (N 78)		
Irikkur (N 79), Iritti (N 81)		
Manjesvar (N 100), Kasargod (N 81)		
Kanjangadu (N 100), Neelesvar (N 100)		
Adimali (H 100), Devikulam (H 100)		
Peerumedu (H 100), Thodupuzha (H 100)		
Elandesam (H 100), Idukki (H 100)		

Source:Same as 4.10

Appendix 4.3

DETAILS OF BLOCKS WITH HYV ADOPTION IN GROUP FARMING AREAS

VIRIPPU	MUNDAKAN	PUNCHA
0-25		
Pattanakkadu (S 2.6), Kondotti (N 21.63)	Nemom (S 22.5), Chirayinkil (S 16.7)	Ithikkara (S 25), Chavara (S 15.3)
Meladi (N 16.6), Vypin (P 1.6)	Chavara (S 24.16), Karunagappalli (P 3.6)	Malappuram (N 20), Cholannur (N 5.3)
	Kulasekhara (S 9.17), Mukhathala (S 7.8)	Balusserei (N 13.84), Payyannur (N 20.34)
	Parakkode (S 18.93), Ollukkara (S 16.73)	Kattappana (H 20.56), Nedumgandam (H 19.04)
	Wandoor (S 8.01), Kondotti (N 9.6)	
	Manjeri (N 19.34), Vengara (N 22.87)	
	Cholannur (N 5.2), Alangadu (C 5.1)	
	Edappalli (P 18.3), Angamali (C 20.74)	
	Vazhakulam (C 15.38), Vaduvancode (C 21.21)	
	Koovappady (C 17.59)	
25-50		
Perumkadavila (S 49.96),	Kazhakuttom (S 34.73), Kilimanur (S 36.71)	Nemom (S 33.3), Perumkadavila (S 26.3)
Kazhakkuttom (S 49.17), Kilimanur(S 33.09)	Varkala (S 27.13), Ithikkara (S 33.37)	Pattambi (C 46.15), Kondotti (N 31)
Varkala (S 36.19), Nedumangad (S 40.81)	Anjalmoodu (S 44.8), Chavara (S 24.16)	Kozhikode (N 47), Cholannur (N50)
Sreekrishnapuram (C 27.04),	Chittumala (S 25.54), Vettikavala (S 40.38)	Tuneri (N 50), Balusseri (N 50)
Thrithala (C 34.7), Valacherry (N 33.04)	Chadayamangalam (S 27.82), Anchal (S 44.53)	
Tirurangadi (N 42.16), Thanur (N 30.97)	Sasthamkotta (S 44.02),	
Kondotti (N 21.63), Manjeri (N 27.45)	Sreekrishnapuram (C 26.53)	
Mankada (S 48.29), Vengara (S 30.98)	Ottappalam (C 48.07), Pattambi (C 26.7)	
Cholannur (N 28.31), Pandalayani (N 47.65)	Thrithala (C 29.68), Tirurangadi (N 35.34)	
Kunnummel (N 46.51), Payyannur (N 48.37)	Thanur (N 32.67), Mankada(N31.18)	
Manjeswar (N 44.8), Kanhangad (N 41.05)	Perinthalmanna (N 31.29), Panthalayani (N48.8)	
Nileswar (N 34.95), Chovannur (C 45.52)	Kunnamangalam (N 45.5), Badagara (N 44.4)	
Parakadau (C 31.24)	Tuneri (N 27.36), Kunnummal (N 26.7)	
	Edakkad (N 30.2), Manjeswar (N 46.09)	
	Kodakara (C 27.64), Chalakkudy (C 30.57)	
	Chavakkad (C 30.34), Chovannur (C 45.33)	
	Pampakuda (C 36.4)	
50-75		
Athiyannur (S 51.2), Perinkadavila (S55.9)	Athiyannur (S 57.41), Perinkadavila (S 58.1)	Athiyannur (S 55.5), Parassala (S 58.8)
Parassala (S 64.19), Chirayinkil (S 52.02)	Parassala (S 62.32), Nedumangad (S 74.73)	Mannarkkad (C 68.25),
Vellanad (S 60.57),	Vamanapuram (S 77.25), Vellanad (S 70.79)	Sreekrishnapuram (C 73.28)
Trivandrum Rural (S 69.27)	Trivandrum Rural (S 73.43),	Ottappalam (C 66), Kunnamangalam (N 56.52)
Itikkara (S 64.6), Mukhathala (S 51.24)	Kottrakkara (S 54.73), Pathanapuram (S 78.5)	Alangadu (C 71.26), Vazhakkulam (N 75)
Chavara (S 66.33), Chittumala (S 67.51)	Pandalam (S 56.2), Mannarkkad (C 54.96)	
Chengannur (S 74.59), Alathur (C 52.8)	Valancherry (N 56.7), Nilambur (N 71.91)	
Mannarkkad (C 61.1), Ottappalam (C 55.06)	Malappuram (N 71.75), Koduvalli (N 66.2)	
Pattambi (C 58.53), Andanthode (N 74.46)	Payyannur (N 65.87), Taliparambu (N 58.53)	
Thuneri (N 62.07), Malappuram (N 51.51)	Tellicherry (N 56.98), Peravur (N 56.81)	
Kozhikode(N 62.35), Kunnamangalam (N 59.5)	Kannur (N 56), Irikkur (N 64.95)	
Vadakekar(N 55.7), Taliparambu (N 62.83)	Iritti (N 69.1), Kasargod (N 57.41)	
Talasseri (N 64.72), Manthuruthi(C 64.38)	Kanhanad (N 73.51), Nileswar (N 67.13)	
Koothurprambu (N 60.03), Peravoor(N 64.44)	Kalpatta (M 56.26), Mananthavadi (H 77.76)	
Edakkad (N 64), Kasargod (N 64.98),	S.Bathery (H 74.89), Puzhakkal (P 66.950	
Devikulam (H 68.39), Anthikkad (P 57.5)	Velangallur (C 68.11), Chalakkudy (C 67.92)	
Velangallur (C 64.92), Chalakkudy(C 62.41)	Irinjalakuda (C 57.59), Mala (C 65.94)	
Mala (C69.7), Pazhayannur(C67.32)	Mullasseri (P 67.47), Kothamangalam (C 55.25)	
Parakkadavu (C 31.24), N.Parur (C 24.86)	Mulanthuruthi (C 54.11)	

Mulanthuruthi (C 64.38)

VIRIPPU	MUNDAKAN	PUNCHA
75-100		
Vamanapuram (S 80.21),	Vamanapuram (S 77.25), Pathanapuram (S 98.5)	Elanthur (S 100), Pandalam (S 100)
Karunagappali (P 86.15)	Konni (S 82.89), Elanthur (S 78.23)	Kulanada (S 100), Koippuram (S 100)
Oachira (P 96.94), Kottarakkara (S 100)	Kulanada (S 89.83), Koippuram (S 93.54)	Pulikesh (S 100), Mallappalli (S 100)
Vettikkavala (S 89.46),	Mallappalli (S 100), Ranni (S 100)	Aryad (P 100), Ambalapuzha (P 100)
Chadayamangalam (S 99.8)	Aryad (P 100), Ambalapuzha (P 100)	Chengannur (S 94.74), Mavelikkara (P 100)
Anchal (S 95.3), Pathanapuram (S 92.33)	Kanjikuzhi (S 100), Chengannur (S 82.41)	Bharanikkavu (S 100), Harippad (P 100)
Sasthamkotta (S 78.57), Parakkode(S 98.67)	Mavelikkara (P 97.5),Bharanikkavu (S 92.27)	Sreekrishnapuram (C 73.28)
Konni (S 90.57), Elanthur (S 97.48)	Bharanikkavu (S 92.27), Muthukulam (P 100)	Andanthode (N 100), Tirur (N 100)
Pandalam (S 95.73), Kulanada (S 100)	Harippad (P 100), Alathur (P 90.18)	Valancherry (N 100), Ponnani (P 96.76)
Koipuram (S 91.8), Pulikesh (S 100)	Koilman (C 99.97), Nenmara (C 100)	Nilambur (N 100), Mankada (N 100)
Mallappali (S 100), Ranni (S 100)	Chittur (C 98.74), Kollengode (C 98.83)	Perinthalmanna (N 100), Vengara (N 100)
Aryad (P 100), Ambalapuzha (P 100)	Palakkad (C 91.48), Andanthode (N 82.16)	Thanur (N 77), Pandalayani (N 98),
Thaikkattusseri (S 93.3),	Ponnani (P 84.7), Tirur (N 80.92)	Thondannur (N 100), Koduvalli (N 100)
Kanjikuzhi (S 100), Chambaulam (P 100)	Thondannur (N 100), Thodupuzha (H 100)	Meladi (N 100), Perambra (N 100)
Velianadu (P 100), Mavelikkara (P 98.74)	Elamdesam (H 100), Mananthavadi (H 77.76)	Iritti (N 100), Mananthavadi (H 100)
Bharanikkavu (S 91.5), Muthukulam (P 100)	S.Batheri (H 74.89), Lalam (P 94.27)	Kalpatta (H 94.4), S.Batheri (H 91.64)
Harippad (P 100), Lalam (S 100)	Uzhavur (S 74.79), Vaikkom (P 100)	Kaduthuruthi (S 100), Ettumanoor (P 100)
Vazhoor(S 98.84), Vaikkom (P 100)	Kaduthuruthi (S 100), Pallom (P 100)	Pallom (P 100), Mallappalli (S 100),
Kaduthurithi (P 100), Ettumanoor (P 97.8)	Madappalli (S 100), Vazhoor(S 100)	Anthikkad (P 100), Cherppu (P 100)
Pallom (P100), Madappalli (S 100)	Pambadi (S 100), Anthikkad (P 99.43)	Ollurkkara (C 100), Mallisseri (P 100)
Vazhoor(S 100), Pambadi (S 100)	Cherppu (P 89.89), Muvattupuzha (C 63.79)	Kodakara (C 87.32), Puzhakkal (P 96.04)
Koyalman(C 99.9), Nenmara (C 100)		Velangallur (C 80.06), Chalakkudy (C 84.32)
Chittoor (C 98), Kollengode (C 99.6)		Irinjalakuda (C 77.14), Mala (C 80.13)
Palakkad (C 90.3), Nilambur (N 79.02)		Chavakkad (C 86.32), Chovannur (C 99.53)
Vandoor (N 96.38), Tuneri (N 94.7)		Parakkadavu (C 82.72), Muvattupuzha (C 100)
Thondannur (N 100), Koduvalli (N 87.5)		Kothamangalam (C 80), Vaduvancode (C 79)
Balusseri (S 100), Perambra (S 81.2)		Kuvappadi CS 82), Pambakuda (C 100)
Kannur (N 80), Irikkur (N 78.26)		Mulanthuruthi (C 100), Angamali (C 82)
Iritti (N 82.75), Adimali (H 89.86)		Vazhakkulam (C 75)
Nedumkanda (H 83.47), Thodupuzha (H 100)		
Elamdesam (H 100), Idukki (H 100)		
Cherppu (P 92.32), Kodakara (C88.04)		
Ollurkkara (C 87.05), Puzhakkal (P 90.72)		
Alangadu (C 75), Edappalli (P 100)		
Vytila (P 100), Palluthurty(P 100)		
Muvattupuzha (C 96.32),		
Kothamangalam (C 95.36), Pampakuda (C 99.14)		

Source: Same as 4.10

Appendix 4.4

DETAILS OF BLOCKS, HYV ADOPTED NON-GROUP FARMING

0-25

VIRIPPU	MUNDAKAN	PUNCHA
Athiyannur (S 5.43), Nemom (S 1.93)	Athiyannur (S 14.2), Nemom (S 2.7)	Tirurangadi (N 21.87), Mankada (N 6.8)
Perinkadavila (S 5.56), Parassala (S 15.49)	Perunkadavila (S 17.1), Chirayinkil (S 20.11)	Payyannur (N 14.28)
Vellanad (S 21.12), Aryad (P 12.85)	Vellanad (S 19.26), Ithikkara (S 19.51)	
Thaikkattusseri (S 1.3), Chengannur (S 24.87)	Mukhathala (S 13.3), Chavara (S 6.3)	
Sreekrishnapuram (C 20.38), Thrithala (C 25)	Karunagappali (P 4.8), Chittumala (S 7.1)	
Tirur (N 21.79), Tirurangadi (N 13.08)	Vettikkavala (S 10.02),	
Tanur (N 12.4), Kondotti (N 1.02)	Chadayamangalam (S 4.4), Anchal (S 2.9)	
Wandoor(N 20.53), Malappuram (S 75.59)	Parakkode (S 5.4), Koippuram (S 1.26)	
Vengara (S 12.43), Kozhikode (N 14.42)	Thrithala (C 14.04), Thanur (N 10.49)	
Cholannur (N 5.3), Vadakekar(N 4.9)	Kondotti (N 9.11), Manjeri (N 14.2)	
Tuneri (N 14.04), Balusseri (N 13.84)	Mankada (N 23.33), Vengara (N 17.05)	
Perambra (N 29.86), Payyannur (N 20.24)	Kozhikode (N 5.28), Cholannur (N 14.3)	
Tallasseri (N 5.4), Kanhangad (N 14.85)	Badakara (N 19.2), Tuneri (N 8.04)	
Mulanthuruthi (C 23.07)	Balusseri (N 7.84), Thondannur (N 11.2)	
	Meladi (N 15.17), Perambra (N 20.75)	
	Taliprambu (N 7.79), Edakkadu (N 13.98)	
	Manjeswar (N 21.27), Kalpetta (H 22.98)	
	Pambadi (C 13.36), Kothamangalam (C 18.61)	

25-50

VIRIPPU	MUNDAKAN	PUNCHA
Anchalummudu (S 33.3),	Parassala (S 35.67), Trivandrum R.(S 46)	Andathode (N 31.4), Cholannur (N 28.57)
Karunagappalli (P 25.05), Oachira (P 27.42)	Kottarakka (S 42.25), Pathanapuram (S 38.53)	Badakara (N 28.07), Thondannur (N 30.23)
Chittumala (C 33.44), Mannarkkad (C 38.62)	Sasthamkotta (S 34.5), Konni (S 31.88)	Balusseri (B 47.05), Edakakdu (B 40)
Ottappalam (C 44.71), Pattambi (P 31.08)	Elanthur (S 26.4), Mannarkkadu (C 29.16)	Velangannur(C 33.43), Kothamangalam (C
46.15)		
Andathode (N 27.49), Valancherry (N 34.37)	Ottappalam (C 38.46), Pattambi (C 38.46)	
Manjeri (N 28.93), Mankada (N 31.58),	Andanthodu (N 32.13), Tirur (N 26.46)	
Perinthalmanna (N 44.83),	Valancherry (N 45.53), Tirurangadi (N 27.08)	
Kunnamangala (N 31.1), Thondannur (N 26.85)	Malappuram (N 44.86), Perinthalmanna (N 31.4)	
Koduvalli (N 45.17), Perambra (N 29.86)	Kunnamangalam (N 26.85), Kunnummel (N 24.7)	
Taliparambu (N 32.45), Peravoor(N 40.16)	Koduvalli (N 25.13), Payyannur (N 34.7)	
Edakkad (S 49.2), Irikkur (N 33.71)	Kannur (N 28.57), Irukkur (N 31)	
Manjeswar (N 28.1), Kasargod (N 36.43)	Kasargod (N 28.76), Kanjangad (N 41.3)	
Neeleswar (S 27.13), Devikulam (S 42.51)	Nileswar (N 30.57), Erattupetta (S 32.5)	
Irattupetta (C 34.4), Ollurkara (C 47.1)	Puzhakkal (P 43.8), Irinjalakkuda (C 50)	
Puzhakkal (P 43.51), Wadakkancherry (C 28.12)	Muvattupuzha (C 39.9)	
Cholannur (C 47.17), Mullasseri (C 49.9)		
Pazhayannur (C 33.23)		

50-75

VIRIPPU	MUNDAKAN	PUNCHA
Chirayinkil (S 56.03), Kilimanur (S 58.04)	Kilimanur (S 73.93), Attappadi (C 56.05)	Athiyannur (S 73.3), Chengannur (S 59.3)
Varkala (S 55.31), Vamanapuram (S 52.49)	Nilambur (N 57.78), Lalam (S 75)	Attappadi (C 56.3), Ponnni (P 54.83)
Chavara (S 51.9), Pathanapuram(S 72.39)	Uzhavur (S 59.05)	Thanur (N 61.1), Meladi (N 64.15)
Parakkode (S 51.16), Konni (S 72.88)		Perambra (N 62.16), Koothuparambu (N 62.65)
Ranni (S 50), Ponnani (P 67.53)		Irikkur (N 59), Chalakkudy (N 56.7)
Nilambur (N 58.13), Meladi (N 57.14)		S.Batheri (H 57.21), Muvattupuzha (H 71.96)
Irikkur(N 57.08), Elanthur (S 75),		
Uzhavur (S 72), Cherppu (P 71)		

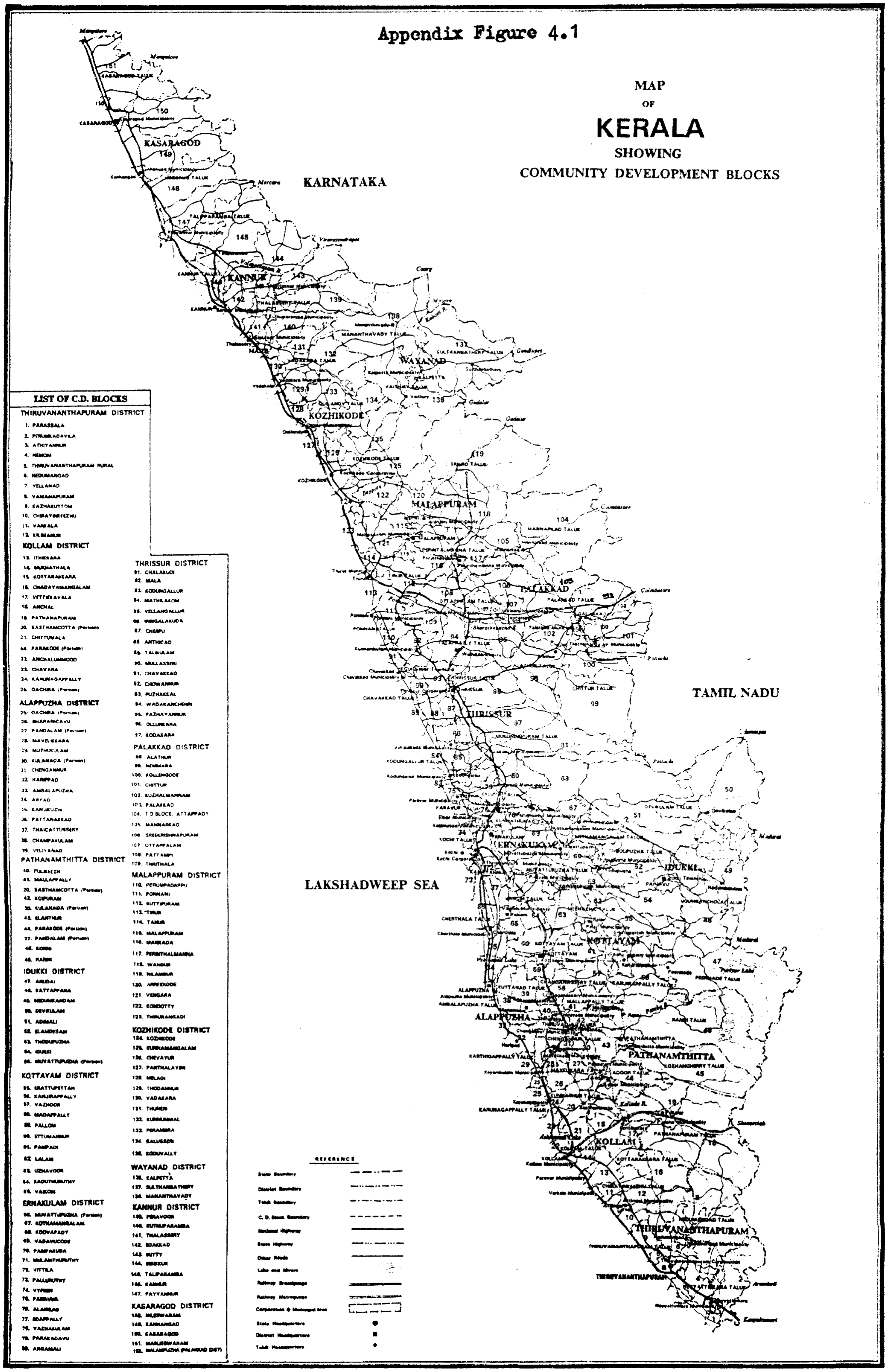
VIRIPPU	MUNDAKÂN	PUNCHA
75-100		
Mukhathala (S 76.6), Kottarakkara (S 87.43)	Kazhakuttom (S 84.6), Varkala (S 80.3)	Parassala (S 100), Pandalam (S 100)
Vettikkavala (S 95.4),	Pandalam (S 81.37), Ranni (S 76.19)	Kulanada (S 100),Koippuram (S 100)
Chadayamangalam (S 87.26), Anchal (S 97.18)	Alathur (C 100), Chittur (C 82.08)	Pulikezh (S 100), Mallappalli (S 100)
Pathanapuram (S 72.34), Elanthur (S 98.82)	Talasseri (N 100), Thodupuzha (H 100)	Chambakulam (P 100), Velianadu (P 100)
Mallappali (S 100), Velianadu (P 100)	Elamdesam (H 100), Idukki (H 100)	Mannarkkadu (C 83), Tirur (N 89.43)
Chambakulam (P 100), Alathur (C 100)	Lalam (S 77), Pallom (P 100),	Valancherry (N 100), Nilambur (N 100)
Koilmannam (C 100), Nenmara (C 100)	Vaikom (P 100), Kaduthuruthi (S 100)	Malappuram (N 100), Vengara (N 93)
Chittur (C 83.2), Kollengode (C 100)	Ettumanur (P 100), Madappalli (S 100)	Taliprambu (N 100), Koduvalli (N 100)
Adimali (H 78.79), Peerumade (H 100)	Pambadi (S100), Vazhur (S 100)	Iritti (N 100), Kalpatta (H 77.1)
Thodupuzha (H100), Elamdesam (H 100)	Kodakara (C 87)	Mananthavadi (H 93.04), Kaduthuruthi(S100)
Idukki (H 100), Lalam (S 100),		Ettumanur (P 100), Lalam (S 100)
Vaikkom (P 100), Kaduthuruthi (P 100)		Uzhavur (S 100), Erattupetta (S 100)
Ettumanur (P 100), Pallom (P100)		Pallom (P 100), Madappalli (S 100)
Madappalli (S 100), Vazhoor(S 100)		Cherppu (C 100), Kodakara (C 100)
Pambadi (S 100), Anthikkadu (P 91.77)		Ollurkkara (C 100), Puzhakkal (P 100)
Pambakuda (C 86), Kothamangalam(C 100)		
Muvattupuzha (C 90.6)		

Source: Same as 4.10

N -- Northern Zone S -- Southern Zone C -- Central Zone H -- High Range Zone P _ Problem Zone

Figures in parantheses denote percentage of HYV adopted.

Appendix Figure 4.1



CHAPTER 5

SUMMING UP

Significance of the Study

Among the many forms of agricultural technology, biological technology is of crucial importance. This is so because apart from its own role in improving productivity, it influences the scope and effectiveness of the other forms of technology as well. In economies where the land is limited it is the most viable option to achieve productivity.

The biological technology is however subject to geo-climatic and environmental interactions. Thus, there ia lag between the actual and potential yield, especially in the case of seed technology. This underlines the need for planning and prioritisation of research systems that is responsible for the generation and diffusion of technology. Today, research systems are highly developed at the international, national and regional levels.

The regional research systems encompassing in its fold agricultural research, extension and education is of crucial importance for the location specific agricultural innovations and diffusion which in turn influences productivity. The present study attempted to examine the process of generation and diffusion of agricultural innovations and relate it with the performance of agriculture in the State of Kerala. In what follows, the major findings of the study are summarised and the policy implications for integrating research and extension activities with agricultural policy in a decentralised framework are suggested.

Major Findings of the Study

The agricultural sector is still the largest contributor to the State Domestic Product (SDP) in terms of income and employment in Kerala. However, as pointed out in a plethora of studies, the agricultural growth has been declining since the mid-seventies. This declining trend, however, has generally been seen from the angle of crop specificity or certain specific dimensions like inputs, for example, irrigation or fertilisers. The attention given to technical change in relation to growth performance has been scanty.

Our analysis of data clearly pointed out the declining trend in the growth in production since the 1970's. This is distinctly so in the case of paddy. Although the yield has been showing a marginal increase, there has been a drastic decline in the area and there has been a decrease in the production. The decline is sharper in the area under HYV paddy. This is a disturbing situation and deserves a close examination in light of the importance of rice production from the point of food security, employment and ecological balance.

The study shows that sustained agricultural development requires much more than just provision of physical inputs like seeds, fertilisers, and modern implements. An effective explanation of the agricultural development of any region, Kerala in particular, is in terms of inputs and technology as endogenous to the process of development itself. This clearly shows why the same technology or inputs meet with differential successes in different regions. Further, the study also found out that the generation and adoption of technological change should be consistent with the physical endowment of the State. From, the discussion, it transpired that depending on the resource endowments, an appropriate technical, organisational, and institutional strategy should be designed for specific regions of the State.

In an attempt to understand the relation between the yield and various inputs, the tools of regression and input matrix was used in a partial analysis. The composite index of fertilisers, area under HYV and area under irrigation showed a positive and significant impact on the yield. The variables like research expenditure and agricultural population was also positive and significant. However, the impact of farm machinery is negative and insignificant. This can be attributed to the slow rate of mechanisation in Kerala. The limitations of a partial analysis made it necessary to do a total analysis.

While attempting to measure the rate of technical change in Kerala, by calculating the Total Factor Productivity using the divisia index we have found that the annual TFPG is 1.79 per cent and the rate of technical change is 34 per cent. Further, while examining the sources of growth, we have found that fertilisers contributes 40 percent to the output growth, while the contribution of land and labour is marginal and that of energy and implements is negative. Land is already under exhaustion in Kerala. The results also show that the rate of mechanisation is negative. Hence, the technical change that has taken place in the State during the past three decades is merely due to fertilisers which is a case of embodied (chemical) technology. In this juncture, it becomes necessary to examine the research systems that generate and diffuse the technology in agriculture. The analysis of the organisation structure shows that Kerala Agricultural University (KAU) and the State Department of Agriculture (DOA) are the major bodies that generate and diffuse technology, besides the other national research bodies like ICAR institutions. However, our analysis uncovers the duplication of efforts in respect of extension, education and research. Also there is a continuous neglect of extension activities which has a major role in diffusing technology.

On examining the growth rates of expenditure in research, extension and education activities in the state by the State department, KAU and the total expenditure for the period 1957-92, a clear neglect of extension is shown. However, the growth rate of research expenditure is as high as 11.86. Further, dissecting the pattern and direction of the expenditure on all the three items, we see a clear shift in the priorities from food crops to cash crops. This is distinct from the mid-seventies. After 1989, much thrust is given to paddy activities in terms of development activities but the State department does not indulge in any activities on paddy research. It concentrates on research on coconut and oil palm. The analysis of research expenditure among crops in the State as a whole, shows that till 1988 major proportion of the expenditure was spent on paddy and after that coconut was given more attention. Also, research among disciplines is not balanced between crop husbandry and agricultural engineering, and basic sciences. Looking at the expenditure pattern,only a meagre (3 percent) amount is spent on extension. A further break up of expenditure shows that a good proportion is spent on pay of scientists, technical and administrative salary etc. Another disquieting feature is that the trend in ICAR contribution and the State's share in these projects are falling. Innovation Support policies by the State are very important in agricultural development. The efforts on part of the State policies in Kerala are very extensive. But clear priorities in terms of crops because there are several national institutes that undertake research exclusively on certain specific crops, for example, Coconut Board. Then again, schemes like crop insurance should be given more thrust in Kerala where agriculture is exposed to vagaries of weather. Several efforts is respect of paddy like introduction of group farming, programs like the Intensive Paddy Cultivation, and Intensive Rice Development after 1989 has shown positive trends in the coverage of area and yield. The various innovative support development programmes and the introduction of group farming as an institutional innovation has really helped in reaping the benefits of economies of scale.

On seeing that there is high generation of research in terms of investment we now turn on to the diffusion process in varieties of paddy. It was observed that a number of varieties have been released from international, national and zonal research stations. The diffusion model (following Hayami) is fitted in the case of Kerala to test the diffusion rate. The results show that the yield of HYV (proxy for technology) is getting stabilised in most of the districts.

However, looking at the spread effect in terms of area coverage the results are contrasting. More area is allotted to the local varieties which are less yielding than the HYV. This is acute especially in the mundakan (winter) season. To examine this phenomenon further, a block level analysis is attempted. The diffusion is seen among districts, zones, irrigated area, unirrigated areas, group farming areas and non-group farming areas. The analysis reiterates that adoption of HYV does not depend on yield but other factors. In this respect, the risk factor plays a major role as the HYV's are highly prone to vagaries of weather, not location specific and susceptible to pests and diseases,. It is highly dependant on complementary inputs like water and fertilisers. In the flood prone regions, fertiliser application is a problem as the basal fertilisers are washed off in heavy rains. Fertilisers also affect rice based fish farming in certain areas.

Thus, the study highlights that location specific research is lacking in Kerala. This can be connected with the generation of research and its priorities. The point is that the lab to land linkage is missing. The proportion of research expenditure in Kerala is high and much effort in terms varietal improvement has taken place. However, the diffusion in terms of intensity,that is yield has taken place but the spread effect is very low. Thus, factors other than yield affect adoption of (biological) technology in Kerala. Factors like risk play an important role in this respect. This is due to the abominable neglect of extension activities. Emphasis on adaptive research is crucial here. A dynamic interaction is to be evolved between the institutional and technical change. There should be a continuity in the innovation and diffusion process. The process of diffusion requires that the capability to acquire, adapt, and improve and make available the technology consistent with the local conditions. It is also necessary that proper innovation and supportive policies by the State is complemented. In this context, the role of local bodies like the panchayats and Krishi Bhavans are relevant in training and extension activities. Therefore, if growth has to be achieved in Kerala's agriculture, effective working of research institutions and effective resource utilisation which generates appropriate technology is the solution. Thus, one may state that the institutional framework holds a vital consideration in the generation and spatial diffusion of any agricultural technology.

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