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RESEARCH AND DEVELOPMENT IN SMALL CARDAMOM BY ICRI: AN EVALUATION

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ABSTRACT

Realising the vital role of research and development for building international competitiveness of plantation sector, the Ministry of Commerce established research institutes under different Commodity Boards to undertake research and development on specific crop(s) assigned to them. This study, apart from being a preliminary evaluation of recent research undertaken by Indian Cardamom Research Institute (ICRI) under the Spices Board of India, is a first step towards exploring the synergy between different research institutions under the commodity boards. By conceptualising innovation as a cumulative, interactive and socially embedded process, the study has taken into account both the inputs and outputs of research with due consideration for the institutional context in which research is undertaken. The study comes up with a number of recommendations and is presented in the concluding section of this paper.

1. Introduction

Plantation sector in India overtime has undergone significant changes in terms of its varied structural dimensions and the international trading environment in which it operates. Major structural changes included are in ownership structure, organisation structure, size structure and market orientation. In terms of ownership, the change has been *inter alia* in terms of shift from foreign hands to local owners, in terms of organisation and size structure, the change involved a shift away from large estates and public limited companies to small holders and new organisational forms like self help groups and worker managed estates. Viewed in terms of the trading environment, there has been a marked shift away from export orientation to domestic market oriented production. Along with the removal of tariff barriers the non tariff barriers in the form of standards and phytosanitory conditions have become stronger than ever before. These changes have necessitated innovations at different stages of production, post harvest operations, marketing and trade for enabling the sector to survive in the highly competitive environment. It is in this context that the role of state in promoting research and development in plantation sector assumes added

importance. Also, recent study on structural Infirmities in India's plantation sector argued that

> *Plantation sector is not merely a foreign exchange earner but a key sector in India's strategy to achieve inclusive development. However, it is suffering from many structural infirmities that adversely affect the price, output and competitiveness. This calls for concerted efforts towards evolving an internationally competitive system of production which in turn call for a vibrant innovation system through the coordinated actions of different stakeholders. The challenge before the Commodity Boards in the context of globalisation is to facilitate a transition from factor intensive production to knowledge intensive production by addressing varied infirmities*[1]

Indeed, the relevance of research and development for building international competitiveness in plantation sector has been explicitly recognised by the Ministry of Commerce from the very beginning. This led to the establishment of research institutes under each commodity board to deal with all the aspects of specific crop(s) assigned to them. This study is an attempt to undertake a preliminary evaluation of research undertaken by Indian Cardamom Research Institute (ICRI) under the Spices Board, on cardamom. It should be noted that the study raises more issues which needs further inquiries and pointers for reflection by the authorities concerned than unambiguous conclusions.

2. Evaluating Research: The Approach

Evaluating research is indeed a difficult task on account of the uncertainty associated with research on the one hand and lack of consensus on appropriateness of the indicators often used for evaluation.

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1. Joseph, K. J. and P. S. George (2010), Structural Infirmities in India's Plantation Sector, Report Submitted to the Ministry of Commerce, Centre for Development Studies (NRPPD), Trivandrum.

Nonetheless, different indicators are often made use of in assessing research[2]. One of the approaches is often called "input approach" wherein research is evaluated on the basis of research effort measured in terms of the amount of money involved and (or) the number of scientists engaged in research. Another may be called "output approach" where in the focus is on research output measured in terms of number of plant varieties developed, number of solutions evolved for specific problems, number of publications, patents obtained and other such indicators. Here it is also relevant to consider the outcomes of the research output as evident from the feedback from the users of the research output.

In general, technological change is considered as involving three different stages-invention (a new idea), innovation (commercial application a new idea), and diffusion (spread of commercial viable ideas among different uses). While the first two may fall under input approach the latter relates to output. Thus viewed, while evaluating the research, its effectiveness in these three stages identified could be useful. It might be possible that while overall performance appears impressive in terms of invention but it fails at the stage of innovation. Alternately, there might be situations wherein despite impressive performance in terms of invention and innovation, diffusion may not be to the level of expectation of researchers on account of varied reasons.

While the conventional wisdom on technological change considers invention, innovation and diffusion as a linear process, the recent research tends to suggest that these three processes need not necessarily be linear. Thus viewed, technological change is increasingly being considered as an incremental, cumulative (path dependent), interactive and socially embedded process wherein different actors and institutions (policies, rules, norms, conventions and others) play an

2. See in this context among others Patel P and Keith Pavitt (1995) Patterns of Technological Activity; Their Measurement and Interpretation, in Stoneman, P (ed.) Handbook of the Economics of Innovation and Technological Change, Cambridge, Blackwell.

important role[3]. Hence, the outcome of research is bound depend on the manner in which research is undertaken and institutional context in which it has been organised and be implemented.

Very often it is shown that the relation between input and output of research and its outcomes are not straightforward because of the inherent risk involved in any research activities. At the same time, like any other economic activity, research outcome also depends, to a great extent, on the scale at which research is organised indicating positive scale economies even in research as in any other economic activities.

In this study, by conceptualising innovation as a cumulative, interactive and socially embedded process, we shall adopt a method that combines both research inputs and outputs with due consideration for the institutional context and the manner in which research is undertaken in. Hence, we shall begin with an examination of inventive and innovative effort undertaken by different research divisions in ICRI. We also examine the overall research effort in cardamom by examining the R&D investment in terms of money invested and number of scientists engaged. This is followed by an examination of initiatives undertaken by ICRI towards transferring the technologies and innovative practices developed by the scientists to the growers.

With a view to gauge the effectiveness of research in terms of its outcomes as perceived by the growers (the consumers of the research output), we organised consultation with growers in two major cardamom growing areas of Kerala namely Nedumkandam and Vandanmedu. In addition, we had individual consultation with leading farmers in the

3. Here the reference is to the growing body literature using innovation systems approach. In the literature innovation system has been analysed at the national, sectoral, regional and at the technological level. However, most of the studies using innovation system framework has been based on the empirical evidence and experience of developed countries. For recent study from the developing country perspective please see Lundvall B.A, K.J. Joseph, C. Chaminade & Jan Vang (2009) Handbook of Innovation Systems and Developing Countries, Cheltenham, Edward Elgar.

area and also had telephonic conversation with a number of growers who have been associated with various programmes of ICRI.

Towards having an understanding on the manner in which research has been undertaken as well as the institutional context, we had two rounds of consultations with scientists in ICRI and discussion with the current and previous Directors. During the first round of consultation meeting all the scientists in the institutes were met as a group. The second round of consultations involved separate meetings with scientists of different research divisions. During consultations with both scientists and growers the prime objective has been to discern how the research problem was conceptualised and implemented, the outcomes were diffused and the effectiveness of the research outcome in addressing the farmers' needs.

3. Research and Development by ICRI

Indian Cardamom Research Institute (ICRI) was established by the Spices Board in 1978 under the Ministry of Commerce and Industry, Government of India, at Myladumpara a remote location in Idukki district of Kerala. ICRI, with other three Regional Research Stations, located at Tadong (Sikkim), Saklespur (Karnataka) and Thadiyankudisi (Tamil Nadu). One satellite Biotechnology laboratory at Cochin and Quality Evaluation Laboratory under it, undertakes research on all aspects of cardamom production.

The primary mandate of ICRI is to develop sustainable production, plant protection and post-harvest technologies for small and large cardamom (see Box 4.1 for mandates of ICRI). It has been stated that its activities have been recently expanded to cover comprehensive research studies on vanilla and export-oriented adaptive research programmes on other spices such as black pepper, ginger, turmeric, chilli, tree spices, herbal spices, paprika seed, and minor spices. The current emphasis is on evolving agro-techniques for the production of organic spices by integrating bio-control and eco-friendly nutritional management of spices.

Box 1: Mandate of ICRI

The mandate of ICRI has undergone changes with changing needs of time and at present it stands as;

- To undertake basic and applied research on small and large cardamom.
- To undertake basic and applied research on export-oriented exotic spices such as vanilla and herbal spices.
- To conduct field adaptation trials, evaluation and validation of technologies (on-farm research and demonstration) on all spices varieties developed by other research institutes under ICAR, State Agricultural Universities (SAUs) and other agencies.
- To focus on post-harvest technology including processing, storage and handling of spices for the production of clean spices.
- To develop appropriate technologies for organic spice production.
- To provide advisory services to farmers based on soil and plant test reports, spice quality analytical report, supply of bio-agents and other organic inputs, and production technology requirements.
- To support the Development and Marketing Departments of the Spices Board in tackling specific issues on production and quality of export-oriented spices.
- To focus on transfer of technologies to farmers and targeted groups through various extension activities such as scientist-farmer interface, group meetings, seminars, workshops, demonstration plots, audio and visual media, and publications.
- To conduct training programmes for Spices Board's Development Department staff and impart scientific skill development of agriculturists and unemployed youths on Good Agricultural Practices for quality spice production.

Source: http://www.indianspices.com/html/spices_board_resrchl_indcardins.htm

3.1 R&D Manpower in ICRI

As of August 2011, ICRI has a total research staff strength of 53 of which 21 are scientists and others being research associates, senior research fellows and supporting staff (see Table 1). Among the scientists, 14 are with Ph.D degree. Research in the Institute has been undertaken under six different research divisions (Agronomy, Soil Science, Crop Improvement, Biotechnology, Plant Pathology and Entomology) for carrying out various laboratory and field experiments both in the main and regional stations.

The distribution of research staff across different research divisions is given in Table 1. The main institute is expected to have Senior Scientist, Scientists and Junior Scientists in the major divisions such as Agronomy and Soil Science, Crop Improvement and Biotechnology, Plant Pathology and Entomology. In the Regional Stations one Senior Scientist is expected to head the Station and at least one Scientist or Junior Scientist present in each division. Although specific programmes are identified for each scientist, the main project is implemented as a team work of the Institute and the Regional Stations.

From Table 1, one finds a significant variation in terms of the number of scientists involved in each research division. While pathology division has four scientists, crop improvement has only two. Yet another point of concern for someone who considers technological change (innovation for shorthand expression) as an interactive process, is the location of the biotechnology division in Cochin, far away not only from the main research station but also the plantations/growers. Hence, it is advisable that all the research divisions are under the same roof. Similar asymmetry appears to be present across different research stations. Thadiyankurissi has no scientists as of now. Also, one finds significant variation in terms of the availability of experimental land per scientist across different stations. It is as high as eight hectares in Sakleshpur, four in Myladumpara and two hectares in Tadong (Sikkim) (Table 2)

Table 1: Distribution research staff across different research divisions and research station of ICRI

Station/Division	Scientists	Senior Agricultural Asst.	Research Associates	Senior Research Fellows	Other Research Asst. Staff†	Total
Myladumpara						
Crop Improvement Division	2		1	1	1	5
Bio Technology Division	2			1	1	4
Agronomy & Soil Science	3		1	4		8
Entomology	3		1			4
Pathology	4	1			4	9
Others*					2	2
Sakleshpur						
Regional Station	3	3		1	3	10
Thadiyankudisai						
Regional Station	0	1			1	2
Sikkim						
Regional Station	4		2		3	9
Total	21	5	5	7	15	53

† Junior & Senior Lab Technician, Supporting Staff, Extension Assistant, Junior Technical Assistant

* Statistician 1, Librarian 1

Source: Based on information provided by ICRI

Table 2: Size of experimental farms in different research centres

Station	Total Land/ Area per ha.	No. of Scientists	Area/ Scientists
1. Myladumpara	64.67	15	4
2. Sakleshpur	24.00	3	8
3. Thadiyankurissi	6.50	0	0
4. Sikkim	9.00	4	2

Source: Based on Information provided by ICRI

3.2. Research Issues and Objectives

Annexure 1 presents an outline of the major issues and objectives of the experiments/projects being undertaken by five different divisions of ICRI. It is evident that wide range of issues relating to various aspects of cardamom production has attracted the attention of researchers. These include;

Thrips Management

Thrips is the most important pest, which causes severe reduction in quality and production of cardamom. A multi-disciplinary inter-institutional programmes on a mission mode is required to address this preplan.

Fusarium Disease Management

The fungus, fusarium has overtaken all other diseases in cardamom in both severity and difficulty in management. Basic and applied research on development of IDM practices is to be undertaken.

Physiological, bio-chemical and agronomical approach for drought management

There is a drastic change in climatic conditions in recent years in the cardamom tract. Drought Management strategy has to be intensified for sustaining cardamom production.

Germplasm Characterisation

The large germplasm has to be characterised chemically as well as at molecular level for registering with the national repository and to tackle IPR issues.

Low cost Production Technology

At present the cost of production has increased substantially and ranges between Rs.1.25 to Rs.2.0 lakhs per ha depending upon the intensity of management. The cost benefit ratio is drastically affected with market fluctuation. This calls for the identification of critical points for reduction of cost.

Validation of GAP at farmer's field

ICRI has formulated GAP for cardamom cultivation. The enterprising Kerala farmers have also come out with new technologies. These technologies are to be evaluated in farmers field in all agro-ecological conditions of the cardamom tract so as to sustain in the production and productivity.

Characterisation and mapping of cardamom soils and isolation of useful PGPRS

Cardamom soil has to be classified based on productivity index so as to define appropriate management practices. Being a forest soil, beneficial organism including entomopathogenic nematodes are to be located from cardamom soil for developing a consortium of useful micro-organisms.

Large Cardamom

Intensifying research on identifying the cause for large scale drying of plants and production decline in large cardamom and their management

This malady is of a recent origin in large cardamom causing substantial crop loss to farmers and to the state. This malady is characterised by sudden drying up of the plants. The cardamom seeds remain immature and there is poor setting. Initial investigations lead to the identification of fungal pathogen as primary cause. However, physiological reasons due to drought or other unknown problems need to be looked into. A multidisciplinary and inter-institutional approach is warranted to tackle the problem.

Isolation and screening of local strains of bioagents, mass production and imparting training on use of bioagents

Sikkim is declared as an organic state. Due to drastic changes in the ecology of the cardamom belt disease problems have caused a severe dent in the production of large cardamom. From a position of net exporter, the country has turned to be a net importer.

Onfarm quality assurance and certification programme for chilli and cardamom

High pesticide residues and other physical and chemical contaminants due to improper care and management at the farm level is the main reason for poor quality of spices for export. Thus a systematic approach for producing pesticide free quality spices at the farm level is to be undertaken. This is a novel programme where the quality certificate issued at the farm gate level so that the exporters can source the material accordingly and in the near future such quality assurance will attract other farmers to join the quality assurance programmes. This programme will be initially tested for cardamom and chilli.

Eurogap and organic certification of research farms

All the research farms of the institution are to be systematically managed in line with the modern quality assurance system. The research farms have a demonstration value also.

Strengthening bio-technology research programmes on spices

Large scale production of tissue culture plants of various spices, impart training to unemployed youths and molecular characterisation are the programmes involved.

3.3. Observations on Research Issues and Mode of undertaking Research

The sincerity and commitment of the researchers and the hard work that they have been putting in was evidently clear during the discussion with scientists in different research divisions. Since the ICRI has a system of peer research review every year, the scientific relevance of the projects and experiments also cannot be questioned.

Having said this, a careful examination of the objectives of various experiments/projects undertaken by different divisions tend suggest that numerous issues relating to different aspects of cardamom production are being addressed by the scientists in ICRI. Hence, there appears to be a lack of focus on research especially given limited number of scientists in ICRI. The strategy of spreading too thinly the limited research efforts across a wide range of issues might have its impact on the research outcome.

It also appears that as an institute with a mandate to deal with the real world problems confronted by the cardamom growers, it is not sufficiently interactive with the growers concerned. It is surprising to note that an institute with over 50 staff and annual research outlay of over four Crores of rupees do not have web site of its own. What is available as of now is a page in the web site of spices Board presenting very limited information. Hence, there is an urgent need to set up a vibrant website with relevant information for the growers like package of practices, pests attack and ways and means to control them, weather forecast, and provision for the growers and others concerned to interact with the scientists in the institute.

Also, one who enters the ICRI premises does not get the "feel" of cardamom research institute. It is advisable that all the available varieties of cardamom are planted and maintained with maximum care around the premises of the institute itself such that it attracts the attention of anyone who visits the institute and induces to visit the demonstration plot of the institute.

Someone going through the annual research report of ICRI also fails to get an idea about the vision of the institute and focus of research during the period under consideration. What is presented as a research report, as of now, is the details of each experiment, and an effort to consolidate the research outcomes is found missing in the Annual Reports.

During our interaction with planters it was conveyed that despite the different varieties developed overtime by ICRI, Njallani variety continues to be the most preferred one by the growers. This variety, however, has its own problems in terms of its high susceptibility to pests and insects, intensive use of chemical fertilizers and the associated problems. The fact that Njallani variety was introduced almost 20 years ago and the problems of this variety still remain unaddressed, despite the concerted efforts by ICRI, needs to be viewed with concern. The growers, however, are in search out for a variety that will combines all the good qualities of Njallani without its negative sides. This has led to the development of a few new varieties by the growers with comparable yield potential and other qualities. (see Box 2) The growers also have been able to come up with innovations like fuel efficient driers and cardamom cleaning machine which is found helpful in increasing the quality of dried cardamom. The message is that the farmers, for various reasons, are always in search of solutions for varied issues confronted by them in

Box 2: Select New Cardamom Varieties Developed by Planters

Panikulangara Green Bold No.1

A progressive farmer, Joy Peter has developed a cardamom variety called *Panikulangara Green Bold No.1* through selection process. The new variety is less prone to biotic and abiotic stresses and its ripe capsules retain green colour and size even after drying.

Lack of adequate irrigation facilities is a major constraint for cardamom cultivation in Idukki district. But the new variety performs well under rainfed condition and hence it is suitable to be grown in the areas where there are no irrigation facilities. Significant differences in the characteristics viz., yield per plant, capsule's shape & colour and its duration are observed in this variety.

This new variety was formally released by the former Director of Development, Spices Board in 2000, and more than 6000 clones were said during that year. Local KVK also studied the variety and felicitated him. Scientists from Kerala Agricultural University also visited his farm. Till date he has given more than one lakh seedlings all over Kerala.

Cardamom Research Station, Kerala Agriculture University mentions that this variety responds well under average management conditions. The variety is free from blight disease even in less shade area and is moderately tolerant to thrips, stem borer and other leaf diseases. However the number of capsules/panicle (235) is less than in *Njallani* variety (265).

White Flower and King of Cardamom

"White Flower" selected by Mr. K.J. Joy who won the National Innovation Foundation award is shown to be having high oil content. Since the capsule is smaller in size, this variety has not been found much popular among the growers as it gives less weight per litre. Indeed for medicinal purpose and oil extraction this is a preferred choice.

Of late Mr. Joy has evolved yet another variety called King of cardamom. The capsules of this variety is much bolder than Najalalni hence giving higher weight per litre. We are told that over 50,000 seedlings of this variety have already been distributed among the large and established estates.

Source: Joseph K.J. and P.S. George (2010), Structural Infirmities in India's Plantation Sector, Report Submitted to the Ministry of Commerce, Centre for Development Studies (NRPPD), Trivandrum.

cultivation and post harvest operations. Going by the available evidence they are found to be highly innovative as well.

While growers have achieved some success in evolving new varieties, the scientists in a sense appear to have lagged much behind. It is true that ICRI has come up with ICRI-5. The field trial of this variety is still going on and the response of the growers who have adopted this variety at best has been mixed. Perhaps, it is time for the ICRI to recognise that a variety that could challenge Njallani and other varieties developed by the other growers, in terms of yield is yet to emerge. Hence, the focus of research by the scientists need not be to "reinvent the wheel". For

scientists who consider innovation as path dependent, cumulative and interactive process, the challenge is to find ways and means to address the issues confronted by Njallani and other varieties that followed Njallani.

While dealing with such innovative growers, the scientists cannot afford to take the conventional approach of considering scientists as innovators and growers as blind adopters of innovations. What is perhaps called for is a more interactive approach especially in research agenda setting and preferably in research implementation which involves combining the knowledge base of the scientists and that of growers for addressing the specific problems. In such a context, the research agenda of the institute for a specific period could be developed in an interactive and socially embedded manner. In this process the growers are made to become the active partners in the innovation process rather than being passive adopters. If such a strategy is adopted, it is unlikely that the farmers complain about the ineffectiveness of research as they often do at present.

However, as of now due to the absence of appropriate institutional arrangement, it is rather difficult to harness effectively the co-operation from farmers. Hence, for evolving such an interactive innovation process there is the need for the establishment of Spice Producers' Societies (SPS) in a democratic manner. Here it is worth noting that such institutional arrangements have already being in evolved in case of natural rubber with immense social returns.

Once such institutional arrangements are in place, the ICRI could even consider organising a seminar/symposia wherein the growers are provided an opportunity to present their ideas on specific issues (it could also be on the specific issues of focus for the research agenda by ICRI) in the form of written papers in a competitive manner. This might also take us a long way in facilitating the documentation of the traditional knowledge base of the farmers who are known to be much innovative.

4. R&D Investment and R&D Intensity

Table 3 presents data on R&D investment in cardamom. It is evident the share of R&D in the total expenditure by the Spices Board has been showing a declining trend from nearly 10 per cent in 2002-03 to a little over 6 per cent in the terminal year. This is a trend that that needs to be reversed especially given the heightened competitive environment wherein innovation is the key to survival. At the same time, investment per scientist has increased over time mainly due to decline in the number of scientists over the years. Perhaps a more appropriate indicator is the R&D expenditure per unit of value of output by the sector. It is evident that R&D expenditure as a proportion of the value of output has been fluctuating over time (due to changes in the value of output) and in most years less than one per cent. The indicators presented here calls for enhancing the research effort.

Table 3: R&D expenditure and R&D intensity in spices

Year	R&D Expenditure (Rs Lakhs)	Total Spices Board Expenditure (Rs Lakhs)	Share of R&D in total Expenditure by the Board	R&D/ scientist (Rs lakhs)	R&D as % of the value of output
2002-03	206.74	2079.41	9.97	5.91	0.31
2003-04	250.11	2642.16	9.46	7.15	0.60
2004-05	263.11	2997.00	8.68	7.52	0.77
2005-06	284.86	3502.00	8.14	8.14	1.05
2006-07	333.00	4560.13	7.30	9.51	0.94
2007-08	402.50	5800.03	6.94	11.50	0.85
2008-09	709.00	6665.47	10.64	20.26	1.19
2009-10	476.50	7643.02	6.23	13.61	0.63

Source: Compiled from Spices Board India, Annual Report, Different Years, Spices Board Cochin.

Here it needs to be noted that the R&D expenditure per scientist in ICRI is comparable to that of RRII. However, R&D infrastructure as

well as R&D manpower engaged in rubber research is at a much larger scale as compared to cardamom. In RRII 102 scientists are engaged in rubber research of which 63 are with Ph.D degree. Studies have shown that like any other economic activity, knowledge generation activities such as R&D are also associated with economies of scale. Hence it may be inferred that larger scale of R&D in natural rubber, *inter alia*, might have been instrumental in enabling RRII to record an impressive R&D outcome. Hence, a case could be made for enhancing the scale of R&D in ICRI.

Such simple comparison in terms of R&D manpower and R&D outlay might conceal more than what is revealed without a proper understanding of the plant characteristics. Cardamom, in comparison with many other plantation crops, could be considered as one of the most "complicated crop" on account of its high sensitivity to weather conditions and susceptibility to numerous diseases and pests attacks which in turn calls for a number of cultural operations. To illustrate, there are over 17 diseases that affect the cardamom plant from the nursery stage to estate level and as many as four major pests are found affecting the cardamom plants (see Table 4). The complexity of the crop in

Table 4: Different diseases and pests of cardamom at different stage of cultivation and control measures

Diseases in nursery stage	
Diseases	Control measures.
1. Leaf spot	Prophylactic Spraying fungicides(2 to 3 rounds).
2. Nursery Leaf rot	Spray Indofil M-45 twice at 15 days interval.
3. Seedling rot	Fumigate the nursery buds by treating with formalin; application of Tricohderma.
4. Clump rot	2 to 3 rounds of COC drenched at 15 days interval.

Diseases in plantation stage	
5. Kette disease	Various measures are recommended.
6. Nilgiri necrosis disease	Same as above.
7. Kokke Kandu disease	Same as above.
8. Azhukal disease	Phytosanitation and Fungicidal application.
9. Clump rot or rhizome rot	Plant sanitation and COC application. Also biocontrol measures.
10. Chenthal	Fungicide application.
11. Leaf blotch	Application of Bordeaux mixture.
12. Leaf rot and leaf rusts	Fungicide application.
13. Capsule brown spots	Same as above.
14. Leaf blight	Bordeaux mixture.
15. Pseudostem rot	Spraying of hexaconazole 0.2%.
16. Root tip root	Spraying contaf 0.2%(15-20 days interval).
17. Panickle wilt	Application of bioagents.
Major pests	
1. Cardamom thrips	
2. Shoot/Panickle capsule borer	Injection of insecticides.
3. Early Capsule borer	
4. Root grub	
Minor pests	
1. Cardamom whitefly,	Spraying a mixture of neem oil.
2. Hairy caterpillars	
3. Shoot fly	
4. Lace wing bug	
5. Red spider mites	
6. Mid rib caterpillar	
7. Cardamom aphid	
8. Cutworm	

Source: Compiled from Spices Board (2009) *Cultivation Practices for Cardamom*, Spices Board, Cochin.

general and numerous cultural practices along with large scale incidence of pests and diseases imply that cardamom cultivation raises many issues to be addressed that in turn calls for much larger scale of enquiry to answer such questions. Hence, the research effort needed in cardamom is likely to be much higher than in any other crops.

In the case of natural rubber, RRII is the sole agency concerned with R&D where as in the case of spices there are multiple actors (see Box 3). It appears that there is a case for scaling up of R&D activities in spices and initiating steps for better coordination among different actors involved in R&D, innovation and different aspects of production and processing in order to evolve a vibrant system of innovation.

Research undertaken as of now at the instance of Spices Board involves mainly agronomic research and research on socio-economic aspects have not received the attention that they deserve. In the case of Rubber Board, there is a vibrant research unit undertaking research on various socio economic aspects of rubber production, processing and marketing with a good publication record. The impact of these inputs cannot be considered negligible. It is recommended that the Spices Board also should recognise the importance of research on socio-economic issues.

It appears that the research agenda of ICRI has not taken note of the acute labour shortage being faced by the sector. Needless to say, development of appropriate machines/equipment for mechanising various farm operations, especially the labour intensive ones like harvesting, should occupy an important role in the agenda of ICRI.

It is also to be noted that Spices board has under its purview 52 spices and the effective promotion of trade in these spices invariably calls for substantial research on this crops. As of now, apart from cardamom and limited research on black pepper and vanilla, issues

Box 3: Multiple actors in spice research

Indian Cardamom Research Institute Myladumpara

The Main Research Station viz. Indian Cardamom Research Institute (ICRI) at Myladumpara (Kerala) and the Regional Research Stations at Tadong (Sikkim), Saklespur (Karnataka) and Thadiyankudisai (Tami Nadu) are involved in undertaking R&D activities. Though its primary mandate has been to work on cardamom, as of now it is engaged in the R&D of more than half a dozen spice crops.

Indian Institute of Spices Research

The Indian Institute of Spices Research (IISR), Calicut a constituent body of Indian Council of Agricultural Research (ICAR) is a major Institute devoted to research on spices. In 1976, it started as a Regional Station of the Central Plantation Crops Research Institute (CPCRI), Kasaragod engaged in research on spices. A National Research Centre for Spices was established in 1986 with its headquarters at Calicut, Kerala by merging the erstwhile Regional Station of CPCRI at Calicut and Cardamom Research Centre at Appangala, Karnataka. Realising the importance of Spices Research in India this Research Centre was upgraded to Indian Institute of Spices Research in 1995.

The Cardamom Research Station, Pampadumpara

The Cardamom Research Station, Pampadumpara was established in the year 1956 under the State Department of Agriculture, Government of Kerala. It was later transferred to the Kerala Agricultural University in February, 1972. The station was selected as one of the co-ordinating centres for spices under the All India Co-ordinated Research Projects in 1972.

Pepper Research Station, Panniyur

Pepper Research Station, Panniyur, was started in 1952 as part of a scheme to improve pepper cultivation, and it was upgraded to the status of a research station under the KAU in 1972. The station concentrates on crop improvement, crop management and crop protection aspects of black pepper. It is an important co-ordinating centre of the All India Co-ordinated Research Project on Spices of the ICAR. Besides research, nucleus planting materials of released varieties of black pepper, *viz*. Panniyur 1, Panniyur 2, Panniyur 3, Panniyur 4, Panniyur 5, Panniyur 6, Panniyur 7 and Panniyur 8 are also been distributed.

Source: Joseph K. J. and P.S. George (2010).

relating to other crops rarely receive the attention of scientists. ICRI cannot for long afford to keep a blind eye to the varied issues confronted by these crops. In a context wherein a large number of spices are not covered by the R&D activities of the Spices Board and given the practical difficulties associated with setting up research Centres for each and every crop, ICRI shall consider greater collaboration with select agricultural universities in promoting research on the neglected spice crops.

We are told that ICRI has already initiated steps to evolve collaboration with other institutions. For example, the National Network programme on Neem with the involvement of 16 national institutions under the Ministry of Petroleum. The DBT sponsored project on INM twelve national institutions including ICRI & RRII. Yet another project on monitoring of pesticide residue involve 24 national institutions. We make the case for scaling up these activities such that a vibrant system of innovation and production is evolved.

Finally, while the need for harnessing modern technology, including ICT, is often acknowledged, there is also the need for

conservation, development and use of local and traditional varieties and development of new processing devices by designing appropriate incentive systems to induce the scientific community to work with farmer groups.

5. Transfer of Technology

Various initiatives are being undertaken by the ICRI to diffuse the research outcomes among the farmers. These include but not limited to demonstration of good agricultural practices, farmer advisory programs within the institute, weather forecast, TV programmes, mass multiplication and distribution of bioagents such as *Trichoderma and pseudomonas* distribution of seedlings, demonstration of high yielding varieties developed by ICRI (like ICRI-5 & ICRI-7) in farmer's fields and reaching out to farmers' site through mobile clinics, What follows is a brief discussion on the work done in each of these heads.

5.1. Extension Activities

Extension work formed an integral part of the activity of ICRI and the benefits from this institute reached the spice growers through several programmes organised by the institute. It is evident that 19 training programmes have been conducted by the ICRI in different locations during September 2010 to March 2011 where in 559 persons were trained (see Table 5). The training was conducted in all the cardamom growing states including the north eastern states where the large cardamom is cultivated. The training dealt with various aspects of cardamom cultivation like post-harvest operations, bio-agent multiplication, safe use of pesticides and mechanisation in cardamom cultivation and processing. The trainees included not only farmers but also students from Agricultural universities and biotechnology institutes. This is an indication of the potential for ICRI to get engaged in the teaching and research activities of the leading universities and research institutes.

Table 5: Training programmes conducted at ICRI, Myladumpara: 2010-11

Sl. No	Programme	Number of trainees	Date
1	Institution visit of RAWE students from KAU, Mannuthy	15	9-09-2010
2	Industrial visit of TNAU (B. Tech Horticulture) students	26	15-09-2010
3	Industrial visit of students from Hajee Karutha Howdia college, Uthamapalayam	52	17-09-2010
4	Orientation training to new recruits of Spices Board	51	30-9-2010
5	Training on cardamom for farmers from Puttady	24	01-10-2010
6	Farmer scientist interface (farmers from Attappady)	12	05-10-2010
7	Training on cardamom production technologies for farmers from North eastern states	32	18-11-2010
8	Training for cardamom for farmers from Vandanmedu	14	23-11-2010
9	Bio agent mass multiplication (Hands on training)	4	14-12-2010
10	Bio agent mass multiplication (Hands on training)	11	15-12-2010
11	Training for cardamom growers on safe use of pesticides	43	28-12-2010
12	Bio agent mass multiplication (Hands on training)	9	03-02-2011
13	Farmer scientist interface and ICRI Visit	14	07-02-2011
14	Training on cardamom production technologies for farmers from North eastern states	30	17-02-2011
15	Visit of farmers from Vanagur, Karnataka	50	24-02-2011

16	Training on cardamom production technologies for farmers from North eastern states	26	27-02-2011
17	Industrial visit of M.Sc/ B.Sc Bio technology students from Mar Augustinos college, Ramapuram	31	25-02-2011
18	Students of Kerala Agricultural University	64	8-02-2011
19	Mechanisation in cardamom cultivation & processing	51	18-03-2011
	Total trainees	**559**	

Source: ICRI Annual Report 2010-11

5.2. Farmer Advisory Centre

The farmer advisory centre is providing advisory services to the spice farmers. Farmers coming with various problems are directed to concerned divisions/scientists for solutions. Soil and leaf analysis were

Table 6: Advisory service to spice growers 2010-11

Division	Aspects	No: of farmers
Agronomy and soil science	Analysis of soil samples	1142
	Analysis of leaf samples	163
	Analysis of organic manures and compost	22
	Analysis of Neem cake	4
	Analysis of Copper sulphate	5
	Analysis of Copper Oxy Chloride	2
Entomology	Advisory service on IPM for cardamom. Biological control of root grub using EPN, Management of scale insects, whitefly and red spider mites.	108
Plant Pathology	Advisory service on IDM for cardamom, pepper and other spices	472
Total		1918

Source: ICRI Annual Report 2010-11

done free of cost to the farmers and the need based recommendations are given based on the results. Pest and disease affected plant samples are analysed and suitable recommendations are given for management. From Table 6 it is evident that 1918 farmers from Kerala have availed the advisory services of the scientists from the agronomy and soil science, Entomology and plant pathology. Similarly 337 planters visited the Sakalespur station and had taken advice on cultivation and management of cardamom and pepper.

In addition, the scientists of plant improvement division have organised six training programmes for the benefit of cardamom growers in six different locations (see Table 7).

Table 7: Seminar/ Trainings imparted by the Scientists of crop improvement division

Sl. No	Date	Topic/ Programme	Place
1	March, 2010	Cardamom – Production Technology	Rajakumary
2	July, 2010	Seminar on cardamom – GAP	Anakara
3	November, 2010	Training to Officials of Agricultural department, Idukki district.	Thodupuzha
4	November, 2010	Cardamom and black pepper-production technology	Cheetukuzhy
5	November, 2010	Seminar on Cardamom - GAP	Ramakkalmedu
6	March, 2011	Training Mr. Harsha Gowda on Crop Improvement in Cardamom	Myladumpara

Source: ICRI Annual Report 2010-11

5.3. Weather Forecast

Of late, the weather changes have had significant impact on cardamom cultivation and that various cultural operations to be effective needs to be in tune with the prevailing weather conditions. Therefore, the growers have been demanding weather forecast. ICRI is providing weather forecasting services for the benefit of farmers. Regular updates are given through e-mails (114 ids) including all the Spices Board offices, NGOs, TV channels, farmers etc. The forecast includes predictions on weather parameters such as maximum temperature, minimum temperature and other microclimatic parameters for the next 1-5 days.

5.4. Mass Multiplication of Bio Agents

ICRI has been undertaking the Mass multiplication of bioagents such as *Trichoderma harzianum*, *Pseudomonas fluorescens*. *Beauveria bassiana* and *Lecanicillium lecanii* for distribution to planters. These bioagents are being recommended by ICRI and are used by the planters for controlling the various types of fungal diseases in cardamom, vanilla, ginger and black pepper. Besides disease suppression, these bioagents also improve the growth of plants. *Trichoderma* has been produced in solid form in sterilized coffee husk and also in liquid form as spore suspension. The bio-agents such as *Pseudomonas fluorescence*, *Trichoderma harzianum* and *Lecanicillium lecanii* were produced in liquid form in both cultures. As is evident from Table 8 during 2010-11 ICRI has mass multiplied and distributed 4385.5 Kg of *Trichoderma* solid culture, 1801 liters of *Trichoderma* liquid culture, 8278.5 liters of *Pseudomonas* liquid culture,1174.5 Kg of *Pseudomonas* solid culture,55 Kg of *Beauveria bassiana* solid culture,50 Kg of *Lecanicillium lecanii* solid culture and 6 liters of *Lecanicillium lecanii* liquid culture.

Bio-agent production and distribution at ICRI, research station in Saklespur has been of the order of Trichoderma (S) - 1326 kg, Trichoderma (L) - 343 and Pseudomonas - 211 L. In addition, the scientists also undertake visits to problem plots/advisory visits to different farms.

Table 8: Production of Bio-agents during 2010 -2011 period at ICRI, Myladumpara

Month	*Trichoderma Harzianum*		*Pseudomonas Fluorescens*		*Beauveria bassiana*	*Lecanicillium lecanii*		*AMF* Solid(Kg)
	Solid(Kg)	Liquid(L)	Solid(Kg)	Liquid(L)	Solid(Kg)	Solid(Kg)	Liquid(L)	
April 2010	-	221	-	378.5	-	-	-	-
May 2010	134.0	21.0	-	684.0	-	-	-	10.0
June 2010	280.0	286.0	-	601.5	-	-	-	75.0
July 2010	223.5	175.0	-	511.0	-	-	-	10.0
Aug. 2010	538.0	443.0	-	753.0	-	-	-	-
Sept. 2010	629.5	102.0	110.0	876.0	-	-	-	-
Oct. 2010	846.5	218.0	314.5	590.0	-	-	-	-
Nov. 2010	621.0	93.0	534.0	730.0	-	-	-	-
Dec. 2010	905.0	57.0	116.0	520.0	-	-	6	-
Jan. 2011	198	111	100	804	50	50	-	100
Feb. 2011	10.00	28.00	-	928.50	5.00	-	-	-
Mar. 2011	-	46.0	-	902.0	-	-	-	-
Total	4385.5	1801	1174.5	8278.5	55.0	50	6.0	195

Source: ICRI Annual Report 2010-11

5.5. Mobile Spice Clinics and Scientist- farmer Interface

Mobile clinic is an initiative undertaken collectively by the scientists in all the research divisions. The resource persons included scientists representing Crop improvement, Agronomy, soil science, Entomology and Plant Pathology divisions. Problematic fields identified by the field officers are visited by the group of scientists and recommendations are given to solve the problems. The mobile spice clinics are arranged in close association with the development wing of Spices Board. As per the information furnished, during 2010-11 ICRI organized 29 mobile spice clinics in Kerala (including one in Coimbatore) and eight clinics by the research station at Sakleshpur in Karnataka (see Table 9 and 10) A total of 859 growers in Kerala (including Coimbatore) and 450 in Karnataka participated in these clinics. While the large scale participation of growers is an indication of the popularity of the programme, a comparison of the data on farmers' participation in Kerala and Karnataka raises some concerns; Despite most of the clinics have been held in those areas where cardamom is more intensively cultivated in Kerala, the number of farmers participated per clinic in Kerala was only 30 as compared to 56 in Karnataka. Secondly, it appears this programme is not actively pursued in Tamilnadu due to the lack required manpower in the Thadaikurissi research station.

5.6. Demonstration of ICRI-5 & ICRI-7 in Farmer's Fields

ICRI has been, for a long time, undertaking concerted efforts towards developing new varieties of cardamom. Latest in this series being ICRI 5 and ICRI 6 and ICRI 7. Demonstration plots of released varieties such as ICRI-5, ICRI-6 and the improved clone, MCC-346 were established in ICRI farm Myladumpara. About 180 demonstration plots of ICRI-5 were laid out across the cardamom belt and 10 demonstration plots of ICRI-7 were also laid out in Wayanad hills.

Table 9: Mobile Spice Clinics organised by ICRI Myladumpara during 2010-11

SI No	Date	Field unit	Location	Scientists attended	No. of Farmers attended
1	8.4.2010	Rajakumari	Rajakumari(N)	Dr. K.M. Kuruvila Dr.A.K.Vijayan Dr. P.Natarajan Dr.S.Chandrashekar	28
2	2.6.2010	Adimali	Kurisupara	Dr. K.Dhanapal Dr. P.Natarajan Mr. M.A. Ansar Ali Dr. V.V.Radha krishnan	32
3	16.6.2010	Rajakumari	Rajakumari	Dr. K.Dhanapal Mr. M.A. Ansari Dr. V.V. Radhakrishnan	37
4	23.6.2010	Santhanpara	Santhanpara	Dr. S. Varadarasan Dr. K.M. Kuruvilla Dr. K. Dhanapal	6
5	30.6.2010	Myladumpara	Myladumpara	Dr. A.K.Vijayan Dr. S.Chandrashekar	15
6	07.07.2010	Nedumkandam	Pavakkodi	Dr. P. Natarajan Mr. M.A. Ansar Ali	7

7	14.07.2010	Pampadumpara	Pampadumpara	Dr. A.K. Vijayan Dr .P .Natarajan Mr. M.A. Ansar Ali Dr. V.V. Radhakrishnan	23
8	21.07.2010	Thankamani	Thankamani	Dr. K. M. Kuruvilla Dr. K.Dhanapal Dr. S.Chandrashekar	21
9	28.07.2010	Kattappana	Vallakkadavu	Dr. A.K. Vijayan Dr. S. Chandrashekar	23
10	01.09.2010	Marykulam	Marykulam	Dr. A.K. Vijayan Dr. P.Natarajan Mr. M.A.Ansar Ali Shri. John Jo Varghese Dr.D. Ajay	55
11	08.09.2010	Kumily	Pathumuri	Dr. S. Varadarasan Dr. P.Natarajan Dr. V.V.Radha Krishnan Dr. D.Ajay Miss. Anu Anie Mathews Mr. Manoj Oommen	26

12	09.09.2010	Coimbatore	Kolli hills	Dr. J.Thomas Dr. A.K.Vijayan Dr. S.Chandrashekar	36
13	05.10.2010	Myladumpara	Myladumpara	Dr. M.R.Sudharshan Dr. K. M. Kuruvilla Dr. A.K.Vijayan Dr. P.Natarajan Shri. John Jo Varghese	13
14	06.10.2010	Puttady	Puttady	Dr. A.K.Vijayan Dr. S.Chandrashekar Dr. V.V.Radhakrishnan Shri. John Jo Varghese Miss. Anu Anie Mathews	4
15	13.10.2010	Thookupalam	Cumbammettu	Dr. B.Gopakumar Dr. K. M. Kuruvilla Dr. K.Dhanapal Shri. John Jo Varghese Miss. Anu Anie Mathews	31
16	14.10.2010	Kumily	Kumily	Dr. J.Thomas Dr. A.K.Vijayan Dr. S.Chandrashekar Dr. P.Natarajan	52

17	27.10.2010	Poopara	Thondimala	Dr. M.R.Sudharshan Dr. S.Varadarasan Dr. A.K.Vijayan Shri. John Jo Varghese	8
18	03.11.2010	Marayur	Kanthalloor	Dr. B.Gopakumar Dr. K.Dhanapal Dr. V.V.Radhakrishnan Mr. Manoj Oommen	71
20	03.12.2010	Attapady	Attapady	Dr. A.K.Vijayan Mr. M.A.Ansar Ali	7
21	24.11.2010	Mangathotty	Vattappara	Dr. S.Varadarasan Dr. P.Natarajan Dr. K.Dhanapal Dr. V.V.Radhakrishnan	22
22	15.12.2010	Murikkassery	Murikkassery	Dr. K.Dhanapal Dr. V.V.Radhakrishnan Mr. M.A.Ansar Ali Mr. Manoj Oommen	5
23	09.02.2011	Adimali	Thokkupara	Dr. A.K.Vijayan Mr. M.A.Ansar Ali Shri. John Jo Varghese	31

24	16.02.2011	Nedumkandam	Manjapetty	Dr. K.Dhanapal Dr. D.Ajay Mr. M.A.Ansar Ali Shri. John Jo Varghese	36
25	17.02.2011	Pampadumpara	Pampadumpara	Dr. A.K.Vijayan Shri. John Jo Varghese	73
26	24.02.2011	Santhanpara	Mathikettan	Dr. A.K.Vijayan Dr.S.Chandrashekar Miss.Anu Anie Mathews Mr. Manoj Oommen	24
27	15.03.2011	Nedumkandam	Nedumkandam	Dr. A.K.Vijayan Shri. John Jo Varghese	60
28	16.03.2011	Karimannur	Cheruthony	Dr. A.K.Vijayan Shri. John Jo Varghese	37
29	24.03.2011	Kalpetta	Kalpetta	Dr. A.K.Vijayan	76

Source: ICRI, Annual Report 2010-11

Table 10: Spice clinics conducted by ICRI, RS, Saklespur during 2010-11

MONTH	PLACE	TOPIC	No. of Farmers attended
April	1) Bommenahalli	Cultivation & disease management of Cardamom & Pepper	15
	2) Bookanakere		20
	3) Kalasa		10
May	Sakleshpur	Cardamom & Other Spices	75
July	1) Hucchangi	Cultivation & disease management of Cardamom & Pepper	20
	2) Odahally		21
August	Hetthur	Cultivation of Spice Crops	25
September	1) Huchangi	Organic cultivation of Spices	17
	2) Arehally	Cultivation & disease management of Spices	32
December	Kowdahally	Cultivation & disease management of Cardamom & Pepper	28
January 2011	Kaloor (Coorg)	Cultivation & disease management of Cardamom & Pepper	31
February	1) Athihalli	Cultivation & disease management of Cardamom & Pepper	103
	2) Hamyala (Coorg)		35
	3) Bhagamandala		18

Source: ICRI Annual Report 2010-11

Observations were made on the plant growth characters such as tillers/clump, tiller height (cm), panicles/clump, panicle length (cm), racemes/ panicle and capsules/ raceme from the plots of ICRI-5 established in the cardamom tract of Idukki district. The performance of ICRI-5 varied in different locations. Eight plots out of 30 were having good growth and capsule formation. Out of the eight plots two registered high yield and superior performance with respect to growth characters. Variability has been noticed among the plants in many plots.

The observations of the farmers on ICRI-5 are the following;

1. Panicle is relatively short and exhibits low yield performance compared to other popular cardamom varieties.

2. Harvesting of physiologically mature capsules is cumbersome due to its intrinsic character of the variety (compactness of capsules on the raceme).

3 The variety provides high percentage of quality capsules due to extra bold nature.

4 The variety registers relatively high recovery percentage due to more number of seeds (> 18/ capsule).

6. Achievements of ICRI

ICRI in general has many achievements to claim. To list a few;

- ICRI maintains the national conservatory of germplasm of small and large cardamom with the worlds' largest collection of 800 accessions of small cardamom and 300 accessions of large cardamom. This genepool is the base for all present and future crop development programmes in cardamom.

- Location specific cardamom clones ICRI-1, ICRI-2, ICRI-5, ICRI-6 and ICRI-7 were developed for Kerala; ICRI-3 for Karnataka; ICRI-4 for Tamilnadu and ICRI Sikkim-1 and ICRI Sikkim-2 for

Sikkim and Northeastern Region and released for cultivation at state/ national level. These improved clones have contributed substantially to the increase in the production and productivity of small and large cardamom.

- The fruits of biotechnology were taken to the farm gate level by demonstrating the performance of tissue culture plants of small cardamom in 100 hectares, large cardamom in 100 ha; vanilla in 111 hectares and black pepper in 100 hectares. Many of these beneficiaries were the recipients of productivity awards for the respective crops at national Level.

- Good Agricultural Practices for mandate crops were evolved in tune with changing ecological, climatic and economic scenario to ensure sustainability of its cultivation.

- Cardamom soils have been characterised and agro-ecological zones of Cardamom Hill Reserve (CHR) have been defined for better location specific management of cardamom and other spices.

- Integrated pest and disease management strategies were developed which has helped to reduce crop loss to less than 10%. Presently, the research focus is to reduce the toxic chemical load in the crop ecosystem for which effective native isolates of useful micro-organisms (bio-agents) have been identified. *Trichoderma viridi*, ICRI Strain-T14, *Tharzianum* ICRI Strain-T12, ICRI Vanilla *Trichoderma* strains - VT-4, VT-2. Arbiscular mycorrhiza fungi ICRI strains GMC-1, GFC-2 and GMIC-3 for disease management and Entomopathogenic Nematode strain ICRI-18 are major breakthrough in non-chemical pest and disease management.

- The research efforts of ICRI form the base for introduction and popularization and successful cultivation of the exotic spice

vanilla and making India, a reliable source of quality vanilla beans since the year 2000. Today, over 5000ha of area is under vanilla cultivation in Karnataka, Kerala and Tamilnadu.

- ICRI improved bhatti system for large cardamom curing has helped in producing high premium large cardamom of international quality standard. ICRI drier helped the farmers to fetch premium price for their produce due to the retention of original pink colour of the capsules after curing.

- The flagship three months residential training programme on Good Agricultural Practices (GAP) for quality spice production has helped in skill development in spice production of rural unemployed educated youths belonging to farming communities. Two hundred unemployed youths belonging to the Northeastern Region and other spice growing states were benefited from this programme and most of the trainees are involved in some income generating activities.

- Mobile spice clinic, Farmer's Advisory Centre, soil testing and advisory services, pesticide monitoring and farm gate quality assurance programme, periodic scientist-farmer interfaces, farm bulletin through All India Radio and local TV channels are effective farmers' service providers of ICRI.

7. Concluding Observations

Realising the relevance of research and development for building international competitiveness in plantation sector the Ministry of Commerce established research institutes under each commodity board to deal with all the aspects of specific crop(s) assigned to them. This study is an attempt to undertake a preliminary evaluation of research undertaken by Indian Cardamom Research Institute (ICRI) under the Spices Board on cardamom.

In this study, by conceptualising innovation as a cumulative, interactive and socially embedded process, we adopted a method that combines both the input approach and output approach with due consideration for the institutional context and the manner in which research is undertaken. Hence, we began with an examination of inventive and innovative efforts undertaken by different research divisions in ICRI. We also examined the overall research efforts in cardamom by examining the R&D investment in terms of money invested and number of scientists engaged. This is followed by an examination of initiatives undertaken by ICRI towards transferring the technologies and innovative practices developed by the scientists to the growers.

With a view to gauge the effectiveness of research in terms of its outcomes as perceived by the growers (the consumers of the research output), we organized consultations with growers in two major cardamom growing areas of Kerala namely Nedumkandam and Vandanmedu. Towards having an understanding on the manner in which research has been undertaken as well as the institutional context, we had two rounds of consultations with scientists in ICRI and discussion with the current and previous Directors.

The study found significant variations in terms of the number of scientists involved in each research division. While pathology division has four scientists, crop improvement has only two.

Yet another point of concern for someone who considers technological change (innovation for shorthand expression) as an interactive process, is the location of the biotechnology division in Cochin, far away not only from the main research station but also the plantations/growers. Hence, it is advisable that all the research divisions are under the same roof.

Similar asymmetry appears to be present across different research stations; Thadiyankurissi has no scientists as of now; Also one finds

significant variation in terms of the availability of experimental land per scientist across different stations; It is as high as eight hectares in Sakleshpur, four in Myladumpara and two hectares in Tadong (Sikkim).

A careful examination of the objectives of the various experiments/ projects undertaken by different divisions tends to suggest that numerous issues relating to different aspects of cardamom production are being addressed by the scientists in ICRI. Hence, there appears to be a lack of focus on research especially given limited number of scientists in ICRI. The strategy of spreading too thinly the limited research efforts across a wide range of issues might have its impact on the research outcome.

Going by the available evidence, the cardamom growers are highly innovative by themselves. Yet, it appears that the present approach is one wherein scientists are considered as inventors and innovators and growers as blind adopters of innovations. We make the case for a more interactive approach towards research agenda setting and research implementation which involves combining the knowledge base of the scientists and that of growers for addressing the specific problems.

As of now due to the absence of appropriate institutional arrangements, it is rather difficult to harness effectively the co-operation from farmers. Hence, for evolving such an interactive innovation process, there is a need for the establishment of Spice Producers' Societies (SPS) in a democratic manner. Here, it is worth noting that such institutional arrangements have already being in evolved in case of natural rubber with immense social returns.

It is surprising to note that the institute, despite having over 50 scientists and a research outlay of four Crores of rupees, does not have a web site of its own. There is an urgent need to set up a vibrant website with relevant information for the growers like package of practices, pests attack and ways and means to control them, weather forecast, details on each of the scientist, and provision for the growers and others concerned to interact with the institute.

The share of R&D in the total expenditure by the Spices Board has been showing a declining trend from nearly 10% in 2002-03 to a little over 6% in 2009-10. Moreover, R&D expenditure as a proportion of the value of output has been fluctuating over time (due to changes in the value of output) and in most years less than one per cent. These trends point towards inadequate investment in research. Hence, the trend needs to be reversed at the earliest especially given the heightened competitive environment wherein innovation is the key to survival.

Further, the scale of R&D in spices is at a much smaller scale as compared to natural rubber despite the fact that there are 52 spices under the Spices Board. Studies have shown that like any other economic activity, knowledge generation activities such as R&D are also associated with economies of scale. Hence, the larger scale of R&D in natural rubber, *inter alia*, might have been instrumental in enabling RRII to record an impressive R&D outcome. Hence, a case could be made for enhancing the scale of R&D in ICRI by including other spices as well under its purview.

In the case of natural rubber, RRII is the sole agency concerned with R&D where as in the case of spices there are multiple actors. At this same time, it is also to be noted that Spices Board has under its purview 52 spices and the effective promotion of trade in these spices invariably calls for substantial research on this crops. As of now, apart from cardamom and limited research on black pepper and vanilla, issues relating to other crops rarely receive the attention of scientists. ICRI cannot afford for long keep a blind eye to this issue. Along with scaling up of R&D activities in spices there is also the need for initiating steps for better co-ordination among different actors involved in R&D, innovation and different aspects of production and processing in order to evolve a vibrant system of innovation.

Various initiatives undertaken collectively by the scientists in ICRI for the transfer of technology are highly laudable. These include

demonstration of good agricultural practices, farmer advisory programmes within the institute and reaching out to farmers' site through mobile clinics, weather forecast, TV programmes, mass multiplication and distribution of bio-agents such as *Trichoderma harzianum*, *and distribution of seedlings*, demonstration of high yielding varieties developed by ICRI (like ICRI-5 & ICRI-7) in farmer's fields.

However, the feedback from many of the growers of these programmes was not very encouraging. To illustrate, despite most of the spice clinics have been held those areas where cardamom is more intensively cultivated in Kerala, the number of farmers participated per clinic in Kerala was only 30 as compared to 56 in Karnataka. The growers seem to be not highly convinced of the usefulness of the varied efforts by ICRI as one of the growers remarked "the cardamom plants in ICRI farm is nowhere near the cardamom plants of an average grower".

It appears that there is the need for ICRI to have a demonstration plot on a highly visible and accessible location that stands heads and shoulders above the best estate in the region. It is also advisable that all available varieties of cardamom including the ones developed by ICRI shall be grown with utmost care around the premises of the main office of ICRI as a first display of the institute's capability that in turn attract the growers to the institute.

Despite the initiatives by ICRI to transfer technology, there is large scale prevalence of consultants in cardamom growing areas. Such consultants, given their narrow focus on only increasing productivity at any cost, often prescribe package of practices that are highly intensive in the use of chemical fertilizers and insecticides. The adverse impact of such practices on environment on the one hand, and plausible adverse effect on demand (both export and local) on account of pesticide residues and other issues needs no elaboration.

A major issue with scientific research institutions established in India after independence is that hardly any one of them has been engaged

in teaching. The result has been that there was very little participation by leading scientists in the country in the shaping of younger generation of researchers. This lacuna in our research system has increasingly been corrected. But in the case of ICRI, which is conceived as an institution engaged only in research, there is hardly any linkage with the university system and there is no active engagement in the generation of future researchers. Hence, it is important that ICRI should make an attempt at the earliest to affiliate itself with any university in the country.

It is also to be noted that ICRI is perhaps the only institute in the world with so much of accumulated research experience on a single crop. Hence, there is an opportunity by building upon its knowledge base to emerge as an international institute dealing with all aspects of cardamom. Organisation of an international conference by involving researchers from other countries involved in the research on cardamom might be a first step in this direction.

At this juncture it is also to be noted that the reward system as it exists today for the scientists in ICRI, compares very poorly with their counterparts with comparable qualification and working in universities or national research laboratories. Hence, to attract best minds for research on spices anomalies in the reward system, if any, need to be corrected sooner than later. This, along with the governance structure of various institutions under the commodity Boards is an issue that needs more detailed exploration.

From a long term development perspective, narrowly focused research on a specific crop with the sole objective of enhancing productivity might do more harm than good. Hence, it is important that the issue of overall development of region in general and sustainable development in particular, has to be integrated with cardamom research as well. This might call for broadening the research agenda with due attention to long term development implications.

Acknowledgement

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Annexure 1: Research issues and objectives of various experiments/projects undertaken by different divisions in ICRI during the last two years (2009-10 and 2010-11)

CROP IMPROVEMENT (2009-10)

	Research Issues	Objectives
1	Survey and Collection of germplasm accessions (1979).	To collect all the genetic variants of cardamom from various habitats for exploitation in the crop improvement programmes.
2	Multiplication and conservation of germplasm accessions (1993-94).	To multiply the germplasm accessions and elite cardamom clones for evaluation and utilisation.
3	Evaluation (1988-89) At Myladumpara: Performance evaluation of landraces of cardamom.	To evaluate landraces with respect to growth, yield and quality attributes for identifying promising genotypes for further breeding programmes.
4	Preliminary Evaluation Trial (2005) At Myladumpara.	To evaluate germplasm accessions with respect to growth, yield and quality attributes for identifying promising genotypes for further breeding programmes.
5	Comparative Yield Evaluation in cardamom.	To study the comparative performance of accessions selected from preliminary evaluation trials.
6	Multilocation trials in cardamom.	To study the location specificity or adaptability of hybrids/selections of cardamom.
7	Location specific trial on cardamom in Wayanad.	To find out suitable selections/ hybrids for the Wayanad area of the cardamom tract.
8	Coordinated Varietal Trial (CVT) on cardamom.	
9	Evaluation of F1 Hybrids.	
10	Screening for katte resistance.	To breed plants tolerant/resistant to katte disease of cardamom through mutation breeding.

11	Breeding cardamom for drought tolerance.	To evaluate adaptive performance of drought tolerant lines in lower Pulney hills of Tamil Nadu.
12	Bio-efficacy evaluation of Siapton 10L on cardamom.	To study the effect of Siapton 10L on growth and yield of cardamom.
13	Adaptive Trials on other spices: Black Pepper: At Myladumpara: Evaluation of released varieties of pepper.	To identify suitable variety/varieties for large-scale cultivation in the High Ranges of Idukki district of Kerala.
14	Evaluation of released varieties of pepper.	To identify suitable variety/varieties for large-scale cultivation in the High Ranges of Karnataka.
15	Hybridisation in cardamom.	To develop cardamom hybrids with high yield and export quality capsules suited to various zones of the cardamom tract for sustainable production.
16	Diallele crosses in cardamom.	(i) Evolving high yielding clones suited to Karnataka (ii) Genetic up gradation of Malabar Cardamom.

CROP IMPROVEMENT 2010-11

	Research Issues	Objectives
1	Survey and Collection of germplasm accessions.	To collect all the genetic variants of cardamom from various habitats for exploitation in the crop improvement programmes.
2	Multiplication and conservation of germplasm accessions.	To multiply the germplasm accessions and elite cardamom clones for evaluation and utilisation.
3	Preliminary Evaluation Trial.	To evaluate germplasm accessions with respect to growth, yield and quality attributes for identifying promising genotypes for further breeding programmes and elite cardamom clones for evaluation and utilisation.
4	Comparative yield evaluation in cardamom.	To study the comparative performances of accessions selected from preliminary evaluation trials.

5	Multilocation trials in cardamom.	To study the location specificity or adaptability of hybrids/selections of cardamom.
6	Location specific trial on cardamom in Wayanad.	To find out suitable selections/ hybrids for the Wayanad area of the cardamom tract.
7	Cordinated Varietal Trial (CVT) on cardamom.	
8	Screening for Katte resistance.	To breed plants tolerant/resistant to katte disease of cardamom through mutation breeding.
9	Breeding for thrips tolerance in cardamom.	To develop thrips tolerant lines in cardamom.
10	Bio-efficacy evaluation of Siapton 10L on cardamom.	To study the effect of Siapton 10L on growth and yield of cardamom.
11	**Adaptive Trials on other spices: Black Pepper:** Evaluation of released varieties of pepper.	To identify suitable variety/varieties for large-scale cultivation in the High Ranges of Idukki district of Kerala.
12	Hybridisation in cardamom.	To develop cardamom hybrids with high yield and export quality capsules suited to various zones of the cardamom tract for sustainable production.
13	Diallele crosses in cardamom (Karnataka).	i. Evolving high yielding clones suited to Karnataka. ii. Genetic up gradation of Malabar Cardamom.

PLANT PATHOLOGY (2009-10)

	Research Issues	Objectives
1	Screening of improved cardamom selections and hybrids for rot tolerance (2003).	Screening of improved cardamom selections, released varieties and hybrids for tolerance to rot diseases.
2	Survey and isolation of *Fusarium exysporum* from various locations.	i. Survey and isolation of *Fusarium* sp. from different infected plant parts and also from various localities for establishing the specificity of the pathogen by cross inoculation studies.

		ii. To identify and characterize the various types/isolates of *Fusarium oxysporum* causing root rot & leaf yellowing, pseudostem rot and panicle wilt in cardamom.
3	Integrated management of *Fusarium oxysporum* infections in small cardamom in the field.	To work out an integrated disease management strategy for controlling *Fusarium ozysporum* diseases in the field.
4	Utilisation of rot tolerant lines of Cardamom (2007).	To develop rot tolerant lines of cardamom through screening for rot pathogens.
5	Testing the field tolerance of short listed rot tolerant selections and hybrids in sick plots.	**Work under this experiment is reported under plant pathology No 37.**
6	Survey for the identification of disease escapes (Azhukal and or rhizome) from rot affected plantations.	For studying the susceptibility of disease escapes to inoculation with rot pathogens.
7	Survey, Isolation and *in vitro* testing of PGPRs and other fungal antagonists (2007).	To develop a consortium of bio agents and PGPRs which can be effectively utilised for the control of diseases in cardamom.
8	Isolation, identification, screening and utilisation of native *pseudomonas* and *Bacillus* for small cardamom production.	To develop an efficient native strain of *Pseudomonas* and *Basillus* for small cardamom.
9	Collection and Utilisation of Katte and Kokke kandu escapes of cardamom in Karnataka.	i. To identify and collect natural disease escapes by surveying in hot spot areas in Karnataka. ii. Testing their disease tolerance level under green house conditions and their further utilisation in developing tolerant lines. iii. Planting the screened lines for evaluation in the hot spot area.

10	Evaluation of Copper hydroxide 46.1% DF for the field control of azhukal disease (paid up trial) (2007).	To evaluate the efficacy of Copper hydroxide 46.1% DF, a new formulation for the control of rot diseases in the field.
11	Establishment of Biocontrol production centre for spices in Idukki (2008).	i. To establish a bio-agent production center at ICRI, Spices Board for spice farmers of Idukki. ii. To supply quality bioagents to spices farmers of Idukki district so as to reduce the usage of chemical pesticides. iii. To train and encourage the adoption of integrated pest and disease management to spice farmers so that export quality spices could be produced from the district. iv. To promote an alternative spice production technology, which is sustainable, economic and eco-friendly.

PLANT PATHOLOGY (2010-11)

	Research Issues	Objectives
1	Screening of improved cardamom selections and hybrids for rot tolerance (2003).	Screening of improved cardamom selections, released varieties and hybrids for tolerance to rot diseases.
2	Studies on leaf blotch disease.	i. To assess the level of disease incidence in various localities. ii. To assess the disease incidence in various accession of germplasm under field condition. iii. Isolation of the pathogen and pathogenicity studies. iv. Isolate phylloplane bacteria and assess its potential of using as antagonist.
3	Survey and isolation of Fusarium oxysporum from various locations.	i. Survey and isolation of Fusarium sp. from different infected plant parts and also from various localities for establishing the specificity of the pathogen by cross inoculation studies.

		ii. To identify and characterize the various types/isolates of *Fusarium oxysporum* causing root rot & leaf yellowing, pseudostem rot and panicle wilt in cardamom.
4	Integrated management of *Fusarium oxysporum* infections in small cardamom in the field.	To work out an integrated disease management strategy for controlling *Fusarium oxysporum* diseases in the field.
5	Survey for the identification of disease escapes (Azhukal and/or rhizome rot) from rot affected plantations (2007).	For studying the susceptibility of disease escapes to inoculation with rot pathogens.
6	Survey, Isolation and *in vitro* testing of PGPRs and other fungal antagonists (2007).	To develop a consortium of bioagents and PGPRs which can be effectively utilized for the control of diseases in cardamom.
7	Isolation, identification, screening and utilisation of native *pseudomonas* and *Bacillus* for small cardamom production (2009).	To develop an efficient native strain of *Pseudomonas* and *Basillus* for small cardamom.
8	Effect of coir pith as mulch on microbial activity in Cardamom cultivation.	i. To assess the effectiveness of raw coir pith mulch in retention of various microbial inoculants. ii. Incidence of various diseases. iii. Effect on decomposition process.
9	Collection and Utilisation of Katte and Kokke kandu escapes of cardamom in Karnataka (2008).	i. To identify and collect natural disease escapes by surveying in hot spot areas in Karnataka. ii. Testing their disease tolerance level under green house conditions and their further utilisation in developing tolerant lines. iii. Planting the screened lines for evaluation in the hot spot area.

10	Evaluation of Copper hydroxide 46.1% DF for the field control of azhukal disease (paid up trial) (2007).	To evaluate the efficacy of Copper hydroxide 46.1% DF, a new formulation for the control of rot diseases in the field.
11	Establishment of Bio-control production centre for spices in Idukki (2008).	i. To establish a bio-agent production center at ICRI, Spices Board for spice farmers of Idukki. ii. To supply quality bio-agents to spices farmers of Idukki district so as to reduce the usage of chemical pesticides. iii. To train and encourage the adoption of integrated pest and disease management to spice farmers so that export quality spices could be produced from the district. iv. To promote an alternative spice production technology, which is sustainable, economic and eco-friendly.
12	Management of foot rot in black pepper in farmers field (2010).	Field management of foot rot in planters field using fungicides and bio-agents.

ENTOMOLOGY (2009-10)

	Research Issues	Objectives
1	Demonstration of Good Agricultural Practices for cardamom (2010).	To evaluate the holistic package of cultivation of cardamom in different agro climatic locations.
2	Bio-efficacy of Flubendiamide 480 SC (W/V) (FAME 480 SC) on cardamom shoot, panicle, and capsule borer, *Conogethes punctiferalis Guen).*	To evaluate bio efficacy of Flubendiamide 480 SC (FAME 480SC) on cardamom shoot, panicle, and capsule borer.
3	Screening of cardamom accessions for thrips tolerance	To identify thrips tolerant cardamom accessions.
4	Integrated Management of cardamom thrips with lesser number of pesticide sprays(This experiment is under the Neem Project Phase II**,** sponsored by the Ministry of Chemicals and Fertilisers, Government of India).	Evaluation of different levels(rounds) of insecticides/ botanicals (Neem based) on damage of capsules by cardamom thrips.

5	Integrated Management of chilli pest, and organic management of black pepper, large cardamom, ginger and turmeric with NEem Kernel Aqueous Extract 5% (NKAE 5%).	Evaluation of NKAE 5% in the IPM of chilli, black pepper, Large cardamom, ginger and turmeric.
6	Studies on thrips damage in cardamom at different levels of pest management.	To assess qualitative loss caused by damage on cardamom capsules thrips, *Scithrips cardamomi* (Ramk).
7	Isolation, identification, synthesis, laboratory and field evaluation of female sex pheromone components of *Conogethes punctiferalis.*	Objective of the work is to explore the possibility of using female sex pheromone of *conogethes pubctiferalis* for monitoring/mass trapping.
8	Management of cardamom root grub, *Basilepta fulvicorne* with Entomomopathogenic Nematodes.	

ENTOMOLOGY (2010-11)

	Research Issues	Objectives
1	Bio-efficacy of Flubendiamide 480 SC (Fame 480 SC) on cardamom thrips and borer.	To evaluate the bio efficacy of new molecule Flubendiamide 480 SC (FAME 480SC) on cardamom thrips and shoot, capsule and panicle borer.
2	Isolation, identification, synthesis, laborary and field evaluation of female sex pheromone components of *Conogethes punctiferalis.*	To isolate, identify and synthesise the female sex pheromone of cardamom shoot borer and evaluate under field conditions.
3	Studies on outbreak of red spider mite on cardamom.	To explore the causes for the outbreak of mites and evolve suitable management practices.
4	Insect Pest Surveillance in Cardamom.	To survey insect pests, nematodes and natural enemies of pests of cardamom at monthly interval in various cardamom agro eco-systems in Idukki district of Kerala and ICRI farm.

5	Studies on factors leading to outbreak of whitefly of cardamom and its population dynamics.	To explore cause for the outbreaks of whiteflies and evolve suitable management practice.
6	Resurvey for root grubs in cardamom ecosystems.	To study the population pattern of cardamom root grub in view of continuous occurrence in cardamom ecosystem in association with alternate host.
7	Evaluation of NKAE 5% against cardamom thrips.	Evaluation of NKAE in the IPM of small cardamom
8	Evaluation of NKAE 3% against pest/diseases of black pepper.	Evaluation of NKAE in the IPM of black pepper.
9	Biological control of cardamom pests with EPF.	Identification and evaluation of EPF on cardamom.
10	Biological control of cardamom pests with EPN: Evaluation of Gel and cadaver formulation of EPN on cardamom root grub.	Standardisation of proper formulation of EPN.
11	Biological control of cardamom pests with predators and parasitoids.	Identification of efficient parasitoids/ predators of cardamom pests, mass multiplication in suitable media and testing their parasitizations potency.
12	Screening of cardamom accessions for thrips tolerance.	Identification of thrips tolerant cardamom accessions.

AGRONOMY AND SOCIAL SCIENCE (2009-10)

	Research Issues	Objectives
1	Nutritional management for different cardamom genotypes.	To find out the major nutrient requirements for different high yielding varieties of cardamom.
2	Performance of different genotypes to various levels of fertilizer in Karnataka.	To study the different genotypes to various levels of fertilizer.
3	Long term fertilizer experiment on cardamom.	To evaluate the effect of application of fertilizers and organic manures on soil fertility, growth and yield of cardamom on a long-term basis.
4	Studies on nutrient uptake pattern of Njallani.	Study on nutrient uptake pattern of Njallani cardamom at various growth stages.

5	Eco-friendly production of export oriented spice crops using coir products - Phase II – "Standardization of greenhouse technology using coir boovastra".	i. To evaluate the use of coir geo-textiles as a shade material for spices production. ii. To standardise the micro-environmental parameters (viz., temperature, RH and Sunshine) inside the coir geo-textile lines poly houses for production of cardamom and other spices. iii. To study the phenology & growth characters of Cardamom & Black Pepper under poly-house conditions. iv. To study the quality aspects of herbal spices under various geotextile lined polyhouses. v. To study the use of coir as trailing material for black pepper. vi. Rapid multiplication of black pepper using serpentine method under various geo textile lined poly houses (May 2010).
6	Rapid multiplication of black pepper using serpentine method under various geotextile lined polyhouses (April 2010).	To evaluate the growth and rapid multiplication of black pepper using Serpentine method under various geotextile lined polyhouse conditions.
7	Monitoring of pesticide residues at national level sponsored by department of agriculture and cooperation ministry of agriculture, New Delhi.	i To undertake field monitoring of pesticide residues in selected spices at farm gate level (Cardamom and Pepper). ii. To analyse and compile the field level data for determining the source, nature and extent of contamination in the spices. iii. To monitor water samples for pesticide residues in the spice (cardamom) growing tracts. iv. To formulate proper action plan for handling and usage of pesticide in spices production.

8	Pesticide persistence study in cardamom.	i. To study the persistence of commonly used pesticides in the cardamom field condition. ii. To study the persistence of pesticides in the cardamom capsules during storage.
9	Integrated plant nutrient supply system (IPNS) in selected export oriented spices-sponsored by Dept. of Biotechnology GOI, New Delhi.	**Nursery Trials:** i. Trial No.C/N 2008 PM/01 (M): Effect of INM on small cardamom sucker nursery in trenches. ii. Trial No.C/N 2008 PM/ 02(SKP): Effect of INM on small cardamom seedbed nursery of Cardamom. **Field Trials: Existing Plantation** i. Trial No C/F 2008 PM/01 (M): Effect of INM on growth and yield of small cardamom in the existing plantation. (18 months old) ii. Trial No C/F 2008 PM/02 (M): Effect of INM on growth and yield of small cardamom in the existing plantation(24 months) **Field trial with unfortified seedlings:** i. Trial No.C/F 2009 PM/04 (SKP): Effect of INM on growth and yield of unfortified (Bio- consortium) seedlings of Cardamom.
10	Effect of INM on small cardamom sucker nursery in trenches.	To standardise the integrated nutrient requirement for small cardamom sucker nursery in trenches.
11	Effect of INM on seedbed nursery of Cardamom.	To standardise the integrated nutrient requirement for cardamom seed bed nursery.
12	Effect of INM on growth and yield of cardamom in the existing plantation.	To standardise the integrated nutrient requirement for sustained production of cardamom.

13	Effect of INM on growth and yield of cardamom in the existing plantation.	To standardise the integrated nutrient requirement for sustained production of cardamom.
14	Effect of INM on growth and yield of unfortified seedlings of cardamom.	To standardise the integrated nutrient requirement for sustained production of unfortified seedlings of cardamom.
15	Integrated Plant Nutrient supply system (IPNS) in selected export oriented Spices-Black pepper-Sponsored by Dept. of Biotechnology, GOI, New Delhi.	**Nursery Trials:** i. Trial No.BP/N2008 PM/03(SKP): Effect of INM on Poly bag nursery of Black Pepper. ii. Trial No.BP/N 2009 PM/04 (M): Effect of INM on Poly bag nursery of Black pepper. **Field Trials:** i Trial No.BP/F2008 PM/03 (SKP): Effect of INM on growth and yield of Black pepper in the existing plantation(8years).
16	Effect of INM on Poly bag nursery of Black Pepper.	To standardise the integrated nutrient requirement for black pepper Poly bag nursery.
17	Effect of INM on Poly bag nursery of Black pepper.	To standardise the integrated nutrient requirement for black pepper Poly bag nursery.
18	Effect of INM on growth and yield of Black Pepper in the existing plantation.	To standardise the integrated nutrient requirement for sustained production of Black Pepper.
19	Organic cultivation of small cardamom and other high value spices (Development of model organic farm sponsored by NCOF Ghaziabad).	i. To develop a model organic farm on small cardamom for demonstration. ii. To evolve scientific package of practices for organic cultivation of small cardamom and other inter cropped spices. iii. To evaluate the quality parameters of small cardamom grown under organic cultivation. iv. To access the changes in the soil fertility status under organic farming.

20	Establishment of Plant Health Clinic in Idukki District (Sponsored by State Horticulture Mission, Kerala).	To establish agri clinic in Idukki district for monitoring of soil, plant and environmental health in cardamom plantation.

AGRONOMY AND SOCIAL SCIENCE (2010-11)

	Research Issues	Objectives
1	Nutritional management for different cardamom genotypes.	To find out the major nutrient requirements for different high yielding varieties of cardamom.
2	Performance of different genotypes to various levels of fertilizer in Karnataka.	To study the different genotypes to various levels of fertilizer.
3	Effect of water soluble fertilizes on growth and yield of cardamom.	To study the comparative efficiency of different water soluble fertilizers against traditional fertilizers in improving growth and productivity of cardamom.
4	Organic nutrition in cardamom (SKP).	To standardise the effect of different organics on growth, yield and quality of cardamom.
5	Long term fertilizer experiment on cardamom.	To evaluate the effect of application of fertilizers and organic manures on soil fertility, growth and yield of cardamom on long-term basis.
6	Studies on nutrient uptake pattern of Njallani.	Study on nutrient uptake pattern of Njallani cardamom at various growth stages.
7	Studies on climatic factors on cardamom productivity.	
8	Field evaluation of mechanical weed cutter.	To evaluate the efficiency of mechanical weeder for doing weeding in cardamom and to find out the economics.
9	Field evaluation of Cardamom washing machine.	To evaluate the efficiency of Cardamom washing machine.
10	Documentation of sprinkler and mist irrigation system.	To evaluate the efficiency of sprinkler and mist irrigation systems in cardamom plantation.

11	Effect of irrigation and fertilizer levels on yield of cardamom (SKP).	To determine the response of cardamom for levels of fertilizers and Irrigation.
12	Effect of different fertigation schedules on growth and yield of cardamom (MYL) (New experiment).	To study the efficacy of different fertigation schedules on growth and yield of cardamom.
13	Effect of coirpith as mulch in cardamom (New experiment).	i. To assess the effectiveness of raw coir pith mulch in managing weeds. ii. To assess the effectiveness of raw coir pith mulch in soil moisture retention. iii. To assess the effectiveness of raw coir pith mulch in Root growth. iv. To assess the effectiveness of raw coir pith mulch in growth and yield of cardamom.
14	Assessment of high density planting in cardamom (New experiment).	To assess the production of tillers when more than one planting material is planted in the same pit.
15	Assessment of pit less planting method in cardamom (New experiment).	To assess the plant growth performance on adopting pit less planting method in cardamom.
16	Eco-friendly production of export oriented spice crops using coir geotextiles and other coir products(2007)-Phase II.	i. To evaluate the use of coir geo-textiles as a shade material for spices production. ii. To standardise the micro-environmental parameters (viz., temperature, RH and Sunshine) inside the coir geo-textile lines poly houses for production of cardamom and other spices. iii. To study the phenology & growth characters of Cardamom & Black Pepper under polyhouse conditions. iv. To study the quality aspects of herbal spices under various geotextile lined polyhouses.

		v. To study the use of coir as trailing material for black pepper. vi. Rapid multiplication of black pepper using serpentine method under various geotextile lined polyhouses (May 2010).
17	Rapid multiplication of black pepper by serpentine method and trailing method under various geotextile lined polyhouses).	To evaluate the growth and rapid multiplication of black pepper using Serpentine method under various geotextile lined polyhouse conditions.
18	Organic cultivation of small cardamom and other high value spices (Development of model organic farm sponsored by NCOF Ghaziabad).	i. To develop a model organic farm on small cardamom for demonstration. ii. To evaluate scientific package of practices for organic cultivation of small cardamom and other inter cropped spices. iii. To evaluate the quality parameters of small cardamom grown under organic cultivation. iv. To access the changes in the soil fertility status under organic farming.
19	Monitoring of pesticide residues of spices.	i. To undertake field monitoring of pesticide residues in cardamom. ii. To monitor water samples for pesticide residues in the spice growing tracts.
20	Effect of processing on pesticide residues in cardamom capsule.	To study the residue level of pesticides in cardamom capsule when subjected to washing, curing and polishing.
21	Pesticide persistence study in cardamom.	i. To study the persistence of pesticide in the cardamom under field condition. ii. To study the persistence of pesticides in the cardamom capsules during storage period.

22	Integrated plant nutrient supply system (IPNS) in selected export oriented spices-sponsored by Dept. of Biotechnology GOI, New Delhi.	**Nursery Trials:** i. Trial No.C/N 2008 PM/01 (M): Effect of INM on small cardamom sucker nursery in trenches. ii. Trial No. C/N 2008 PM/ 02(SKP): Effect of INM on small cardamom seedbed nursery of Cardamom. **Field Trials: Existing Plantation** i. Trial No. C/F 2008 PM/01 (M): Effect of INM on growth and yield of small cardamom in the existing plantation (18 months old). ii. Trial No. C/F 2008 PM/02 (M): Effect of INM on growth and yield of small cardamom in the existing plantation (24 months). **Field trial with unfortified seedlings:** i. Trial No. C/F 2009 PM/04 (SKP): Effect of INM on growth and yield of fortified and unfortified (Bioconsortium) seedlings of Cardamom. **Field trial with fortified and unfortified planting materials:** i Trial No. C/F 2010 PM/08 (M):Effect of Bio-consortia and source of planting materials on growth and yield of cardamom. ii Trial No. C/F 2009 PM/09 (SKP): Effect of INM on growth and yield of fortified planting materials in cardamom.

23	Effect of INM on small cardamom sucker nursery in trenches.	To standardise the integrated nutrient requirement for small cardamom sucker nursery in trenches.
24	Effect of INM on growth and yield of cardamom in the existing plantation.	To standardise the integrated nutrient requirement for sustained production of cardamom.
25	Effect of Bio-consortia and source of planting materials (fortified and unfortified) on growth and yield of cardamom.	To standardise the effect of Bio-consortia and source of planting materials on growth and yield of Cardamom.
26	Integrated Plant Nutrient supply system (IPNS) in selected export oriented Spices-Black pepper-Sponsored by Dept. of Biotechnology, GOI, New Delhi.	**Nursery Trials:** i. Trial No.BP/N2008 PM/ 03(SKP): Effect of INM on Poly bag nursery of Black Pepper. ii. Trial No.BP/N 2009 PM/04 (M): Effect of INM on Poly bag nursery of Black pepper. **Field Trials:** i. Trial No.BP/F2008 PM/03 (SKP): Effect of INM on growth and yield of Black pepper in the existing plantation (8years).
27	Soil based plant nutrient management plan for agro ecosystems of Kerala.	To overall objectives of the project is soil based plant nutrient management plan for the state, Agro ecological zones, districts and panchayats. To meet the overall objective the following specific objectives are set forth. i. Multistage purposive sampling of soil from all panchayats of the state; ensuring sampling from different kinds of soils and cropping systems. ii. Analysis of soils for macro-, secondary and micronutrients (N, P.K.Ca,Mg, S, B,Fe, Mn, Cu, and Zn) and soil reaction in laboratories of state and central organisations.

	iii. Development of application soft wares for data storage, management,automated interpretations and information dissemination to stake holders. iv. Interpretation of results of soil analysis, spatial data processing in GIS and development of plant nutrient management plan for all the panchayats, districts and the whole state

BIOTECHNOLOGY (2010-11)

	Research Issues	Objectives
1	Molecular characterisation of cardamom germplasm.	Molecular characterisation of germplasm accessions of small & large cardamoms.
2	Development of *Fusarium* tolerant lines through cell culture in cardamom.	To develop Fusarium tolerant lines through callus and cell cultures in cardamom.
3	Molecular characterisation of *Fusarium* isolates from Cardamom.	To characterize different isolates of *Fusarium* infecting cardamom.
4	Establishing virus indexing facility for small & large cardamoms and black pepper.	To establish virus indexing facility for small and large cardamoms and pepper.

BIOTECHNOLOGY (2009-10)

	Research Issues	Objectives
1	In *vitro* clonal propagation of two pre-released varieties of small cardamom (2006).	
2	Molecular characterisation of cardamom germplasm.	Molecular profiling of germplasm accessions of small & large cardamoms.
3	Development of *Fusarium* tolerant lines through cell culture in cardamom.	To develop Fusarium tolerant lines through callus and cell cultures in cardamom.
4	Micropropagation of vanilla through protocorm/meristem/bud cultures.	

5	Production of Inter-specific hybrids between *V.planifolia* and *V.wightiana* using embryo rescue followed by tissue culture multiplication.	
6	Molecular characterisation of *Fusarium* isolates from Cardamom.	To develop PCR assay for characterizing different isolates of *Fusarium* infecting cardamom.
7	Scaling up of micropropagation protocol for black pepper.	To scale up micropropagation protocol for producing TC plants of pepper on a large scale.
8	Establishing virus indexing facility for small & large cardamoms and black pepper.	To establish virus indexing facility for small and large cardamoms and black pepper.

Source: Indian Cardamom Research Institute, *Annual Report 2010 & 2011*, Spices Board Cochin.