REPORT OF QUINQUENNAL REVIEW TEAM

INDIAN INSTITUTE OF SPICES RESEARCH
CALICUT

(01.01.2002 to 31.12.2006)
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Indian Institute of Spices Research
(Indian Council of Agricultural Research)
Calicut - 673 012, Kerala
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List of Abbreviations

AAU : Assam Agricultural University
ADB : Asian Development Bank
ADG : Assistant Director General
ADR : Associate Director of Research
AFLP : Amplified Fragment Length Polymorphism
AICRPS : All India Coordinated Research Project on Spices
AICRPV : All India Coordinated Research Project on Vegetables
ANGRAU : Acharya N. G. Ranga Agricultural University
APEDA : Agricultural and Processed Food Products Export Development Authority
APK : Association of Planters of Kerala
ARIS : Agricultural Research Information System
ASTA : American Spice Trade Association
ATIC : Agricultural Technology Information Centre
ATR : Action taken report
BCR : Benefit : Cost Ratio
BIS : Bureau of Indian Standards
BSKKV : Dr. Balasaheb Sawant Konkan Krishi Viswavidyalaya
CCSHAU : Choudary Charan Singh Haryana Agricultural University
CD : Compact Disc
cDNA : Complementary Deoxyribonucleic Acid
CFTRI : Central Food Technological Research Institute
CHNS : Carbon, Hydrogen, Nitrogen, Sulphur (Analyser)
CIMAP : Central Institute for Medicinal and Aromatic Plants
CMFRI : Central Marine Fisheries Research Institute
CMV : Cucumber Mosaic Virus
CPHRI : Central Plantation Crops Research Institute
CPRI : Central Potato Research Institute
CRC : Cardamom Research Centre
CRS : Cardamom Research Station
CRR : Central Rice Research Institute
CSIR : Council for Industrial and Scientific Research
CTCRI : Central Tuber Crops Research Institute
CymMV : Cymbidium Mosaic Virus
DAAD : German Academic Exchange Service
DAP : Diammonium phosphate
DARE : Department of Agricultural Research and Education
DASD : Directorate of Areca Nut and Spices Development
DAS-ELISA : Double Antibody Sandwich-Enzyme Linked Immunosorbent Assay
DBT : Department of Biotechnology
DDG : Deputy Director General
DFRL : Defence Food Research Laboratory
DMSO : Dimethyl sulfoxide
DOEACC : Department of Electronics Accreditation for Computer Courses
DR : Director of Research
DRIS : Diagnosis Recommendation Integrated System
DST : Department of Science and Technology
DTPA : Disodium tetraethylammonium pentaaetate
DVD : Digital Versatile Disc
ELISA : Enzyme Linked Immunosorbent Assay
EST : Expressed Sequence Tag
EU : European Union
FAC : Farm Advisory Committee
FAO : Food and Agriculture Organisation
FLD : Front-line demonstration
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>FYM</td>
<td>Farm yard manure</td>
</tr>
<tr>
<td>GATT</td>
<td>General Agreement on Tariff and Trade</td>
</tr>
<tr>
<td>GAU</td>
<td>Gujarat Agricultural University</td>
</tr>
<tr>
<td>GC-MS</td>
<td>Gas Chromatography-Mass Spectrophotometer</td>
</tr>
<tr>
<td>GDD</td>
<td>Growing degree days</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GUS</td>
<td>Glucoridanase</td>
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<tr>
<td>HACCP</td>
<td>Hazard Analysis and Critical Control Points</td>
</tr>
<tr>
<td>HD</td>
<td>Head of Division</td>
</tr>
<tr>
<td>HPLC</td>
<td>High Pressure Liquid Chromatography</td>
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<tr>
<td>HRD</td>
<td>Human Resource Development</td>
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<tr>
<td>IARI</td>
<td>Indian Agricultural Research Institute</td>
</tr>
<tr>
<td>IASRI</td>
<td>Indian Agricultural Statistical Research Institute</td>
</tr>
<tr>
<td>IBSC</td>
<td>Institute Biosafety Committee</td>
</tr>
<tr>
<td>ICAR</td>
<td>Indian Council of Agricultural Research</td>
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<tr>
<td>IARI</td>
<td>Indian Cardamom Research Institute</td>
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<tr>
<td>IDM</td>
<td>Integrated Disease Management</td>
</tr>
<tr>
<td>IIHR</td>
<td>Indian Institute of Horticultural Research</td>
</tr>
<tr>
<td>IISSR</td>
<td>Indian Institute of Spices Research</td>
</tr>
<tr>
<td>IIVR</td>
<td>Indian Institute of Vegetable Research</td>
</tr>
<tr>
<td>IMC</td>
<td>Institute Management Committee</td>
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<td>IMTECH</td>
<td>Institute of Microbial Technology</td>
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<tr>
<td>INM</td>
<td>Integrated Nutrient Management</td>
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<td>INSA</td>
<td>Indian National Science Academy</td>
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<td>IPGRI</td>
<td>Integrated Plant Genetic Resources Institute</td>
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<tr>
<td>IPM</td>
<td>Integrated Pest Management</td>
</tr>
<tr>
<td>IPNM</td>
<td>Integrated Plant Nutrient Management</td>
</tr>
<tr>
<td>IPR</td>
<td>Intellectual Property Rights</td>
</tr>
<tr>
<td>IRC</td>
<td>Institute Research Committee</td>
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<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
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<td>ISO</td>
<td>International Standards Organization</td>
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<tr>
<td>IRR</td>
<td>Inter Simple Sequence Repeat</td>
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<tr>
<td>ITK</td>
<td>Indigenous Technical Knowledge</td>
</tr>
<tr>
<td>ITS-PCR-RFLP</td>
<td>Internal Transcribed Spacer-Polymerase Chain Reaction-Restricted Fragment Length Polymorphism</td>
</tr>
<tr>
<td>IVLP</td>
<td>Institute Village Linkage Programme</td>
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<tr>
<td>KAU</td>
<td>Kerala Agricultural University</td>
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<tr>
<td>KFRI</td>
<td>Kerala Forest Research Institute</td>
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<tr>
<td>KVK</td>
<td>Krishi Vigyan Kendra</td>
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<tr>
<td>MoEF</td>
<td>Ministry of Environment and Forests</td>
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<tr>
<td>MANAGE</td>
<td>National Institute of Agricultural Extension Management</td>
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<tr>
<td>MAS</td>
<td>Marker assisted selection</td>
</tr>
<tr>
<td>MATSYAFED</td>
<td>Kerala State Cooperative Federation For Fisheries Development Ltd.</td>
</tr>
<tr>
<td>MHRD</td>
<td>Ministry of Human Resource Development</td>
</tr>
<tr>
<td>MKU</td>
<td>Madurai Kamaraj University</td>
</tr>
<tr>
<td>NAA</td>
<td>Naphthalene acetic acid</td>
</tr>
<tr>
<td>NAARM</td>
<td>National Academy for Agricultural Research Management</td>
</tr>
<tr>
<td>NABARD</td>
<td>National Bank for Agriculture and Rural Development</td>
</tr>
<tr>
<td>NAIP</td>
<td>National Agricultural Innovation Project</td>
</tr>
<tr>
<td>NATP</td>
<td>National Agriculture Technology Project</td>
</tr>
<tr>
<td>NBPGR</td>
<td>National Bureau of Plant Genetic Resources</td>
</tr>
<tr>
<td>NDUAT</td>
<td>Narendra Dev University of Agriculture and Technology</td>
</tr>
<tr>
<td>NEH</td>
<td>North Eastern Hill</td>
</tr>
<tr>
<td>NGO</td>
<td>Non Governmental Organization</td>
</tr>
<tr>
<td>NRC</td>
<td>National Research Centre</td>
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<tr>
<td>NRCC</td>
<td>National Research Centre for Cashew</td>
</tr>
<tr>
<td>NRCCS</td>
<td>National Research Centre for Seed Spices</td>
</tr>
<tr>
<td>OFT</td>
<td>On-farm trial</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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<tr>
<td>OPA</td>
<td>Operon Group A</td>
</tr>
<tr>
<td>OUAT</td>
<td>Orissa University of Agriculture and Technology</td>
</tr>
<tr>
<td>PAL</td>
<td>Phenylalanine ammonia lyase</td>
</tr>
<tr>
<td>PC</td>
<td>Project Coordinator</td>
</tr>
<tr>
<td>PCR-RFLP</td>
<td>Polymerase Chain Reaction-Restricted Fragment Length Polymorphism</td>
</tr>
<tr>
<td>PDBC</td>
<td>Project Directorate of Biological Control</td>
</tr>
<tr>
<td>PGPR</td>
<td>Plant Growth Promoting Rhizobacteria</td>
</tr>
<tr>
<td>PHT</td>
<td>Post-Harvest Technology</td>
</tr>
<tr>
<td>POL</td>
<td>Petrol, oil and lubricants</td>
</tr>
<tr>
<td>PRS</td>
<td>Pepper Research Station</td>
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<tr>
<td>PYMoV</td>
<td>Piper Yellow Mottle Virus</td>
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<tr>
<td>QRT</td>
<td>Quinquennial Review Team</td>
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<tr>
<td>QTL</td>
<td>Quantitative trait loci</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RAC</td>
<td>Research Advisory Committee</td>
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<tr>
<td>RAJAU</td>
<td>Rajendra Agricultural University</td>
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<tr>
<td>RAPD</td>
<td>Randomly Amplified Polymorphic DNA</td>
</tr>
<tr>
<td>RARS</td>
<td>Regional Agricultural Research Station</td>
</tr>
<tr>
<td>RAU</td>
<td>Rajasthan Agricultural University</td>
</tr>
<tr>
<td>rDNA</td>
<td>Recombinant deoxyribonucleic acid</td>
</tr>
<tr>
<td>RFLP</td>
<td>Restricted Fragment Length Polymorphism</td>
</tr>
<tr>
<td>RGCB</td>
<td>Rajiv Gandhi Centre for Biotechnology</td>
</tr>
<tr>
<td>RNAi</td>
<td>Ribonucleic acid</td>
</tr>
<tr>
<td>RRL</td>
<td>Regional Research Laboratory</td>
</tr>
<tr>
<td>SAARC</td>
<td>South Asian Association for Regional Cooperation</td>
</tr>
<tr>
<td>SAU</td>
<td>State Agricultural University</td>
</tr>
<tr>
<td>SB</td>
<td>Spices Board</td>
</tr>
<tr>
<td>SCAR</td>
<td>Sequence Characterized Amplified Region</td>
</tr>
<tr>
<td>SERIFED</td>
<td>State Sericulture Cooperative Federation</td>
</tr>
<tr>
<td>SFAO</td>
<td>Senior Finance and Accounts Officer</td>
</tr>
<tr>
<td>SMS</td>
<td>Subject Matter Specialist</td>
</tr>
<tr>
<td>SOP</td>
<td>Sulphate of potash</td>
</tr>
<tr>
<td>SPS</td>
<td>Sanitary and Phytosanitary Measures</td>
</tr>
<tr>
<td>TNAU</td>
<td>Tamil Nadu Agricultural University</td>
</tr>
<tr>
<td>UAS-B</td>
<td>University of Agricultural Sciences-Bangalore</td>
</tr>
<tr>
<td>UAS-D</td>
<td>University of Agricultural Sciences-Dharwad</td>
</tr>
<tr>
<td>UBKV V</td>
<td>Uttar Pradesh Krishi Vidyapeeth</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>VAM</td>
<td>Vesicular Arbuscular Mycorrhiza</td>
</tr>
<tr>
<td>VC</td>
<td>Voluntary Centre / Vice Chancellor</td>
</tr>
<tr>
<td>VVV</td>
<td>Vikas Volunteer Vahini</td>
</tr>
<tr>
<td>UPASI</td>
<td>United Planters Association of South India</td>
</tr>
<tr>
<td>USEFI</td>
<td>United States Educational Foundation in India</td>
</tr>
<tr>
<td>WTO</td>
<td>World Trade Organization</td>
</tr>
<tr>
<td>YSPUHF</td>
<td>Yaswant Singh Parmar University of Horticulture and Forestry</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 The team

The Indian Council of Agricultural Research (ICAR), New Delhi, vide Order No.12-(2)/2007-IA-V dated 11 April 2007, constituted the Quinquennial Review Team (QRT) to review the work done during the period 1.1.2002 to 31.12.2006 at Indian Institute of Spices Research (IISR), Calicut, and All India Coordinated Research Project on Spices (AICRPS). The composition of the team is given below:

1. Dr. G. Kalloo  
Vice Chancellor  
Jawaharlal Nehru Krishi Vishwa Vidyalaya  
Jabalpur - 482004  
Chairman

2. Dr. I. Irlapann  
Former Dean, College of Horticulture  
Tamil Nadu Agricultural University  
3-1-51, Ram Nagar  
T. Kallupatti - 625702  
Madurai District, Tamil Nadu  
Member

3. Dr. K. C. Bansal  
Professor (Plant Biotechnology)  
National Research Centre for Plant Biotechnology  
Indian Agricultural Research Institute  
New Delhi - 110012  
Member

4. Dr. R. Samiyappan  
Director  
Centre for Plant Protection Studies  
Tamil Nadu Agricultural University  
Coimbatore - 641003  
Member

5. Dr. B. N. Choudhary  
Former Assistant Director General (Extension)  
Indian Council of Agricultural Research  
Flat No.154, Keshav Apartments  
Plot No. 15A, Sector-22, Dwarka  
New Delhi - 110075  
Member

6. Dr. A. G. Appu Rao  
Head, Department of Protein Chemistry & Technology  
Central Food Technological Research Institute  
Mysore - 570020  
Member

7. Dr. S. Devasahayam  
Acting Head, Division of Crop Protection  
Indian Institute of Spices Research  
Calicut - 673012  
Secretary
1.2 Terms of reference

The terms of reference of the QRT is given in Annexure I.

1.3 Visits and method of review of QRT

The visits of QRT to IISR, Calicut, and coordinating centres of AICRPS were spread over 6 months between May 2007 to October 2007. Besides visits to the institute headquarters at Calicut, and the Cardamom Research Station at Appangala, the QRT visited eight centres of the AICRPS where presentations of various centres were made. The schedule of visits of the QRT to the institute, various centres of AICRPS and other institutions are furnished in Annexure II.

The method of review of the QRT included critical examination of all the documents provided by the institute, discussion with Deputy Director General (Horticulture), ICAR, interaction with scientists of the institute, Krishi Vigyan Kendra (KVK) and AICRPS, visit to laboratories, experimental fields, and farmers fields. During these visits the QRT had interactions with the concerned scientists regarding their achievements, constraints and future programmes. The QRT had discussions with officials of the State Department of Agriculture, and Directorate of Areacanut and Spices Development (DASD), Calicut. The QRT met the representatives of the administration, accounts and farm sections and the Institute Staff Joint Council and Institute Grievance Cell. The QRT also had an opportunity to interact with the members of the Institute Management Committee.

1.4 Mandate

1.4.1 Institute

- To extend services and technologies to conserve genetic resources of spices as well as soil, water and air of spices agroecosystems
- To develop high yielding and high quality spice varieties and sustainable production and protection systems using traditional and non-traditional techniques and novel biotechnological approaches
- To develop post harvest technologies of spices with emphasis on product development and product diversification for domestic and export purposes
- To act as a centre for training in research methodology and technology upgradation of spices and to coordinate national research projects
- To monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of the farming community
- To serve as a national centre for storage, retrieval and dissemination of technological information on spices

1.4.2 Krishi Vigyan Kendra

- To conduct on-farm testing for identifying technologies in terms of location specific sustainable land use systems
- To organize training to update the training personnel with emerging advances in agricultural research on regular basis
- To organize short and long term vocational training courses in agriculture and allied vocations for farmers and rural youth with emphasis on learning by doing for higher production on farms and generating self-employment
- To organize front-line demonstrations on various crops to generate production data and feedback information.

1.5 Mandate crops

The institute conducts research on the following 11 mandate spice crops:
- Black pepper (*Piper nigrum*)
- Cardamom (*Elettaria cardamomum*)
- Ginger (*Zingiber officinale*)
- Turmeric (*Curcuma longa*)
- Cinnamon (*Cinnamomum verum*)
Introduction

• Clove (*Syzygium aromaticum*)
• Nutmeg (*Myristica fragrans*)
• Allspice (*Pimenta dioica*)
• Garcinia (*Garcinia gummi-gutta, Garcinia indica*)
• Vanilla (*Vanilla planifolia*)
• Paprika (*Capsicum annum*)

1.6 Organization

The Director is the administrative head of the institute. The Institute Management Committee (IMC), Research Advisory Committee (RAC) and Institute Research Committee (IRC) assist the Director in matters relating to management and research activities of the institute (Fig. 1).

Fig.1. Organizational chart of Indian Institute of Spices Research
1.7 Resources and functions

1.7.1 Laboratories and farms

The laboratories and administrative offices of the institute are located at Calicut, Kozhikode District, Kerala (50 m above MSL), 11 km from the city on the Calicut-Kollengal road (NH 212), in an area of 14.3 ha. The research farm is located 51 km north east of Calicut at Peruvannamuzhi (60 m above MSL), at the foothills of Western Ghats, on the Peruvannamuzhi-Poozhithode road in Kozhikode District, in an area of 94.08 ha. The Cardamom Research Centre, Appangala (920 m above MSL) is located at Hervanad Village, Kodagu District, Karnataka on the Madikeri-Bhagamandala road, 8 km from Madikeri, in an area of 17.4 ha. The KVK of the institute is located at Peruvannamuzhi in an area of 20.3 ha.

1.7.2 Staff

The institute has a sanctioned strength of 43 scientific, 36 technical, 19 administrative and 61 supporting staff (Table 1). A list of scientific and technical staff with their designation and qualification is furnished in Annexure III.

Table 1. Staff position of the institute and KVK

<table>
<thead>
<tr>
<th>Category</th>
<th>Sanctioned</th>
<th>Headquarters, Calicut</th>
<th>Exptl. Farm, Peruvannamuzhi</th>
<th>Research Centre, Appangala</th>
<th>KVK Sanctioned</th>
<th>KVK In position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific</td>
<td>43</td>
<td>28</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Technical</td>
<td>36</td>
<td>17</td>
<td>13</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Administration</td>
<td>19</td>
<td>17</td>
<td>-</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Supporting</td>
<td>61</td>
<td>27</td>
<td>14</td>
<td>18</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>159</td>
<td>89</td>
<td>30</td>
<td>29</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

1.7.3 Research

There are three divisions at the institute namely, Division of Crop Improvement and Biotechnology, Division of Crop Production and Post-harvest Technology, Division of Crop Protection and a Social Sciences Section. The institute has well equipped laboratories with state of the art facilities to conduct basic and applied research on all aspects of the mandate spice crops.

The research programmes of the institute are carried under institute and externally aided projects. A total of 105 projects under 12 interdisciplinary mega projects were under operation during the period of report. These projects were being critically reviewed by the RAC and IRC every year. A list of projects in operation during the period under review is given in Annexure IV. The publications that emanated from these projects during the period under report are given in Annexure V.

1.7.4 Teaching

A Human Resources Development (HRD) Cell functions at the institute and its mandate includes recommendation and deputation of staff for symposia/training and study leave for PhD. Besides, the HRD Cell caters to the needs of research scholars working in various schemes to do their PhD. The HRD Cell also facilitates the conduct of various training programmes in the institute. The institute has been recognized as a centre for PhD studies by Mangalore University, Mangalore; University of Calicut, Calicut; Bharathiar University, Coimbatore and Nagarjun University, Nagarjunasagar. The HRD Cell also assists MSc and MPhil students to carry out their project work at the institute.

1.7.5 Extension

The extension services offered by the institute include training, consultancy and contract research. The institute offers training programs on demand from various agencies targeted for field extension functionaries of state departments, research
workers of other institutes and universities, rural youth and progressive farmers. These training programmes are organized to achieve the twin objectives of facilitating functional linkages with the above target groups and provide regular information on the technological developments emanated through research by the institute.

Krishi Vigyan Kendra

The KVK was established at Peruvannamuzhi, for effective transfer of technology to the farming community. The KVK organizes training programmes and field demonstrations on proven technologies in farmers' fields, exhibitions and kisan melas on agriculture, animal husbandry, fisheries and home science for the benefit of farmers, unemployed women and youth and development workers. The KVK has an administrative cum training building and farmers hostel and 20 ha of land with spices, coconut, arecanut and cashew plantations and miscellaneous fruit plants.

The KVK operates a plant and animal clinic to cater various services to farmers. An artificial insemination facility is available under the kendra to upgrade the genetic stock of livestock. The KVK offers consultation, treatment and door services with a nominal fee. The KVK also provides vaccination facility and organizes animal health camps in association with the state animal husbandry department.

Agricultural Technology Information Centre

The Agricultural Technology Information Centre (ATIC) at the institute is a single window delivery system of technological inputs and information emanating from the institute. It ensures better interaction of research workers, farmers, spice traders and entrepreneurs. The ATIC has the mandate to build up required confidence among farmers and to strengthen research-farmer/end user linkages; to provide disease/pest diagnostic and advisory services to farmers; to sell and distribute planting materials of improved varieties of spices, biofertilizers, biocontrol agents, etc.; to provide information on improved technologies through published literature; and to effect resource generation through technology dissemination.
The Director is the administrative head of the institute. The IMC, RAC and IRC assist the Director in matters relating to management and research activities of the institute.

2.1 Institute Management Committee (2002-06)

2002-03

Dr. V. A. Parthasarathy : Chairman
Dr. R. N. Pal : Member
Director of Agriculture (Kerala) : Member
Director of Horticulture (Karnataka) : Member
Dr. E. V. Nybe : Member
Shri. K. Mukundan : Member
Shri. Dhirendra Bahadur Singh : Member
SFAO, CMFRI, Kochi : Member
Dr. M. N. Venugopal : Member
Dr. M. Anandaraj : Member
Dr. B. Chempakam : Member
Dr. B. Sasikumar : Member
Shri. A. P. Sankaran : Member Secretary

2004-06

Dr. V. A. Parthasarathy : Chairman
Dr. K. V. Ramana : Member
Director of Agriculture (Kerala) : Member
Commissioner of Horticulture & Plantation Crops, Tamil Nadu : Member
Dr. P. V. Balachandran : Member
Shri. K. Mukundan : Member
Shri. Dhirendra Bahadur Singh/
Shri. Sanjay Mariwala : Member
Dr. George V. Thomas : Member
Dr. K. V. Nagaraja : Member
Finance & Accounts Officer, CRRI, Cuttack : Member
Dr. S. Devasahayam : Member
Sri. P. A. Mathew : Member
Shri. A. P. Sankaran : Member Secretary

The IMC met seven times during 2002-06.

2.2 Research Advisory Committee (2002-06)

2002-03

Dr. K. V. Ahamed Bavappa : Chairman
Prof. V. Arunachalam : Member
Dr. C. K. George : Member
Dr. R. K. Sharma : Member
Dr. C. B. S. Rajput : Member
Mr. L. Venkataratnam : Member
Shri. Dhirendra Bahadur Singh : Member
Shri. K. Mukundan : Member
Dr. R. N. Pal : Member
Dr. Y. R. Sarma : Member
Dr. K. V. Ramana : Member Secretary

2004-06

Dr. S. Karnaiyan : Chairman
Dr. A. N. Maurya : Member
Dr. A. Manickam : Member
Dr. Y. R. Sarma / Dr. Narain Rishi : Member
Dr. Kuruvina Shetti : Member
Dr. A. K. Misra : Member
Shri. Dhirendra Bahadur Singh/
Shri. Sanjay Mariwala : Member
Shri. K. Mukundan : Member
Dr. K. V. Ramana : Member
Dr. V. A. Parthasarathy : Member
Dr. M. Anandaraj : Member Secretary

The RAC met once every year during 2002-06.

2.3 Institute Research Committee

The IRC of the institute comprises of the Director and all scientists of the institute. The IRC met twice every year. The first meeting was held for reviewing the work done in the existing projects and also for formulating new projects. A mid term review was held after 6 months to review the progress of the work during the first 6 months of the year.
2.4 Scientific Advisory Committee (KVK)

The Scientific Advisory Committee of the KVK meets twice a year and is composed of the following members:

Chairman  
Director, Indian Institute of Spices Research, Calicut

Members  
Director of Extension, Kerala Agricultural University, Thrissur  
The Zonal Co-ordinator, Unit VIII, Bangalore  
Officer-in-Charge, Calicut Research Centre of CMFRI, Calicut  
Associate Director of Research, RARS, KAU, Pattambi  
Conservator of Forests, Northern Region, Calicut  
Principal Agricultural Officer, Department of Agriculture, Calicut  
District Animal Husbandry Officer, Calicut  
District Soil Conservation Officer, Calicut  
Deputy Director of Fisheries, Calicut  
Project Officer, District Khadi and Village Industries Office, Calicut  
District Social Welfare Officer, Calicut  
District Development Officer, Scheduled Caste Development Department, Calicut  
Project Officer, District Rural Development Agency, Calicut  
District Sericulture Officer, Calicut  
Lead District Manager, Canara Bank, Regional Office, Calicut  
Farm Radio Officer, All India Radio, Calicut

The Officer in Charge, Farm Information Bureau, Calicut  
The Station Engineer, Dooradarshan Kendra, Calicut  
The Deputy Director, Dairy Development Department, Calicut  
Sri. K.O. Sebastian, Vaddakkekallunkal, Muthukadu P.O., Calicut (small farmer)  
Sri. Jojo Jacob, Randuplackal, Chembanoda P.O., Calicut (big farmer)  
Smt. Narayani, Kunnel (H), Chembanoda P.O., Calicut (farm woman)  
Smt. Laisamma Baby, Parambukattil, Chembanoda P.O., Calicut (farm woman)  
All subject matter specialists of KVK, Calicut

Member Secretary  
Programme Coordinator, KVK, Calicut.

2.5 Action Taken Report of previous QRT

The previous QRT was constituted during 11.07.2002 to review the work done at IISSR, Calicut and AICRPS during 01.01.1997 to 31.12.2001. The QRT was composed of: Dr. A. Appa Rao (Chairman), Dr. Anupam Varma (Member), Dr. P. Balasubramanian (Member), Dr. T. C. Jain (Member), Dr. Koshy John (Member), Dr. N. M. Nayar (Member), and Dr. M. Anandaraj (Member Secretary). The report including recommendations of the QRT was submitted during November 2003. The action taken report of the recommendations is given in Annexure VI.

2.6 Budget

Table 2. Budget allocation, expenditure and revenue of institute (2002-07)

NON PLAN (in lakh Rs.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Estd. charges</td>
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<td>212.46</td>
<td>228.35</td>
<td>228.35</td>
<td>250.60</td>
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<tr>
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<td>4.50</td>
<td>4.50</td>
<td>5.40</td>
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<tr>
<td>Contingencies</td>
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<td>39.43</td>
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<td>83.00</td>
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<tr>
<td>Assets</td>
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<td>4.06</td>
<td>0.00</td>
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<tr>
<td>Total</td>
<td>260.45</td>
<td>260.45</td>
<td>316.75</td>
<td>316.75</td>
<td>339.78</td>
</tr>
</tbody>
</table>
### PLAN (in lakh Rs.)

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Estt. Charges</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
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<td>5.00</td>
<td>5.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
<tr>
<td>Contingencies</td>
<td>97.29</td>
<td>97.30</td>
<td>35.00</td>
<td>35.00</td>
<td>51.22</td>
<td>51.22</td>
<td>17.08</td>
<td>17.08</td>
<td>21.00</td>
<td>21.00</td>
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<tr>
<td>Assets</td>
<td>87.70</td>
<td>87.70</td>
<td>85.00</td>
<td>85.00</td>
<td>93.78</td>
<td>93.78</td>
<td>112.92</td>
<td>112.92</td>
<td>59.00</td>
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<tr>
<td>Total</td>
<td>189.99</td>
<td>190.00</td>
<td>125.00</td>
<td>125.00</td>
<td>150.00</td>
<td>150.00</td>
<td>135.00</td>
<td>135.00</td>
<td>90.00</td>
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</table>

### REVENUE (in lakh Rs.)

<table>
<thead>
<tr>
<th>Year</th>
<th>2002-03</th>
<th>2003-04</th>
<th>2004-05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>15.66</td>
<td>14.63</td>
<td>21.38</td>
</tr>
</tbody>
</table>

Table 3. Budget allocation, expenditure and revenue of KVK (2002-07)

### Budget allocation and expenditure (in lakh Rs.)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay and allowances</td>
<td>17.50</td>
<td>6.78</td>
<td>20.00</td>
<td>13.76</td>
<td>20.00</td>
<td>19.76</td>
<td>24.00</td>
<td>19.78</td>
<td>24.00</td>
<td>18.09</td>
</tr>
<tr>
<td>TA</td>
<td>0.50</td>
<td>0.23</td>
<td>0.80</td>
<td>0.64</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>0.77</td>
<td>0.75</td>
<td>0.70</td>
</tr>
<tr>
<td>Recurring contingencies</td>
<td>2.00</td>
<td>0.51</td>
<td>2.50</td>
<td>2.40</td>
<td>2.80</td>
<td>2.73</td>
<td>7.20</td>
<td>6.65</td>
<td>1.90</td>
<td>1.40</td>
</tr>
<tr>
<td>Non-recurring contingencies</td>
<td></td>
<td></td>
<td>0.10</td>
<td>0.10</td>
<td>5.60</td>
<td>5.59</td>
<td>9.65</td>
<td>9.15</td>
<td>1.10</td>
<td>0.00</td>
</tr>
<tr>
<td>Total</td>
<td>20.00</td>
<td>7.52</td>
<td>23.4</td>
<td>16.50</td>
<td>29.40</td>
<td>29.08</td>
<td>41.85</td>
<td>36.34</td>
<td>27.75</td>
<td>20.19</td>
</tr>
</tbody>
</table>

### REVENUE (in lakh Rs.)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>5.44</td>
<td>2.84</td>
<td>2.39</td>
<td>4.82</td>
<td>6.63</td>
</tr>
</tbody>
</table>
Spices are high-value export-oriented crops extensively used all over the world since time immemorial mainly for flavouring food and beverages and also in medicines, cosmetics and perfumery. Spices played a significant role in influencing the course of history and modern civilization in the world. India is known as the land of spices and is the largest producer and consumer of spices in the world. Over 100 plant species are known to yield spices among which around 50 are grown in India. Spices are low volume, high value crops and most of the states in the country grow one spice crop or the other playing a crucial role in the economy of these states.

3.1 Area, production and export

Spices are grown in about 25.7 lakh hectares in the country with a production of about 38.2 lakh tonnes annually. India exported 3.2 lakh tonnes of spices and spice products during 2005-06 valued Rs. 2,295 crores. Until about the 1970’s, India had a virtual dominance in international trade of spices. Indian spices flavour foods in over 130 countries and their intrinsic value makes them distinctly superior in terms of taste, colour and fragrance. India has a near monopoly in seed spices and spice oils and oleoresins. Though spice exports form only around 8% of the total produce, India’s export earnings exceeded US $500 million for the first time during 2005-06 (Table 4).

Table 4. Area, production and export of mandate spice crops

<table>
<thead>
<tr>
<th>Crop/Product</th>
<th>Area (000 ha)</th>
<th>Production ('000 MT)</th>
<th>Productivity (kg/ha)</th>
<th>Export (2005-06)</th>
<th>Share in total export</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area</td>
<td>Production</td>
<td>Productivity</td>
<td>Qty. ('000 MT)</td>
<td>Value (Lakh Rs.)</td>
</tr>
<tr>
<td>Black pepper</td>
<td>257.02</td>
<td>79.64</td>
<td>310</td>
<td>16.70</td>
<td>14,050.00</td>
</tr>
<tr>
<td>Cardamom</td>
<td>65.78</td>
<td>10.19</td>
<td>155</td>
<td>0.88</td>
<td>2,700.50</td>
</tr>
<tr>
<td>Ginger</td>
<td>100.27</td>
<td>397.99</td>
<td>3,969</td>
<td>7.25</td>
<td>4,075.50</td>
</tr>
<tr>
<td>Turmeric</td>
<td>161.23</td>
<td>716.84</td>
<td>4,446</td>
<td>46.50</td>
<td>15,300.00</td>
</tr>
<tr>
<td>Clove</td>
<td>2.43</td>
<td>1.81</td>
<td>745</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nutmeg</td>
<td>10.01</td>
<td>2.53</td>
<td>253</td>
<td>1.63</td>
<td>3,255.00</td>
</tr>
<tr>
<td>Cinnamon</td>
<td>0.76</td>
<td>1.66</td>
<td>2,184</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vanilla</td>
<td>5.40</td>
<td>1.96</td>
<td>363</td>
<td>0.72</td>
<td>1,211.00</td>
</tr>
<tr>
<td>Total (including all spices)</td>
<td>2,571.77</td>
<td>3,817.90</td>
<td>-</td>
<td>320.53</td>
<td>2,29,525.00</td>
</tr>
</tbody>
</table>

Source: Spices Board, Kochi; Directorate of Areca nut and Spices Development, Calicut.

3.2 Trade

India’s share in world trade was 3.2 lakh tonnes valued at Rs 2,295 crores during 2005-06. India remains a major player in spices trade. On a global scale, the annual growth rate in spices consumption is estimated to be around 10%. At this rate, the world trade by 2025 will be around 25 lakh tonnes. Among spices, the major ones which contribute to export are, black pepper, cardamom, chillies, ginger, turmeric, coriander, cumin, celery, fennel, fenugreek, garlic, curry powder, spice oils and oleoresins. During the past few years, large cardamom, turmeric, seed spices and curry powder registered substantial increase in export earnings.

India is facing tough challenges with respect to export from several countries such as Malaysia, Indonesia, Sri Lanka, Brazil, Guatemala, China and Vietnam (Table 5). Several countries in the
Mediterranean region are trading in condiments also. Added to this, are the significant changes that are taking place in the international trade, consequent on the emergence of the 'WTO regime'. International trade barriers are steadily being removed and India will have to develop a competitive edge in all respects, if it has to retain its present position in the international trade of spices.

3.3 Trends in area, production and productivity

3.3.1 Black pepper

There was an increasing production trend of black pepper in the past decade with increased productivity. While the area has grown at 0.85%, the production has grown by 2.38% during the period 1987-88 to 1997-98. During 2001-05, the area under black pepper has increased by 4.4%, while the production registered a growth rate of 6.4%. This implies that either the recently extended area is more productive or farmers are giving better care to their existing plantation. However, black pepper productivity in India is one of the lowest in the world (310 kg/ha, while in Malaysia it is 2,925 kg/ha). There is large potential to increase the production of black pepper in the country by replanting of senile and diseased vines and by massive planting of vines in the shade trees of tea plantations in south and north east regions.

3.3.2 Cardamom

The production of cardamom in the country has shown a consistently increasing trend from 1970-71 to 2004-05. The productivity level which was 35 kg/ha during 1970-71 has not shown much improvement till the end of 1980; it has improved from 1990-91 and reached 155 kg/ha during 2004-05. However, the productivity level in Guatemala which is a major competitor is 200 kg/ha.

3.3.3 Ginger

The area under ginger has shown an increasing trend from 1970-71 to 1999-2000, with occasional fluctuations attributing to price fluctuations. The production has also shown an increasing trend from 2,95,900 tonnes in 1970-71 to 3,97,990 tonnes during 2004-05. The productivity of ginger in the country has increased over the years from 1,371 kg/ha during 1970-71 to 3,969 kg/ha during 2004-05. The growth in production was 5.1% during 2000-05 indicating a slight improvement in productivity, which was around 1.1% for the period.

3.3.4 Turmeric

The turmeric producing states showed fluctuation in production due to changes in rate of productivity and area of cultivation. Price also played important role in annual production. The decadal analysis of production showed an increasing trend in two of the five major producing states, Andhra Pradesh (10.7) and Tamil Nadu (16.3), while it is comparatively less in Orissa (0.5) and West Bengal (0.8) and negative in Karnataka (-3.8). India

<table>
<thead>
<tr>
<th>Spice</th>
<th>Competing country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black pepper</td>
<td>Indonesia, Brazil, Malaysia, Thailand, Sri Lanka, Vietnam, China, Madagascar, Mexico</td>
</tr>
<tr>
<td>Cardamom</td>
<td>Guatemala, El Salvador, Indonesia, Malaysia, Papua New Guinea, Sri Lanka</td>
</tr>
<tr>
<td>Ginger</td>
<td>China, Thailand, Japan, Bangladesh, South Korea, Malaysia, Fiji, Philippines, Jamaica, Nigeria, Sierra Leone</td>
</tr>
<tr>
<td>Turmeric</td>
<td>China, Pakistan, Bangladesh, Thailand, Peru, Jamaica, Spain</td>
</tr>
<tr>
<td>Clove</td>
<td>Brazil, Indonesia, Madagascar, Malaysia, Papua New Guinea, Sri Lanka</td>
</tr>
<tr>
<td>Nutmeg and mace</td>
<td>Grenada, Guatemala, Mexico, Nicaragua, Sri Lanka</td>
</tr>
<tr>
<td>Cinnamon</td>
<td>Madagascar, Papua New Guinea, Seychelles</td>
</tr>
</tbody>
</table>
produced 5,21,900 tonnes with a productivity of 4,446 kg/ha during 2004-05. The increase in production is mainly because of either increase in area or productivity or both, despite the year-to-year price changes.

3.3.5 Tree spices

Clove, nutmeg, cinnamon, camphor and kokum are the predominant tree spices cultivated in India. The production of clove in India during 2004-05 was 1,810 tonnes from an area of 2,430 ha. Nutmeg is cultivated in an area of 10,010 ha with a production of 2,530 tonnes. Cinnamon is cultivated in 770 ha with a production of 1,660 tonnes. Not much of information is available in the changes in area and productivity of these crops over the years.

India possesses many innate advantages over all the other spice producing countries - its large area and varied soil and climatic conditions. The major handicaps that Indian spices face in the international market are the high cost of the product and high level of microbial and pesticide contamination. India will need to make concerted efforts for producing clean spices at competitive prices. Considerable efforts will have to go to improve post harvest processing, value addition and storage systems and educating the farmers and traders in handling the produce hygienically and to make spice farming remunerative.

3.4 VISION 2025 - IISR Perspective Plan

As a part of ICAR's visionary approach, the institute has formulated its Perspective Plan (Vision-2025) for the years 2007-2025. This document reviews the growth of spices production and productivity over the years and has also presented a SWOT analysis. Future thrust areas for the institute have been identified for fulfilling its mandate for increasing spices production and export. The salient research achievements and their impact have been summarized. The key factors identified for exploiting the country's potential in spices are, production of export surplus, sustainable and dependable supply, clean spices (organic spices), better interaction between consumer and producer (farmer), and above all effective marketing. Value addition and creation of a branded image for Indian spices have also been suggested to make India a global power in spices production, marketing and export by 2025.

3.5 Major thrust areas and future programmes

- Conventional and biotechnological approaches for development of varieties having high yield and resistance to biotic and abiotic stresses
- Development of integrated pest, disease and nutrient management schedules which are environment friendly and ecologically sound
- Generation of high quality and disease-free planting materials of released varieties and elite genotypes
- Development of production technologies for spices and spices based cropping systems for organic and eco-spices
- Characterization of spices growing soils and assessing soil quality for developing soil based agro-techniques including rhizosphere and water requirement for sustainable spices production
- Value addition through isolation and characterization of bioactive principles in spices, post harvest technology of spices with emphasis on product development and production diversification
- Cost reduction and automation in spice farming

3.6 External collaboration to keep up with cutting edge technologies

- Biotechnological approaches for developing resistant/tolerant genotypes for biotic and abiotic stresses including RNAi technology
- Establishment of in vitro and cryo gene banks
- Molecular and genetic characterization of spices and gene mapping
- Molecular mechanisms of disease resistance and biocontrol
- Gene isolation
- Nutrient recycling pattern in spice growing soils under mixed cropping
- Value added spices based product development
- Drug modeling and identification
- Development of market intelligence systems
- Varietal evaluation of newly developed genotypes to suit specific agro ecological and soil conditions.
3.7 **Key facilities to be established**

- National Gene Bank of Spices
- Advanced Centre for Spices Biotechnology
- Advanced Centre for Spices Post Harvest Technology
- Advanced Centre for Biosystematics of Pests, Pathogens and Biocontrol Agents
- Virus Diagnostics and Quality Testing of Planting Materials
- National Spices Informatics Centre

3.8 **Issues and strategies**

The various issues affecting spices cultivation and the strategies to overcome them are:

3.9 **Gaps identified for strengthening spices research in the XI Five Year Plan**

- Genetic engineering for developing transgenic black pepper resistant to biotic and abiotic stresses
- Marker assisted selection and development of genomic maps in black pepper
- Identification of specific flavour compounds of spices and characterizing the germplasm

<table>
<thead>
<tr>
<th>Issues</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-availability of genes characterized for desirable traits such as yield and quality, disease, pest and drought tolerance for pyramiding in a single cultivar</td>
<td>Broadening genetic resources, their conservation, documentation and preparation of catalogues; locating sources of resistance for stresses using conventional and biotechnological tools</td>
</tr>
<tr>
<td>Lack of quality disease-free planting material and certification standards</td>
<td>Production of certified disease-free quality planting materials of improved varieties and its distribution</td>
</tr>
<tr>
<td>Crop losses by pests and diseases and emergence of new pests and diseases</td>
<td>Development of IPM/IDM practices for increasing the productivity</td>
</tr>
<tr>
<td>Pesticide residues in spices</td>
<td>Determining tolerance limits for pesticide residues and development and popularization of Good Agricultural Practices (GAP) for spices</td>
</tr>
<tr>
<td>Non-availability of methods to control post harvest losses and aflatoxin contaminations</td>
<td>Developing suitable on-farm and primary processing techniques; Developing storage and packaging systems to suit HACCP norms</td>
</tr>
<tr>
<td>Poor adaptability of nutrient management practices by farmers</td>
<td>Dissemination of nutrient management technologies to farmers</td>
</tr>
<tr>
<td>Lack of resistant lines against biotic and abiotic stresses</td>
<td>Breeding varieties for high yield and resistance to biotic and abiotic stresses</td>
</tr>
<tr>
<td>Lack of organic farming technology package for spice based cropping systems</td>
<td>Development of technology package for organic farming</td>
</tr>
<tr>
<td>Market fluctuation influencing technology adoption</td>
<td>Development of value addition to enhance the consumption of spices at domestic and international levels</td>
</tr>
<tr>
<td>Reduction in quality of spices due to mixing up with other inferior varieties imported into the country</td>
<td>Developing varieties with specific qualities such as high oleoresin and essential oil and kits to detect adulteration of spices</td>
</tr>
<tr>
<td>WTO implications</td>
<td>Genetic finger printing of germplasm and patenting varieties and technologies related to spices</td>
</tr>
</tbody>
</table>
• Effect of climate change on production and quality of black pepper, cardamom and turmeric
• Evaluation of black pepper in various farming/cropping systems and studies on nutrient flow cycles in soils
• Organic farming technologies and its effect on soil and produce quality in black pepper, ginger and turmeric
• Enhancing the water and nutrient use efficiency and developing models for targeted production in black pepper, ginger and turmeric
• Development of rapid, sensitive and reliable diagnostics against viral diseases of black pepper
• Transfer of technology using IT based extension methods and developing decision support systems for major spices

3.10 Programmes identified for strengthening research in XI Five Year Plan

3.10.1 Black pepper

• Development of diagnostics for pathogens in soil and plant and infrastructure for large scale production of improved varieties
• Breeding varieties having resistance/tolerance to important pests (pollu), pathogens (Phytophthora, nematodes), viruses and drought by using conventional and biotechnological approaches
• Germplasm characterization using molecular markers and preparation of molecular maps
• Evolving feasible cropping systems with black pepper for augmenting income of small and marginal farmers
• Development of organic farming technology and soil quality evaluation
• Developing fertigation models to maximize productivity and to reduce production cost in black pepper
• Developing soil test based fertilizer recommendations for specific target yields and prescription models for fertilizer recommendations.
• Investigations on protein and ISSR profiles in drought tolerant and susceptible black pepper accessions
• Identification, characterization and preservation of nematodes, fungal pathogens, viruses and biocontrol agents
• Development of IDM strategies including resistant lines, biocontrol agents, botanicals and microbial metabolites for management of foot rot and slow wilt of black pepper
• Evolving mass multiplication and formulation techniques for nematode antagonists, biosafety studies and commercialization of biocontrol agents
• Developing strategies to manage new and invasive insect pests
• Developing strategies to manage post harvest losses and mycotoxins
• Optimizing technology for large scale production of value added products from green pepper and black pepper
• Molecular and quality profiling of traded Indian black pepper for GI appellatiary purpose
• Development of GIS based data base to meet the requirement of decision makers, planners, researchers and farmers

3.10.2 Cardamom

• Breeding varieties having resistance to important pests (thrips), nematodes and drought by using conventional and biotechnological approaches
• Characterizing traded Indian cardamom from the GI point of view
• Developing water and nutrient budgets for specific target yields
• Development of organic farming technology
• Development of strategies for management of viral diseases in cardamom
• Identification of lines to overcome drastic changes in macro and micro environments as influenced by weather parameters

3.10.3 Ginger

• Identification of resistant sources and breeding varieties having resistance to important pests (shoot borer), diseases (rhizome rot), nematodes and low/high fibre types by conventional and biotechnological approaches
• In vitro pollination experiments to understand the reasons for zero seed set in ginger
• Induction of variability through mutagenesis and biotechnological tools
- Studies on phenology of ginger and turmeric and developing crop models designing management strategies, yield forecast, etc.
- Water and nutrient budgeting for enhancing use efficiency, sustaining crop productivity and reducing cost of cultivation
- Development of organic farming technology taking into account the nutrient contribution from different organic sources and microbial fertilizers
- Development of IDM/IPM strategies including biocontrol agents, botanicals and microbial metabolites for management of soft rot, bacterial wilt, nematodes and shoot borer
- Defining the geographically indicated commodities like Cochin ginger

3.10.4 Turmeric

- Breeding varieties having resistance to important pests (shoot borer), diseases (rhizome rot) and nematodes by conventional and biotechnological approaches
- Studying the curcuminoid profile of germplasm accessions
- Defining ‘Rajapuri turmeric’ and ‘Alleppey turmeric’ for GI appellation
- Developing fertilizer prescription models for specific target yields including secondary and micronutrients
- Organic farming technology using different organic sources and microbial inoculants
- Development of IDM and IPM strategies including biocontrol agents, botanicals and microbial metabolites for management of soft rot and shoot borer
- Characterization of bioactive compounds with pharmacological and clinical properties

3.10.5 Vanilla

- Introduction of genetic variability from centres of origin and cultivation such as Mexico, Madagascar and Indonesia
- Induction of genetic variability for yield, quality and disease resistance by seed germination, somaclonal variation, in vitro mutagenesis and characterization of induced variability
- Interspecific hybridization to transfer disease resistance and self-pollinated ability from other species
- Development of diagnostics and management of viral diseases
- Development of IDM strategies including botanicals, biocontrol agents and microbial metabolites for management of rot diseases

3.10.6 Paprika

- Introduction of exotic germplasm and collection of the local variability and characterization
- Developing hybrids with good yield and high quality plus resistance to stresses

3.10.7 Tree Spices

- Characterization of germplasm by conventional and molecular methods and identification of markers linked to sex
- Identification of elite lines and their use in crop improvement
- Evaluation of growth regulators and their application in increasing yield
- Micropropagation techniques for mass multiplication of planting materials
- Drying, packaging and storage of nutmeg and mace and upgradation of quality analysis to ISO 9000/14000 level
- Characterization of bioactive compounds for control of diseases of spice crops

3.11 Impact analysis and technology dissemination

- Economic evaluation on total factor productivity of spice based cropping systems and assessing their sustainability
- Evaluating the impact of socio-ecological changes on spices production in the hill district of Wayanad in Kerala and building a sustainable spice industry for Wayanad in collaboration with developmental agencies of both central and state governments and self-help groups in the district
- Multiplication of quality planting materials and other technological inputs for distribution to stakeholders
- Organizing and evaluating training programs to extension functionaries, researchers, farming community and other stakeholders
• Economic evaluation and impact analysis of promising technologies and investment on spices research and development
• Production cost analysis in different spice growing situations and under various management levels

3.12 Krishi Vigyan Kendra
• Organizing programmes in spice production related enterprises
• Conducting trainings on post harvest management of on-farm horticultural produces
• Developing video conferencing facilities for close interaction with farmers

3.13 Library
• Completion of digitization and automation of the library
• Setting up of an institutional repository using Dspace software
• Digital archiving of spice literature in India
• Documentation of literature from major spice growing countries

3.14 Likely results
• Identification of resistant genes which could be incorporated into other agronomically important varieties which are susceptible to diseases.
• Development of improved varieties with high degree of resistance to biotic and abiotic stresses
• Development of optimum nutrient requirement for augmenting production and quality of improved varieties of spices and fertilizer use efficiency through fertigation
• Development of cropping systems with spices and their economics
• Understanding the biosynthetic pathways of piperine, gingerol and curcumin
• Commercial exploitation of pharmacological and nutraceutical properties of spices for developing new value added products.
• Integrated management of diseases using beneficial organisms such as antagonistic fungi, PGPR and biofertilizers
• Increasing productivity of spices through large scale demonstration of improved technologies in farmers fields
• Generation of on-farm employment opportunities
Research Achievements

The institute has made significant achievements in research in the mandate spice crops during 2002-06 which are highlighted below:

4.1 Crop Improvement and Biotechnology

4.1.1 Black Pepper

Genetic resources
Four hundred and sixty eight accessions including 398 wild and 70 cultivated types were collected during 2002-06. The Germplasm Conservatory consists of 1075 wild, 1282 cultivar accessions and nine exotic species, besides 1375 hybrids. Two hundred and fifty accessions were characterized based on IPGRI descriptor. Molecular characterization using RAPD and ISSR markers were carried out for 15 wild species and 33 cultivated types. Geographic Information System (GIS) was used to understand the pattern of genetic diversity and distribution of Piper spp. in North East India.

The collections registered with NBPGR, New Delhi, include: Coll. 1041, an accession of Thevanmundi registered for its field tolerance to Phytophthora foot rot disease (INGR-03091); Coll. 5455, a Piper nigrum collection from forests of Nelliampathy (Palakkad District) registered for its high oleoresin (28.15%) and bold berries (INGR 04111); and CLTP 123, a local cultivar with high caryophyllene content (INGR 6026).

Improved varieties
The 23rd State Variety Release Committee, Kerala, approved four black pepper varieties namely, IISR Thevam (high yield and field tolerance to foot rot disease), IISR Girimunda (high yield), IISR Malabar Excel (high oleoresin content) and IISR Sakhti (tolerant to foot rot disease) for release.

Identification of hybrids using RAPD markers
Black pepper hybrids were analyzed to identify true hybrids using male parent specific RAPD based DNA markers. Thirty-five decamer primers were used for the analysis and 13 primers yielded reproducible and consistent DNA banding pattern to distinguish hybrids in 8 hybrid populations.

Cloning of Phytophthora resistance gene
Successful Agrobacterium mediated transformation with osmotin was achieved for disease resistance in black pepper. Isolation of the part of the resistance gene sequence from P. colubrinum was achieved by targeted gene amplification using degenerate primers. Sequence comparison of the deduced amino acid sequences of the fragment showed sequence similarity with already identified disease resistance genes in public databases.

Chitinase and Phytophthora resistance
The enzyme chitinase increased in P. colubrinum after challenged with P. capsici and peak activity was found at 60 h after inoculation. An internal fragment of a putative chitinase gene was cloned which showed similarity to known chitinase genes from plants.

Development of mapping population
A mapping population involving Panniyur 1 x Subhakara was developed and another involving P 24 x Subhakara is being developed. RAPD and ISSR polymorphism was scored in about 150 loci for developing molecular maps. Studies on inheritance pattern of Phytophthora resistance in the mapping populations indicated that two genes with duplicate functions were in operation giving a nearest ratio of 1 resistant: 15 susceptible.

Evaluation of tissue cultured plants
On-farm evaluation of tissue cultured black pepper plants in 100 ha in collaboration with KAU and Spices Board in eight states indicated that tissue cultured plants exhibited better field establishment with 20% of them flowering early.

4.1.2 Cardamom

Genetic resources
One hundred and twenty one accessions were added to the germplasm during 2002-06; 435 accessions were maintained in the field gene bank. Two hundred and seventy six accessions were characterized based on IPGRI descriptor. Four
accessions namely, IC 349541 (APG-248) (branches throughout the panicle with high number of branches per panicle, and high yield); IC 349554 (APG-251) (compound panicle with basal branching and bold capsules, and high yield); IC 349599 (APG-306) (resistant to katte disease); and IC 349634 (APG-343) (resistant to rhizome rot and leaf blotch diseases) were registered with NBPGR for their uniqueness.

Evaluation
Based on the per se performance, heterosis and combining ability, 12 hybrids were short listed among 56 diallel hybrids. The short listed hybrids were evaluated for yield and katte resistance and four hybrids (NHY-3, 10, 14 and 35) were short listed for higher yield. Screening of these hybrids against katte resistance is in progress. Crosses were effected between a compound panicle (MB-3) and IISRAvinash (RR-l). Evaluation of hybrids revealed its superior performance for yield and capsule characters.

The promising Malabar accessions were evaluated in the field and based on yield, panicle and capsule characters, the accessions APG-293, 294 and 334 were promising. Among the Vazhukka accessions, VA-1 and VA-8 were promising than the check Green Gold.

Six lines including two hybrids (NHY 3 and NHY 35), two Malabar types (MA-28 and MA-29), two Vazhukka types (VA-1 and VA-8) and two compound panicle types (AMB-2 and MB-3 x RR-1) are in advanced stage of release.

Genetics of katte resistance
Back crossing was carried out with respective resistant and susceptible parents in two promising hybrids (NHY-35 and NHY-3). Two F1 hybrids were also selfed to study the segregation pattern of progenies for katte resistance; 431 seedlings of the above back cross and F1 progenies were raised for screening against katte disease. Two rounds of screening were completed and the third round of screening is in progress.

Biotecnological approaches
Transient gene expression of GUS was induced in embryonic cultures using biolistics; Agrobacterium mediated transformation was attempted and putative transgenic plants were regenerated.

4.1.3 Ginger and Turmeric

Genetic resources
Twenty five Zingiber accessions and 20 Curcuma accessions were added to the germplasm during 2002-06. Six hundred and eighty five accessions of Zingiber and 1040 accessions of Curcuma are conserved in ex situ gene banks. An in vitro gene bank was also established for conservation of germplasm. The significant collections include, a wild Z. officinale with slender rhizomes from Silent Valley, a low fibre type ginger from Mizoram, Z. officinale var. rubens (Kintoki) from Japan and C. ceasia (black turmeric) from Arunachal Pradesh, Acc. 657, a high curcumin AFT turmeric (INGR 03089) and a high oil type ginger (INGR 04110) were registered with NBPGR as unique germplasm.

Molecular characterization
Molecular genetic fingerprints of 15 Curcuma species were developed using ISSR and RAPD markers to elucidate the relationships among the species. Molecular characterization (RAPD and ISSR) of 36 turmeric cultivars from different parts of the country indicated that cultivars collected from the same geographical area were not genetically distinct. Metabolite profiling of 11 Curcuma spp. using rhizome essential oil GC-MS profile and dendrogram based grouping revealed congruent clustering with molecular/morphological identity of the species.

Improved varieties
Two turmeric varieties namely, IISR Alleppey Supreme and IISR Kedaram having high yield and curcumin (>5%) content and resistance to leaf blotch disease were recommended for release by the 23rd State Variety Release Committee, Kerala.

Evaluation
Comparative yield evaluation of 12 selected bold ginger lines from Nepal revealed the superiority of Acc. 578 with a mean yield of 16 kg/bed (3 m²). The dry recovery of this accession was 20%-23% with a fibre content of less than 2.5%.

Stability analysis for rhizome yield in 11 new
genotypes of turmeric including Acc. 126 (Kedaram) and Acc. 585 (Alleppey Supreme) revealed high yield stability of these two lines as revealed by high mean yield, unit regression coefficient \( (b_1) \) and least deviation from regression \( (S_d) \).

**Inducing seed set in ginger**

Acc. 12 (Erattupetta) was found to be unique for its colour pattern of the floral labellum, high pollen stainability (27.5%), high \textit{in vitro} germination of pollen grains (10.4%), better pollen tube growth (mean length of 1209 \( \mu \) after 24 h of culture) and germination of pollen grains on the stigma on self-pollination. This cultivar appears to be suitable for future studies to induce seed set.

**Biotechnological approaches**

A protocol for PCR based, detection of turmeric varieties based on DNA isolated from fresh rhizome was perfected with a view to check unscrupulous seed trade practice.

### 4.1.4 Tree spices

**Genetic resources**

Ninety six accessions of tree spices were added to the germplasm during the period under report (2002-06). A dwarf clove accession and two cassia accessions were registered with NBPGR. Four elite cassia lines were evaluated in the field. A high yielding nutmeg variety IISR Viswashree yielding 3,122 kg nuts (dry) and 480 kg mace/ha during 8th year after planting was released for Kerala. Database of \textit{Myristica} germplasm was developed.

**Characterization**

An efficient protocol was developed for isolation of DNA and molecular fingerprinting of wild and related genera of \textit{Myristica} sp. Unique bands were identified for designating some of the unique accessions like A9/4 (high yielding epicotyl graft with plagiotropic shoots); A9/150 (thick mace and bold fruits) and A4/22 (high number of erect shoots) for identification. Unique markers and finger prints by RAPD, ISSR and PCR-RFLP of 10 elite high yielding accessions, with high sabinene and low myristicin contents were developed. Biotechnological studies on sex differentiation in nutmeg using OPA-17 primer revealed the association of a marker (0.7 kb) with female and bisexual types.

**RAPD profiles** were developed using three polymorphic operon primers and analyzed using NTSYS software and dendrograms constructed to study the interrelationships of \textit{Garcinia} spp. RAPD polymorphism was used to estimate genetic variability in cassia which ranged from 0% to 40%.

**Grafting**

Wedge grafting and approach grafting were successful on \textit{M. malabarica}, \textit{M. beddomeii} and \textit{M. fragrans}. The success was highest on \textit{M. fragrans} (90%), followed by \textit{M. malabarica} (76%) and \textit{M. beddomeii} (68%). Between the two scions A9-4 and A9-69 used for grafting, A9-69 was more compatible with all the rootstocks.

Studies on influence of root stock in nutmeg indicated that growth of grafts was the highest on \textit{M. beddomeii} rootstocks for both A9-4 and A9-69 scions. The scion had an influence on the shape of the canopy and A9-69 had an upright growth when compared to A9-4, which had a spreading canopy. Early flowering was observed in grafts on \textit{M. malabarica} rootstock; among the scions more flowering was observed on A9-4 scions.

### 4.1.5 Vanilla

**Genetic resources**

Eighty collections of cultivated vanilla were made from farmers' gardens in Kerala and Karnataka and one exotic collection each from Madagascar and Mauritius during 2002-06. The important collections include 8 collections of \textit{V. andamanica}, 2 collections of \textit{V. aphylia} and 1 collection each of \textit{V. tahittensis}, \textit{V. wightiana} and \textit{V. pilifera}.

**Evaluation**

Molecular characterization of related species, interspecific hybrids, seed progenies and somaclones were done with DNA markers-RAPD and AFLP, their inter relationships studied and hybridity confirmed. A few sources of resistance to \textit{Fusarium oxysporum} and \textit{Phytophthora medii} were identified for the first time in vanilla. Interspecific hybridization was successful between \textit{V. planifolia} and \textit{V. aphylia}.
Comparative anatomy
Comparative anatomical analysis of internodal region of Vanilla sp. from Andaman and Nicobar Islands and V. planifolia revealed the distinct absence of sclerenchymatous band separating the cortex and ground tissue in the former, which further indicates that Vanilla sp. from Andaman and Nicobar Islands, is closer to the leafless species of vanilla.

Micropropagation
Protocols for micro propagation of vanilla, through direct shoot multiplication as well as callus regeneration were standardized.

4.1.6 Paprika

Genetic resources
One hundred and thirty (96 indigenous and 34 exotic) accessions of paprika and paprika like chillies collected from various sources were purified and maintained. Among the indigenous germplasm, Seln. 2, ICBD-10 and Kt-pl-19 were promising, while in the exotic collections, PBC-171, EC-18 and SSP-1999 were promising. ICBD-10 and EC-171 registered the highest colour value in the indigenous and exotic collections, respectively. The capsaicin content varied from 0.0065% to 0.103% with a mean value of 0.0445% in the indigenous collections and from 0.0056% to 0.101% with a mean value of 0.0389% in the exotics. ICBD-10 and Kt-pl-19 (indigenous) and EC-18 (exotic) were promising for yield and quality.

4.2 Crop Production and Post Harvest Technology

4.2.1 Black pepper

Nutrient management
Application of vermicompost @ 1.25 kg/pot significantly increased the build up of soil P and K and berry yield by 51% over chemical fertilizer sources in bush pepper. The treatment receiving 50% recommended K as SOP recorded the highest yield of 295 g/pot. Under field conditions, maximum yield (3.16 kg/vine) was obtained in recommended K as SOP + Mg SO₄, which was on par with recommended dose of K as SOP and significantly higher than control.

Application of Azospirillum sp. along with nitrogen (70 g), phosphorous (55 g), potash (270 g) and magnesium (200 g) (per plant) increased the yield by 21% compared to control and application of NPK (140:55:270 g/plant) alone.

Nutrient solution for nursery
Application of nutrient solution consisting of urea, super phosphate, potash and magnesium sulphate in 4:3:2:1 proportion at monthly intervals along with solarized potting mixture recorded vigorous and healthy plants in the nursery.

Propagation
Substituting sand with granite powder, a waste material from stone quarries, in potting mixture, was economical in the nursery. Leaf production (4.6), leaf area (136.8 cm²), and biomass (3.9 g) of rooted cuttings were higher for combinations of soil (S), granite powder (G) and farmyard manure (F) (2:1:1). Production cost of rooted cuttings was less for SGF 2:1:1 and SGF 1:1:1 compared to control. Planting cuttings in solarized potting mixture with addition of Trichoderma harzianum and Pseudomonas fluorescens at the time of planting and first and second months after planting resulted in healthy rooted cuttings.

Cover crops and intercropping
Cover crops such as Cassia obtusifolia, Crotalaria anagyroides, C. retusa, C. striata, Pueraria javanica, Mimosa invisa and Indigofera spp. were promising for inter-planting in black pepper. Intercropping P. chaba (4,000 plants/ha on Glyricidia standards) in arecanut plantation provided an additional income of Rs. 32,400 ha⁻¹. In addition, the support tree enriched the soil by fixing atmospheric nitrogen and provided green leaf for mulching.

Soil rhizosphere microbial community structure
The soil microbial community structure in the rhizosphere of agroforestry trees-black pepper systems was investigated using PCR-RFLP. Maximum number of microbial species was identified under Glyricidia-black pepper system (68), followed by Garuga-black pepper (66) and Ailanthus-black pepper systems (65).

Evaluation for drought
Evaluation of black pepper accessions for drought
indicated that Accs. 1495, 813, 931, 1368, 4216, 1585 and 1390 were promising. The tolerant accessions maintained higher relative water content and lower membrane damage. Catalase and superoxide dismutase showed decreased activity while peroxidase, polyphenol oxidase, glutathione reductase and ascorbate peroxidase showed increased activity under stress. Isozyme profiles of catalase and peroxidase did not vary due to stress or between tolerant and susceptible accessions. Super oxide dismutase showed four common bands and two other bands, which were not common to all the accessions. Chlorophyll fluorescence values and photosynthetic rate decreased during severe stress, which was lesser in tolerant accessions.

**Effect of climate**

The data on rainfall, Tmax and Tmin and black pepper productivity were collected from major black pepper areas of Kerala, Karnataka and Tamil Nadu for the past two decades (1984-2004). In general, rainfall and productivity showed decreasing trend while Tmax and Tmin showed an increasing trend. Correlation between black pepper productivity and rainfall for 10 years indicated that previous year’s rainfall was correlated negatively or had no impact on productivity.

The beginning and end of annual cycle of black pepper was identified as 10\textsuperscript{th} (5-11 March) and 9\textsuperscript{th} (26 February-4 March) meteorological weeks, respectively, based on length of growing period (LGP). The magnitude of black pepper-weather relationship was in the order: maximum relative humidity > rainfall > minimum temperature > maximum temperature > sunshine hour > wind > minimum relative humidity > evaporation. A regression model for prediction of black pepper production in Kerala was developed with $R^2 = 0.7057$.

Excess rainfall than normal during initial period of annual cycle of black pepper (between 5-11 March to 25 June-1 July) reduced the yield. The rainfall excess between July to December end was beneficial to the crop and enhanced the yield. The rainfall excess than normal beyond December reduced the yield of black pepper.

Correlation between black pepper yield and weather parameters (weekly rainfall, maximum temperature and maximum relative humidity) indicated that weekly rainfall during crop period (June to January) had a positive association with yield ($R^2 = 0.834$) whereas, weekly maximum temperature during crop period had negative relationship with yield ($R^2 = 0.6113$). Maximum relative humidity showed negative relationship during initial 18 weeks with subsequent positive association ($R^2 = 0.9997$).

Photosynthetic rate in black pepper varieties was not affected much due to an increase in temperature of 2-3 degrees. Selected high yielders in black pepper had higher photosynthetic rate and lower leaf temperature compared to low yielders. Photosynthetic rate ranged from 2.2 to 3.86 in high yielders and from 2.0 to 3.2 $\mu$ moles m$^{-2}$ s$^{-1}$ in low yielders.

**Evaluation for quality**

Evaluation of black pepper accessions for quality indicated that Acc. 5411 had 31% oleoresin and 6.2% piperine, followed by Acc. 5442 with 21% oleoresin and 6% piperine. Essential oil constituents of organically cultivated Panniyur-1 and Karimunda showed higher values of $\beta$-caryophyllene (up to 30% in Panniyur-1 and 24% in Karimunda).

Studies on effect of locations on quality indicated that Panniyur-1 had 25% $\beta$-caryophyllene at Peruvannamuzhi, Panniyur and Dapoli, 9.7% at Yercaud, 14.3% at Pampadumpara and 16% at Ambalavayal. Bulk density (weight/l) ranged from 450 to 640 g/l at various locations.

Analysis of quality parameters of black pepper in different regions of Kerala, Karnataka and Tamil Nadu revealed that oil content ranged from 1.6% to 3.6%, oleoresin 5.0% to 12.0%, piperine 1.0% to 5.5%, test weight 2.7% to 7.4%, fibre 5.2% to 23.3% and berry starch 37.5% to 55.0%. Among oil components, $\beta$-caryophyllene ranged from 6.2% to 32.0%, myrcene 17.7% to 30.7% and limonene 17.7% to 30.7%.

**Detection of adulteration**

Adulteration of powdered market samples of black pepper with ground papaya powder was detected using PCR techniques. RAPD profiling of the traded
black pepper from India, Vietnam, Indonesia and Malaysia revealed distinct genetic identity of the produces from different countries.

**Drying and storage**

Evaluation of various driers and open sun drying indicated that blanching accelerated the rate of drying in all the drying methods. The time required for drying was approximately 36, 32 and 26 h for drying black pepper at 50°C, 55°C and 60°C, respectively, and open sun drying took 68 h for complete drying. Storage of black pepper in polyethylene covers under vacuum, 100% N₂, and 90% N₂ + 10% CO₂ atmosphere for 240 days resulted in no change in oil, oleoresin and moisture contents.

**White pepper**

Conversion of green pepper into white pepper using selected bacterial strains showed Panniyur-1 was more suitable among the varieties evaluated. Ten efficient bacterial strains have been short listed for the process.

**GIS studies**

The biochemical properties of P. nigrum leaves from Western Ghats were studied to explain the diversity in relation to its spatial distribution. A certain patch (10°48'-12°25' latitude) showed high phenolic concentration. β-caryophyllene and Nerolidol were the two important volatile oil constituents present in the leaf oil of P. nigrum in different accessions.

4.2.2 Cardamom

**Soil and moisture conservation**

Introducing contour staggered trenches in coffee and cardamom plantations was effective in conserving soil and water. Cardamom plots with contour staggered trenches (2.00 m x 0.45 m x 0.30 m) in alternate rows recorded less runoff (43.8 mm) and soil loss (148.09 kg/ha) compared to unplanted treatment (fallow), which recorded maximum runoff (216.0 mm) and soil loss (944.12 kg/ha).

**Indigenous nutrient mobilizing bacteria**

Application of *Azospirillum* sp. and phosphobacteria recorded maximum number of leaves, dry weight, total NPK uptake, root colonization and lower disease incidence. The N-fixation capacity of the *Azospirillum* isolate was 7.39 mg g⁻¹ malate whereas the phosphobacteria strain recorded higher solubilization efficiency of up to 220 mg l⁻¹.

**Evaluation for drought**

Four cross combinations (RR-1, CL-893, Green Gold and CCS-1) were evaluated for growth, yield and physiological characters among which RR-1, Green Gold and CL-893 were relatively tolerant to moisture stress. CL-893 and its cross combinations recorded better growth and yield characters. Green Gold (APG-257), Mysore 2 (APG-414) and Malabar 18 (APG-434) maintained higher biomass and higher relative water content under stress and were relatively tolerant to moisture stress.

**Irrigation**

Drip irrigation and sprinkler irrigation once in 12 days recorded significantly higher number of tillers/clump, leaves/tiller and panicles/plant. In spite of early initiation of panicle and poor setting during early stages, drip irrigation @ 81/plant/day recorded higher yield (575 kg/ha) followed by sprinkler irrigation once in 12 days (395 kg/ha).

**Evaluation for quality**

GC-MS profiling of essential oil of export cardamom showed 33 compounds in Indian, 26 in Guatemalan and 35 in Sri Lankan cardamoms; 22 of them were common for all three produces. 1, 8-cineole (27.59%) and α-terpinyl acetate (41.65%) were higher in Indian cardamom when compared to the other produces.

Among the 115 accessions evaluated, Accs. 60, 63, 75 and 273 recorded more than 8% volatile oil. Accs. 259, 325, 277, 257 and 258 recorded 30% α-terpinyl acetate and about 25% 1,8-cineole. Among the 37 samples evaluated, the husk to seed ratio ranged from 38:62 to 25:75; the accessions with high husk to seed ratio were NHY-1, CCS-1 Self and NHY-35.

4.2.3 Ginger and Turmeric

**Phenology**

The time of occurrence of new shoot emergence, appearance of tiller and leaf and maturity were recorded in relation to growing degree days (GDD)
for ginger and turmeric grown under rainfed conditions at Peruvannamuzhi. The GDD required for emergence after planting was 190 and 225 degree days for ginger and turmeric, respectively. First tiller appeared at 646 and 1106 degree days with a total 11 and 6 tillers and maturity (complete drying of all leaves) at 3096.8 and 3571.0 degree days for ginger and turmeric, respectively. Leaf growth followed a quadratic pattern in ginger and linear pattern in turmeric.

**Nutrient management**

Studies on effect of different levels of zinc on activity of nitrate reductase and acid phosphatase in ginger indicated higher activity in foliar applied Zinc than soil application. The threshold value of leaf P/Zn ratio was confirmed to be 90 through second order response function. On validating the same under field conditions, the initial leaf P/Zn ratio at 60 days after planting in the range of 145-223 could be brought in to the threshold range of 69-150 after foliar spray of Zn (0.5%) twice during August and October. By lowering the ratio below 108, increased rhizome yield up to 20% could be achieved.

Based on the initial soil fertility levels of N, P, K and Zn, the fertilizer doses for obtaining 10, 15 and 20 kg/bed yield targets in ginger were worked out and applied. Zinc was supplemented as foliar spray. The achieved ginger rhizome yield was 10.8, 12.4 and 11.4 kg/bed with a deviation of +0.5%, -17.0% and -43.0% from the target. Through targeted nutrient application increased yield of 14%-26% over recommended dose could be achieved in var. Prathiba with reduced fertilizer application.

Application of zinc significantly increased the soil zinc availability in ginger and the highest concentration was obtained with an application of Zn 15 kg/ha. A cubic model satisfactorily explained the relationship between mean rhizome yield and fertilizer application rate. A fertilizer dose of 6 kg/ha of Zn was optimized from the model for getting maximum rhizome yield and the maximum limit of soil DTPA-Zn for obtaining high rhizome yield was 3.4 mg/kg. Critical concentrations for soil and foliar zinc levels were 2.1 mg/kg for soil and 27 mg/kg for foliar concentrations for obtaining profitable yields.

A highly significant positive correlation of leaf P/Zn ratio and a significant negative correlation of soil P/Zn ratio with rhizome yield of ginger were observed. A step wise regression analysis showed that leaf P/Zn was most influencing factor on rhizome yield followed by soil P/Zn ($r^2 = 0.353^*$). The critical range of leaf P/Zn ratio was found to be 27.9 to 90 through Mitscherlich model.

Based on the initial fertility levels of N, P, K and Zn, the fertilizer doses for obtaining 15, 20, 25 kg/bed yield in turmeric were worked out and applied. Zinc was supplemented as foliar spray. The achieved turmeric rhizome yield was 14.8, 15.8 and 16.3 kg/bed with a deviation of -1%, -20% and -34% from the fixed target. Through targeted nutrient application 12%-20% increased yield over recommended dose could be achieved in var. Prathiba with reduced fertilizer application.

Ginger and turmeric were cultivated organically by applying FYM, vermi compost and ash rock phosphate as nutrient source and *Pseudomonas* sp. and *Trichoderma* sp. as biocontrol agents for rhizome rot control. The mean yield recorded in ginger (var. Varada) was 7.5 kg/3 m$^2$ with a reduction of 26.0% and 22.8% rhizome yield as compared to chemical and integrated farming, respectively. Turmeric (var. Alleppey) recorded a mean yield of 15.5 kg/3 m$^2$ under organic cultivation with a reduction of 15.3% rhizome yield as compared to the conventional system.

**Storage**

Evaluation of various containers for storage of fresh ginger indicated that zero energy chamber (a double walled brick structure filled with sand between the walls frequently moistened with water) was ideal for storing fresh ginger.

**Evaluation for quality**

Among the 60 ginger samples evaluated for quality, Gurubathani, Sabarimala and Kozhikkalan, gave above 5.5% oleoresin. Many accessions contained only 2.0%-2.5% crude fibre. GC-MS analysis of ginger oil from Peruvannamuzhi indicated the presence of following major compounds : citral-a: 5.3%, citral-b: 8.1%, ar-curcumene: 7.8%, α-zingiberene:19.1%, β-bisabolene: 7.5%, α-farnesene: 6.6%, β-sesquiphellandrene:10.2%.
Seventy two turmeric germplasm samples were evaluated for oil, oleoresin and curcumin contents; Acc. 50 contained 7.2% curcumin with 21.0% oleoresin. Accessions with above 20% oleoresin were Accs. 1, 25, 35, 21 and 50. Accessions with high oil were Accs. 62, 1, 47, 35, 39, 20, 15, 32, 10, 2, 50 and 23 (above 8%). GC-MS of turmeric rhizome oil indicated the presence of ar-curcumene: 1.5%, α-zingiberene: 1.45%, β-sesquiphellandrene: 1.6%, ar-turmerone: 28.47%, β-tumerone 9.2%, ar-tumerone: 3.1% and α-tumerone: 22.17%.

Turmeric varieties like Alleppey, Prabha and Prathiba showed a decline of 20% curcumin content when cultivated at Nyamthi in Karnataka compared to Calicut. Acc. 126, recorded 6.4% and Sudarshana recorded 6.0% curcumin in that location.

Enhanced activity of phenylalanine ammonia lyase (PAL) was associated with curcumin levels during the early stages of rhizome development. In low curcumin (<2%) accessions, the activity was lower as compared to accessions with high curcumin (>5%), thus confirming the key role of PAL in the initiation of curcumin biosynthesis.

Detection of adulteration
A PCR based method was developed to detect adulteration of traded turmeric (C. longa) powder with powder of C. zedoaria.

4.2.5 Tree spices

Evaluation for quality
Six Cinnamomum spp. namely, C. verum, C. cassia, C. camphora, C. tamala, C. citriodorum and C. malabatrum were evaluated for leaf oil constituents. The major constituents were identified as eugenol (87%), cinnamyl acetate (39%), camphor (59%), eugenol (32%), citronellol (42%) and linalool (32%), respectively. Forty accessions of cinnamon germplasm samples were evaluated for bark oil content; the oil content varied from 1% to 2%. High oil (8%) and oleoresin (14%) in bark was recorded in the cassia accessions 57 and 60.

Drying and storage of mace
Drying of mace took 3½ h at 60°C, while nutmeg took 15 days using hot air drier. The dry recovery of mace was 35.6% and that of nut was 58.2%. The ratio of nut to mace recovery was 5.75:1.00. After 180 days of storage in 300 g polypropylene covers, the mace blanched for 2 min in boiling water showed better colour retention (lycopene-49.9%).

4.2.6 Production of planting materials
Nucleus planting materials of black pepper rooted cuttings (2,58,000), black pepper rooted laterals (2,122), turmeric seed rhizomes (33.5 t), ginger seed rhizomes (17.5 t), nutmeg grafts (34,730), cardamom seedlings (89,299), cardamom suckers (3,000) and cardamom capsules (76 kg) were produced and distributed to farmers during 2002-06. Seedlings of CCS-1 and Mudigere-1 (23,000) and suckers of CCS-1, RR-1 and mosaic resistant selections (2,000) were also produced and sold to elite farmers in Karnataka and Kerala.

4.2.7 Management of mycotoxins
Surveys carried out in warehouses, markets, farm houses and godowns in Kerala and Andhra Pradesh indicated that moisture content was a critical factor for spoilage of samples. A total of 90 fungi were isolated which included Aspergillus niger, A. flavus, Penicillium spp. and Mucor spp. A. flavus and A. parasiticus were isolated from a few samples especially, nutmeg and ginger. DNA was extracted from Aspergillus isolates of black pepper, turmeric, ginger, nutmeg and mace and amplified to identify the species.
4.3 Crop Protection

4.3.1 Black pepper

*Phytophthora* foot rot disease

**Conservation and characterization**

Five hundred and twenty isolates of *Phytophthora* were conserved in the repository. Cryopreservation studies using DMSO (10% and 15%) revealed that in both the concentrations, the survival rate was 72.0%, 55.6% and 55.6% after storing for 24 h, 15 days and 30 days, respectively. Seventy one isolates from black pepper were characterized morphologically and all the isolates produced papillate sporangia, obpyriform, ellipsoid or distorted in shape. Forty two isolates from black pepper were tested for mating types among which 97.6% were A1 mating type, and 2.4% were A2 mating type. Variability in pathogenicity was observed among 50 isolates when tested on susceptible black pepper variety Subhakara.

Two hundred and fifty isolates of *Phytophthora* were characterized using ITS-PCR. PCR-RFLP analysis indicated high levels of intraspecific and interspecific variability in the ITS regions. *Phytophthora* isolates from black pepper (99-166, 05-14, 96-02) were cloned and sequenced. The BLAST search of sequences of cloned black pepper isolates of *Phytophthora* showed 98% similarity with *P. capsici* and *P. tropicalis*. A species specific primer was designed for *P. capsici*.

**Host resistance**

A *Phytophthora* tolerant line IISR Shakti was released by the 23rd State Variety Release Committee, Kerala. Three short listed open pollinated progenies [P 24-04-1, HP 1533 (2) and HP 1533 (3)] were moderately resistant among 8,49,048 seedlings screened and are under field evaluation. A total of 491 accessions of cultivars, 691 hybrids, 124 wild accessions and 182 Karimunda accessions were screened using stem inoculation method. Two cultivars (1239 and 1535), four hybrids (HP 10, HP 780, HP 1372 and HP 1375) and five wild accessions (10, 780, 1372 and 1375) were resistant.

**Management**

Translocation of $^{32}$P labeled potassium phosphonate was studied by drenching of diluted radioactive tracer solution to the collar portion and also through foliar application. The chemical was detected in the whole plant within 2 days by soil application, whereas by foliar application, the compound reached the leaves in 3 days and the roots in 5 days.

The compatibility of antagonist bacterial isolates were tested in vitro against each other and all the short listed bacterial isolates were compatible. IISR-8, IISR-13, PB-21C and PIAR-6 were compatible with P-26 (*T. harzianum*) while the nematode antagonist *Pochonia chlamydospora* was inhibitory to all the bacterial antagonists and *T. harzianum*

Antagonistic potential of 10 bioagents effective against *Phytophthora capsici* were tested against *Pythium aphanidermatum*, *Rhizoctonia solani* and *Fusarium oxysporum* f. sp. *vanillae*. Isolate IISR-853 (which is antagonistic to *Radopholus similis* and *Meloidogyne incognita*) was antagonistic to all other targeted pathogens giving more than 50% inhibition. Evaluation of bioconsortium in the field for the management of foot rot and slow decline diseases indicated that plant stand and vigour was better with the consortium of IISR-6, 8, 13, 51, 151 PB-21C and 853 in cv. Karimunda.

An integrated disease management strategy involving biological and chemical treatments, susceptible and tolerant varieties, organic and inorganic nutrition applied in weeded and un-weeded plots indicated that crop stand was better in plots with clean cultivation compared to plants in un-weeded plots.

**Stunt disease**

**Distribution**

Surveys conducted in Karnataka and Kerala showed highest incidence of the disease in Wayanad District (45.4%) followed by Idukki District (29.4%) in Kerala. In Karnataka, Kodagu District (14.9%) had the highest incidence of the disease followed by Hassan District (5.2%). The incidence and severity of the disease was higher at higher altitudes. In severely infected gardens yield loss up to 80% was recorded.
**Etiology and characterization**

Etiology of the disease showed the association of two viruses namely, *Cucumber mosaic virus* (CMV) and *Piper yellow mottle virus* (PYMoV) and either single or combined infections by the two viruses were seen. Purified CMV particles were spherical (about 28 nm in diameter) while purified PYMoV particles were bacilliform (30 x 125 nm). PYMoV was transmitted by two species of mealybugs (*Ferrisia virgata* and *Planococcus citri*) in semi-persistent manner. The coat protein gene of the CMV was cloned, sequenced and sequence analyses showed that the virus belongs to CMV subgroup IB. Portion of ORF-I and ORF-III of the PYMoV infecting black pepper were cloned, sequenced and sequence analyses showed that the virus is a strain of PYMoV.

**Diagnostics**

Polyclonal antisera were raised against CMV and PYMoV infecting black pepper and DAS-ELISA based methodology was developed for the detection of both the viruses in nursery and field plants. A protocol for isolation of total nucleic acid from black pepper and PCR and RT-PCR based method for detection of PYMoV and CMV in black pepper plants was developed. A procedure for simultaneous isolation of RNA and DNA from black pepper and multiplex RT-PCR for simultaneous detection of both the viruses infecting black pepper was developed.

**Phyllody disease**

**Distribution and etiology**

Survey for incidence of phyllody disease in Kozhikode District showed that a few gardens were severely affected with more than 90% showing the symptoms of the disease. The phytoplasma associated with phyllody disease was identified as a member of aster yellows group of phytoplasma.

**Spike shedding /Anthracnose**

**Distribution and etiology**

Spike shedding varied from 9% to 87%, the highest being noticed in rainfed and heavily shaded plantations at high altitudes. Anthracnose disease (caused by *Colletotrichum gloeosporioides*), predominance of female flowers, lack of pollination in rainfed areas, heavy shade and delayed emergence of spikes were the major reasons for spike shedding. Panniyur-1 was the most susceptible and Panniyur-5, Subbakara, Panchami, Balankotta, Kottanadan, Chomala, Thevanmundi, Karimunda, Chethalli Selection, Aimpirian and Arakulam munda showed field tolerance to anthracnose.

**Management**

Irrigation of black pepper vines 4-5 times at an interval of 5-7 days @ 40-50 l/plant commencing from 22 March, followed by shade regulation of support trees to provide minimum 7,500-10,000 lux light under cloudy condition was optimum for managing spike shedding at high altitudes. The recommended phytosanitary, prophylactic and nutrition management practices are also necessary for holistic management of spike shedding and anthracnose.

**Nematodes**

**Characterization**

Isolation of genomic DNA from *Meloidogyne incognita* and *Radopholus similis* and amplification of rDNA viz., 18S and D2-D3 expansion region, was achieved by using two universal primers. Species specific primers were designed and tested for *Radopholus* and *Pratylenchus*. The ITS region of the black pepper isolate of *R. similis* from India was cloned and sequenced.

**Host resistance**

One hundred black pepper accessions were screened against *R. similis* and one cultivated accession (Acc. 1204), four wild accessions (Accs. 254, 348, 3283 and 3290) and four hybrid accessions (HP-39, 47, 125, 532) were resistant. Forty-five black pepper germplasm accessions were screened against *M. incognita* and all were susceptible. Nine black pepper accessions, short-listed in preliminary screening, were evaluated under field conditions. All the *R. similis* resistant lines namely, HP-39, Accs. 820, 1047 and 1204 were free from nematode infestation after 2 years of planting. Among the short-listed *M. incognita* resistant lines, only two accessions, Accs. 812 and 1090 were free from nematode infestation. Biochemical analysis of nematode tolerant lines revealed enhanced activity
of defense enzymes such as PAL, catalase, peroxidase and superoxide dismutase; acid phosphatase showed a decreased activity.

**Evaluation of antagonists**

Evaluation of 11 promising antagonistic fungi and 1 bacterial isolate (Pasteuria penetrans) for suppression of M. incognita indicated that all of them caused significant suppression of nematodes. Pochonia chlamydosporia, Fusarium sp. and Scopulariopsis sp. also significantly increased the yield of black pepper and ginger besides controlling nematodes. The optimum pH, temperature and nutrition requirements for growth and multiplication of P. chlamydosporia were determined.

Sixteen *Pseudomonas* spp. and 20 *Bacillus* spp. were isolated from rhizosphere of nematode antagonistic plants (Chromolaena odorata, Pimenta dioica, Piper colubrinum and Strychnos nux-vomica) and four unidentified bacteria were obtained from black pepper.

Five isolates of rhizobacteria (ISFR-522, 528, 658, 853 and 859) suppressing both *R. similis* and *M. incognita* were short-listed from a collection of 291 isolates based on *in vitro* tests and greenhouse screening. These isolates were screened against *P. capsici* and ISFR-658, 853 and 869 inhibited *P. capsici* in laboratory tests; these isolates were good *P. capsici* solubilizers too.

One hundred and seventy three isolates of endophytic bacteria were isolated from black pepper among which 81 isolates (from roots) were characterized using C utilization pattern, antibiotics sensitivity, production of metabolites and other biochemical tests. They were identified as fluorescent pseudomonads (12 strains), non-fluorescent pseudomonads (9 strains), *Serratia* sp. (one strain), *Bacillus* sp. (26 strains), *Arthrobacter* sp. (20 strains), *Micrococcus* sp. (6 strains), *Curtobacterium* sp. (1 strain) and 7 unidentified strains.

Fourteen isolates of endophytic bacteria were short-listed for *R. similis* suppression and colonization in black pepper roots. Among them, BP-17 (*Bacillus* sp.) and TC-10 (*Curtobacterium* sp.) followed by BP-10 and BP-35, two *Pseudomonas* isolates, consistently reduced lesion index and *R. similis* population and increased root weight and total biomass of the cuttings. BP-17, 25 and 35 were very good inhibitors of *P. capsici* too. Chitin based formulations sustained comparatively higher population of endophytic bacteria (x 10^7) even after 3 months of storage and had a better shelf-life than talc based formulations.

Based on molecular tools, four short listed endophytic bacterial isolates were identified as *Pseudomonas aeruginosa* (BP-35), *P. putida* (BP-25), *Bacillus megaterium* (BP-17) and *Curtobacterium luteus* (TC-10) by sequencing of 16S rDNA

**Insect pests**

**Pollu beetle**

**Host resistance**

Screening of 265 cultivated accessions and 167 hybrid accessions of black pepper for their reaction to pollu beetle (*Longitarsus nigripennis*) indicated that there was a wide variation in their susceptibility to the pest and the percentage of infested berries varied from 0.8 to 38.5 in the cultivars and 0.4 to 88.3 in the hybrids.

The RAPD profiles of pollu beetle resistant black pepper accessions (Accs. 816, 841 and 1114) and wild *Piper nigrum* accession (Acc. 2070) and susceptible lines (Panniyur-l and P-24) were studied. Twenty eight primers among the 30 primers tested exhibited amplification and one of the primers exhibited a distinct band for the resistant lines. Dendrogram analysis indicated that the resistant lines formed a separate cluster.

**Root mealybug**

**Distribution and biocology**

Surveys conducted in major black pepper areas in Kerala and Karnataka indicated that infestation by root mealybugs was more serious in Wayanad District in Kerala and Kodagu District in Karnataka. Six species of root mealybugs were recorded to infest black pepper vines among which *Planococcus* sp. was more common. The pest infestation resulted in defoliation, yellowing and wilting of
leaves and mortality of vines in severe cases of infestation. The fungal pathogen *P. capsici* and nematodes such as *M. incognita* and *R. similis*, were commonly associated with root mealybug infested vines.

The life cycles of *Planococcus* sp. and *P. citri* were studied. Colonies of root mealybugs were observed on banana, colocasia and turmeric rhizomes and base of stems of coffee and *Erythrina* sp. and on roots of 11 weed plants especially during summer in black pepper gardens. Evaluation of 12 fruits/vegetables/tubers for their suitability for mass culturing root mealybugs in the laboratory indicated that squash (*Cucurbita moschata*) and pumpkin (*C. pepe*) were suitable.

**Management**

Evaluation of alcoholic and water extracts of 10 plant species in laboratory assays indicated that alcoholic extracts (3%) of *Azadirachta indica* and *Vitex negundo* were more effective resulting in over 75% reduction in root mealybug population, 30 days after treatment. Evaluation of organic products in laboratory bioassays indicated that tobacco extract 3% and custard apple seed extract 2% were more promising resulting in over 85% reduction in root mealybug population, 30 days after treatment.

Evaluation of promising insecticides in the field indicated that drenching affected vines with imidacloprid 0.0125% or acetamaprid 0.0125% or carbosulfan 0.075% were promising in reducing the population of root mealybugs up to 60 days after treatment. Evaluation of promising organic products in the field indicated that drenching mildly affected vines thrice at 21 day intervals with tobacco extract 3% was more promising in reducing the population of root mealybugs.

An integrated pest management schedule involving, planting of root mealybug-free rooted cuttings in the field, removal of weeds in interspaces of black pepper vines during summer, drenching imidacloprid 0.0125% or acetamaprid 0.0125% or carbosulfan 0.075% or chlorpyriphos 0.075% on affected vines or drenching tobacco extract 3% on mildly affected vines and adoption of control measures against *Phytophthora* and nematode infections, was suggested for the management of root mealybugs.

### 4.3.2 Cardamom

**Leaf blight and rhizome rot**

**Host resistance**

The incidence of leaf blight and rhizome rot was recorded in 114 accessions of cardamom and 1 highly resistant and 14 resistant accessions were identified. Accessions with erect, semi erect panicles and glabrous leaf characters were resistant to leaf blight and those with prostrate and compound panicles were susceptible to rhizome rot.

Field reaction of 42 entries against leaf blight (*Colletotrichum gloeosporioides*) was recorded; the glabrous selections of Malabar type MA-15, MA-18 and MA-20 were moderately resistant and the compound panicle types, CP-9 and CP-2 were resistant. The land race Green Gold also showed resistant reaction.

### 4.3.3 Ginger

**Bacterial wilt**

**Etiology and characterization**

The bacterial wilt pathogen *Ralstonia solanacearum* isolated from ginger, tomato, *Chromolaena* sp., capsicum and potato from Kerala, Karnataka, Sikkim, West Bengal and Assam were characterized. The strains of *R. solanacearum* causing bacterial wilt was identified as biovar 3 or biovar 4 and the former was dominant. A method was standardized for isolation of PCR amplifiable DNA from soil and ginger plant debris. PCR based identification of *R. solanacearum* using universal *R. solanacearum* specific primer was standardized and Rep-PCR finger printing technique was standardized for strain characterization. Molecular analysis revealed that the ginger strains isolated from different locations were 100% similar according to Dice's similarity coefficient.

High molecular weight membrane protein (42.3 kDa) specific for biovar III of *R. solanacearum* was purified by native gel electrophoresis. Polyclonal antibodies were developed against the protein as
well as heat and glutaraldehyde treated \textit{R. solanacearum} cells. Western blot analysis showed that each of the developed antibody reacted with its own antigen besides reacting with the other two antigens used in the study.

Protein with molecular weights of 14 kDa was induced in root samples at 4, 24 and 48 h after inoculation with \textit{R. solanacearum} and a protein with molecular weight of 38 kDa was induced in roots 4 h after inoculation. No such induction was noticed in other tissues, which indicates that the pathogenesis related proteins are induced in root where the pathogen gains entry in to the plant. Western blot showed the presence of chitinase and glucanase isoforms in the ginger root tissues upon \textit{R. solanacearum} inoculation.

**Host resistance**

A reliable method for screening against bacterial wilt of ginger was standardized. All the available germplasm (650) including somaclones were screened for bacterial wilt resistance using soil inoculation method which did not yield any resistance types. An \textit{in vitro} selection method for bacterial wilt resistance was standardized for rapid screening of somaclones. Among the Zingiberaceae members such as \textit{Curcuma amada}, \textit{C. longa}, \textit{C. zedoaria}, \textit{C. aromatic}, \textit{Kaempferia galanga}, \textit{Elettaria cardamomum}, \textit{Zingiber zerumbet} and \textit{Z. officinale} assayed for their reaction to ginger strain of \textit{R. solanacearum} biovar 3, only \textit{C. amada} was resistant.

**Management**

Rhizome heat disinfection using solarization or microwave was standardized. When the rhizomes were exposed to microwave for a period 30 s, a rhizome temperature of 45°C was recorded. Rhizomes subjected to pulse microwaving involving 4-5 cycles of 10 s, with a pause time of 5 s between cycles, also confirmed the effectiveness of microwave disinfection. The thermal death point and thermal death time for \textit{R. solanacearum} was determined as 47°C and 30 min of continuous exposure in water suspension. The heat-treated rhizomes produced high number of sprouts (97 sprouts/kg) indicating that rhizome solarization could break the dormancy of the rhizome early.

**Soft rot**

**Etiology**

\textit{Pythium} spp. was frequently isolated from rhizome rot affected samples of ginger collected from Wayanad, Calicut (Kerala), Kodagu, Dharwad (Karnataka), Raigarh (Chattisgarh), Pottangi (Orissa), Kumaraganj (Uttar Pradesh), Sikkim and Gudalur (Tamil Nadu). \textit{Pythium} spp. and \textit{ Fusarium} spp were isolated from rhizome rot affected turmeric collected from Kumaraganj (Uttar Pradesh), Medak (Andhra Pradesh), Sikkim and Gudalur (Tamil Nadu). The pathogen causing soft rot of ginger was identified as \textit{P. myriotylum}.

Molecular analysis by ITS-PCR-RFLP placed 29 \textit{Pythium} isolates in five clusters in conformity with their identity such as \textit{P. myriotylum}, \textit{P. ultimum} var. \textit{ultimum}, \textit{P. ultimum} var. \textit{sporangiferum}, \textit{P. deliense} and \textit{P. oceans} based on morphological criteria. \textit{Pythium} spp. causing soft rot in several ginger producing states was identified as \textit{P. myriotylum} in PCR based assay using universal \textit{P. myriotylum} specific primers.

**Host resistance**

Among the 199 germplasm accessions screened against \textit{P. myriotylum}, five accessions (Accs. 6, 17, 130, 155 and 208) were promising.

**Management**

Evaluation of plant growth promoting rhizobacteria (PGPR), against soft rot disease of ginger showed that isolates \textit{IISR-13}, \textit{151}, \textit{152} and \textit{906} were effective in reducing the disease incidence to less than 5%. Seed treatment with metalaxyl-mancozeb 0.125% and soil application of the same twice along with neem cake reduced the disease incidence to less than 10%.

**Nematodes**

**Host resistance**

A root-knot nematode resistant ginger germplasm accession (Acc. 117) was released as \textit{IISR Mahima} by the State Variety Releasing Committee, Kerala, based on multi-location trials.
**Insect pests**

**Host resistance**
Four hundred and ninety five accessions of ginger were screened against shoot borer (*Conogethes punctiferalis*) and 4 accessions had less than 5% infestation; the pest infestation ranged from 5.1% to 32.0% in other accessions. Dried rhizomes of 77 accessions of ginger were screened for damage by cigarette beetle (*Lasioderma serricorne*) and rhizomes of 2 accessions were free of pest infestation.

**Management**
Evaluation of dried leaves of *Strychnos nux-vomica* and *Glycosmis cochinensis* as storage materials along with sawdust (1:1 proportion) after dipping seed rhizomes in quinalphos 0.075% for the management of rhizome scale (*Aspidiella hartii*) of ginger indicated that storage of seed rhizomes in *S. nux-vomica* and sawdust in 1:1 proportion was more effective for obtaining a higher recovery of rhizomes (74.5%), higher number of sprouts (60.5 per 1000 g) and 0 population of rhizome scale.

### 4.3.4 Turmeric

**Soft rot**

**Distribution and etiology**
Thirty five turmeric growing areas in 12 districts in southern India were surveyed for the incidence of soft rot disease. Out of 118 samples collected, 86 samples yielded *Pythium* sp. (72.9%). Pathogenicity was proved for representative isolates and the etiology of soft rot disease of turmeric as caused by *Pythium* sp. was confirmed. Among the *Pythium* species, *P. aphanidermatum* was the most frequently occurring pathogen.

**Management**
Among the 93 putative endophytic bacteria isolated from ginger and turmeric rhizomes, 19 isolates inhibited rhizome rot pathogens such as *Fusarium oxysporum*, *P. myriotylum*, *P. ultimum*, *Rhizoctonia solani* and *R. solanacearum*.

**Shoot borer**

**Damage and crop loss**
Studies on nature and symptoms of damage caused by shoot borer (*Conogethes punctiferalis*) on turmeric indicated that apart from boring into the main pseudostem at the base, the larvae also bored into the leaf petiole and entered into the central shoot. The crop loss caused by the pest infestation on turmeric under various categories of infestation was 72 g and 79 g per clump when 25–50% and 50–75% of shoots, respectively, were damaged by the pest.

**Bioecology**
Studies on pattern of distribution of shoot borer in a turmeric field by determining dispersion indices indicated that it was random during August and September and became aggregated during October to December. Mermithid nematodes were recorded as major natural enemies of shoot borer larvae in the field and the percentage of larvae parasitised by the nematode was higher during August and September.

**Host resistance**
Eight hundred and ninety five accessions of turmeric were screened against shoot borer (*C. punctiferalis*) and two accessions remained free of infestation; the pest infestation in the other accessions ranged from 5% to 75%.

### 4.3.5 Vanilla

**Viral diseases**

**Distribution and etiology**
Surveys conducted in Karnataka and Kerala showed the presence of various kinds of mosaic and necrosis with incidence ranging from 0% to 10%. Electron microscopy of survey samples revealed the association of at least four different kinds of viruses. Of these, two viruses were identified as strains of CMV and *Cymbidium mosaic virus* (CYmMV) based on biological, serological and molecular properties.

**Host range of CMV infecting vanilla was studied. A DAS-ELISA based method was developed for quick detection of the virus in plants. Sequence analyses showed that the virus belongs to subgroup IB of CMV. An RT-PCR based method was also standardized for detection of the virus in field samples.**
**Fungal diseases**

**Etiology**

Association of *Colletotrichum gloeosporioides* was consistently noticed in a disease characterized by premature yellowing and bean shedding. High temperature (>30°C) and low relative humidity (<60%) were identified as predisposing factors for the disease. A new disease of vanilla characterized by brown spot of beans caused by a fungal pathogen (*Cylindrocladium quinqueseptatum*) was also identified.

### 4.4 Social Sciences

#### 4.4.1 Production economics

The cost of cultivation for spice crops was estimated as: i. Black pepper (Rs. 36/kg) ii. Cardamom (Rs. 213/kg in Kerala and Rs. 222/kg in Karnataka) iii. Vanilla (Rs. 332/kg) iv. Ginger (Rs. 36/kg) v. Turmeric (Rs. 38/kg). The economics of coir pith compost making and its application in spices production was worked out; the production of turmeric using coir pith compost resulted in a benefit : cost ratio (BCR) of 1.27.

#### 4.4.2 Economics of low input technology

Economic analysis of low input technology for small and marginal black pepper growers in Kerala indicated that application of ½ recommended dose of fertilizers + Zn as inputs is a risk-free technology for better returns (Rs. 13,124) with lowest standard deviation and index of variability (12.51). However, large and medium farmers with enough resources to spare can opt for ½ recommended dose of fertilizers + biofertilizers for better returns and maximum marginal rate of return.

Application of FYM + ½ N and P can be recommended for small and marginal black pepper growers in Kerala, which could give higher economic benefits of Rs. 1,633,554/ha as net benefit and Rs. 12,577/ha as marginal net benefit. However, drastic price change makes the treatments FYM + ½ P + *Azospirillum* sp. and FYM + ½ N + phosphobacteria as risk-free technologies.

#### 4.4.3 Economics of on-farm processing of spices

Dried ginger after on-farm processing fetched 37.5% more returns than sale of fresh ginger. The benefit : cost ratio was 1.46 when compared to 1.13 in the case of marketing fresh ginger. Economics of on-farm processing (curing) of vanilla indicated that, sale of processed vanilla beans returned a net benefit of Rs. 54,825/q which was 49.8% more over the sale of green beans. Large farms performed better than small farms mainly because of their on-farm processing activities.

#### 4.4.4 Analysis of time series data

Time series data on area, production, productivity, export, import and prices were analysed for individual spice and spices as a whole to know the trend in area expansion, production and productivity and impact of area expansion and productivity on production, to analyse the price trend, assess the impact of world price on domestic price and fit models to estimate demand and supply.

#### 4.4.5 Trade analysis

Analysis of domestic trade indicated that almost 60% of the produce moved through the most common channel of, Producer > Village assembler > Local trader > Wholesaler > Exporter. Except in states like Kerala, where ginger is dried and marketed for export, in all other states harvested fresh ginger is marketed following the channels of vegetable marketing in the region. In some states fresh ginger is listed along with vegetables covered under market regulation.

Analysis of international trade indicated that world trade in spices was around 13,81,152 tonnes valued at US $ 25,34,461 during 2001-02. India's share in world trade in spices came down to 18.4% from more than 40.0% in the past. Spice exports from India recorded an average annual compound growth rate of 6.8%, 15.6% and 7.7% respectively, for volume, value and unit price during 1980-81 to 2003-04. Commodities like black pepper and chillies dominated the composition of export basket from India. However, in recent years, there is change in
4.4.6 Impact of WTO on Indian spice industry

Under WTO regime, the Indian spice industry in particular faced a declining trend in export. The decline was not only due to fall in prices but also due to fall in quantity exported. The country witnessed a spurt in spice imports especially in commodities like ginger, black pepper and cardamom. The estimated growth rate for individual spices before and after removal of quantitative restrictions revealed that except black pepper and cardamom, all other spices recorded a positive growth rate in terms of export volume, value and unit price. Value added products achieved the highest growth rate. The country's share in world market for spices in terms of volume and value declined especially after the removal of quantitative restriction in the WTO regime, while there was an increasing level of imports.

4.4.7 Demand and supply estimates

The status of world spice industry in general and Indian spice industry in particular was analysed in terms of year-wise production, price trend, change in consumption pattern and finally the forecasted demand and supply position for individual crops using appropriate techniques.

4.4.8 Decision support system for spices

In the process of analysing the impact of socio-ecological changes on spices production, a GIS based decision support system (DSS) for agriculture in general and spice industry in particular for Wayanad District is being built. Spatial data layers were prepared for the DSS and point data collected on socio-economic and agro-ecological data were analysed to bring out the impact on spices production in the region.

4.4.9 Economic evaluation of transferred technology

Economic evaluation of investment on soil-water conservation technology for cardamom based cropping system resulted in a BCR of 1.95, less than 2 years of pay back period and 140% internal rate of return (IRR) at individual farm level. Mass multiplication technology for biocontrol agents was economically viable with 1.84 BCR and 121 IRR on investment @ 11% for 10 years.

An investment of Rs. 14.2 lakhs over a period of 5 years in the DBT sponsored project to develop and commercialize mass multiplication techniques for *Trichoderma harzianum* for control of *Phytophthora* foot rot disease in black pepper generated a net economic surplus (social gain) of Rs. 11.41 lakhs. After 6 years of adoption, the observed maximum adoption level was 5% and the investment has returned an IRR of 19% and BCR of 2.5.

In the NATP sponsored project, a research investment of Rs. 13.27 lakhs over a period of 3 years to develop soil and water conservation measures for the cardamom based cropping system in Kodagu District returned a net economic surplus (social gain) of Rs. 28.07 lakhs with IRR of 38% and BCR of 3.4 after 7 years of adoption.

4.4.10 Databases

Two databases populated with published authentic information on spices namely, SpicesTech (crop details and technology related information) and SpicesStat (time series data on area, production, price, export-import) were developed and maintained. The Spice Database was linked to the National Data Warehouse on Agriculture at IASRI, New Delhi. Two softwares namely, Crop Stat (for storing and retrieving time series data on any crop) and Code Book (commercial profile with international commodity codes) were developed.

4.4.11 Training for development

The partnership services offered by the institute include training, consultancy and contract research. The institute offers training programmes on demand from various agencies targeted for field extension functionaries of state departments, progressive farmers and research workers of institutes and universities. The topics covered included 'Spices production technology; Nursery,
pest and disease management in major spices; Post harvest technology and Computer applications'. A total of 29 courses were offered in which 398 extension functionaries/progressive farmers participated; the beneficiaries were trained for 1,243 man-days.

Special programmes for the benefit of extension functionaries and farmers of north eastern states including Sikkim under the 'Technology Mission for Integrated Development of Horticulture in NE States including Sikkim' was conducted in Nagaland and Sikkim. A manual 'Major Spices-Production and Processing.' was also brought under the programme.

4.4.12 Agricultural Technology Information Centre

The ATIC was involved in technology dissemination through various divisions of the institute. During 2002-06, a revenue of Rs 8,61,936 was realized through sale of institute products, services and information. The sale of planting material and publications during 2006 registered an increase of 42.3% and 45.6%, respectively, compared to the past three years. The total income generated during 2006 registered an increase of 25% over the average income during the past three years. During 2002-06, 7876 beneficiaries availed advisory services from ATIC. There was an increase of 21.7% in the number of visits to the institute during 2006 compared to the past three years.

4.4.13 Audio visual aid support

A Touch Screen/Kiosk was installed with user friendly software that provides technology information to farmers. The satellite technology based Village Resource Centre Scheme sponsored by the Kerala State Planning Board was commissioned. The scheme envisages interactions between experts in identified knowledge centres and farmers enrolled in resource centres in Wayanad District through video conferencing. A film on the institute's activities and services was shot under the Karshaka Information Systems and Networking Project, Kerala in collaboration with Indian Institute of Technology Management, Calicut.

4.4.14 Bioinformatics

A Bioinformatics Centre was established with dedicated internet connectivity and hardware and software resources to initiate and support bioinformatics and biotechnology programmes in spices. Computational and information support to various R & D projects of the institute was provided by the centre which resulted in the publication of 12 research papers with bioinformatics components. Bioinformatics research in the field of comparative genomics and cheminformatics related to spices was also initiated.

Twelve databases and 10 software programmes related to spice Bioinformatics, many of which are accessible over the internet were designed, developed and made available. A Bioinformatics Library with over 100 reference books, journals, and databases was developed. Eight training programmes and three workshops were conducted during the period that was attended by 99 and 115 participants, respectively.

The institute's website 'www.spices.res.in' which is rated as one of the best sites under ICAR was designed, developed, hosted and maintained by the centre. The centre also helped several other institutions in designing their web sites. An intranet facility 'SPICENET' and e-mail facility 'Spicemail', was also developed for the benefit of the institute staff.

4.5 Krishi Vigyan Kendra

Four hundred and eighty five training programmes (315 on-campus and 170 off-campus programmes) were organised for farmers, youth and extension personnel of the district. These programmes were attended by 13,249 persons including 5,777 females and 1,311 persons belonging to socially and economically backward communities; the beneficiaries were trained for 35,782 man-days. One hundred and thirty five programmes were conducted exclusively for women benefiting 2,783 participants.

The kendra developed 21 role models and leader farmers in various agricultural related enterprises through its activities and assisted in the formation
of 138 self help groups and 2 farmers Vikas Volunteer Vahini (VVV) clubs for effective transfer of technologies. Many women self help groups have started successful enterprises in agriculture and related fields, earning additional income, resulting in their social recognition and improving their living conditions.

The Plant and Animal Health Clinic of the kendra extended timely help to farmers in crop and livestock management. The kendra treated 38,049 animals and artificially inseminated 1,630 animals during the period.

The kendra maintained 13 demonstration units in various crops and enterprises for the benefit of farmers. The kendra developed production units in nursery plants, *Trichoderma*, mushroom spawn and poultry, and materials worth more than Rs. 25 lakh were supplied to farmers. Eighteen front-line demonstrations and 15 on-farm trials were conducted and 4 farming system models were developed in farmers fields. Twelve indigenous technologies practiced by local farmers were documented.

The kendra conducted 41 field days, 17 exhibitions, 29 farmers fairs/days and 65 animal health camps during the period under report. The kendra also published 4 booklets and 96 popular articles and broadcasted 66 radio talks for the benefit of the farming community.
Technologies Developed

The institute has developed many technologies including improved varieties, nutrition management and pest and disease management especially in black pepper, cardamom, ginger and turmeric. In addition many processes in research, databases and softwares have been developed during the period of review.

5.1 Black pepper

- Development of three improved varieties of black pepper namely, IISR Girimunda, IISR Malabar Excel and IISR Thevam for adoption by farming community
- Successful Agrobacterium mediated transformation with osmotin for disease resistance in black pepper
- ISSR primers were designed for amplification of genomic DNA of Piper species
- Identification of hybrids in black pepper using male parent specific RAPD markers
- Development of a cheap, safe and efficient method for hardening of tissue cultured plants with over 90% establishment, free from nursery diseases using individual polybags and solarised potting mixture
- Foliar application of Zn (0.25%) twice, during June and August for increasing the yield of black pepper
- Application of coir pith compost @ 1.25 t/ha integrating with ½ the recommended fertilizer dose and Azospirillum sp. @ 20 g/vine for higher yield and fertility build up in black pepper gardens
- Application of half the dose of recommended fertilizers + zinc for better returns for small and marginal black pepper growers in Kerala. However, large and medium farmers with enough resource to spare, application of FYM + ½ recommended P + Azospirillum sp. or FYM + ½ recommended N + Phosphobacteria is recommended for higher returns
- Substitution of granite powder for sand in black pepper nursery mixture
- Development of a regression model for prediction of black pepper production up to 70% dependence for Kerala with monthly rainfall as predictors
- Intercropping Piper chaba (4,000 plants/ha on Glyricidia standard) in arecanut plantation for obtaining additional income of Rs. 32,400/ha and enrichment of soil by fixing atmospheric nitrogen and providing green leaf for mulching by the standard
- Development of foot rot tolerant variety (IISR-Shakthi) of black pepper
- Mass production of bacterial biocontrol agent (Pseudomonas fluorescens) against nematodes and fungal pathogens of black pepper, involving solid and liquid fermentation technologies
- Development of ELISA and PCR based diagnostics for detection of viruses infecting black pepper
- Identification of fungal biocontrol agent (Pochonia chlamydospora) for managing root-knot nematodes of black pepper
- Identification of promising rhizobacteria (IISR-853, 859) and endophytes (TC-10, BP-17) for suppressing nematodes infesting black pepper
- Identification of Radopholus similis resistant black pepper lines (C-820, HP-39).
- Molecular diagnostics for R. similis
- Integrated management of root mealybug (Planococcus spp.) involving, planting of root mealybug-free rooted cuttings, removal of weeds in interspaces of vines during summer, drenching suitable insecticides on affected vines or drenching tobacco extract 3% on mildly affected vines and adoption of control measures against Phytophthora and nematode infections

5.2 Cardamom

- Introducing contour staggered trenches in coffee and cardamom plantations for conserving soil and water
- Irrigating cardamom with drip (8 l/clump), or sprinkler irrigation for 6 h once in 12 days during summer months for increased capsule setting and yield
- Development of rhizome rot tolerant variety (IISR-Avinash)
• Development of katte resistant variety (IISR-Vijetha)
• Development of protocol for isolation of PCR amplifiable genomic DNA from dried capsules of cardamom

5.3 Ginger and Turmeric

• Development of two improved turmeric varieties namely, IISR Kedaram and IISR Alleppey Supreme
• Development of two improved varieties of ginger namely, IISR Rejatha and IISR Mahima
• Direct in vitro regeneration of plantlets from aerial stem of ginger
• Development of PCR based technique to discriminate ginger varieties using rhizome DNA for preventing unscrupulous seed trade practice, which cannot be discriminated by rhizome morphology
• Development of protocol for isolation of PCR amplifiable DNA from fresh rhizomes of turmeric and ginger
• Development of protocol for isolation and PCR amplification of DNA from turmeric powder
• Developed a novel PCR based technique to detect plant-based adulterants in marketed turmeric powder
• Development of technology for cryopreservation of encapsulated shoot buds of Piper barberi, vanilla, cardamom and ginger using encapsulation, dehydration and vitrification methods for long term conservation of germplasm
• Development of micro rhizome technology for production of disease free planting materials in ginger and turmeric
• Application of 6 kg ha⁻¹ of Zn for getting optimum yield based on cubic response model
• Fabrication of zero energy chamber (a double walled brick structure filled with sand between the walls frequently moistened with water) for storing fresh ginger
• Development of technology for rhizome heat treatment by solarization for disinfection of Ralstonia solanacearum on ginger rhizomes
• Development of ELISA and PCR based detection of Ralstonia solanacearum in ginger rhizomes and soil
• Integrated management of rhizome scale (Aspidiella hartii) of ginger by discarding severely infested rhizomes, dipping in quinalphos 0.075% and storing rhizomes in dried leaves of Strychnos nux-vomica and sawdust in 1:1 proportion

5.4 Tree spices

• Development of improved nutmeg variety namely, IISR Viswashree
• Standardization of softwood grafting of Myristica fragrans on M. malabarica and M. beddomeii rootstocks
• Standardization of softwood grafting of Garcinia gummi-gutta on its own rootstock and on G. indica rootstock
• Development of protocol for PCR amplifiable DNA from Myristica fragrans and nine other wild and related genera of Myristica

5.5 Vanilla

• Development of ELISA and PCR based diagnostics for detection of viruses

5.6 Databases

• Spice Genes-Part 1: Black Pepper: A database of black pepper germplasm resources available at IISR. Available online as well as CDs (http://www.iisr.org/germplasm/index.htm)
• Spices Genes-Part 2: Curcuma Species: An offline database on various Curcuma species
• Spices Genes-Part 3: Myristica Species: A database of different Myristica species and nutmeg germplasm
• Spice Prop: A database of micro propagation protocols for spices, developed by IISR
• Chitinase database: An online database.
• PAL database: An enzyme database of phenylalanine ammonia lyases
• Piperbase: A database of Piper species of India that includes botany, taxonomy, agronomy, biochemistry and medicinal properties of various Piper species
• Spicepat: A database on all patent information related to spices developed using Visual Studio dot Net
• Phytophthora Information Resource (PIR): A comprehensive web resource for the Phytophthora species
• CardCC & Mpbase: A cheminformatics database on chemical compounds in cardamom
• PhyDisH: A database on Phytophthora diseases of horticultural crops in India. It also includes searchable information on Phytophthora cultures maintained in the Institute repository
• SpiceTech: A database on spice crop details and technology related information
• SpiceStat: A time series data on area, production, price, export-import

5.7 Softwares

• SOILLAB: A soil test based fertility classification and fertilizer recommendation for major spices crops
• Phytfinder: An expert system for identification of Phytophthora species based on morphological characters
• Restalizer and Translator: A software to find out restriction sites in a nucleotide sequence and to predict the amino acid sequence from a nucleotide sequence
• Disect 2000: A software for laboratory management
• Agtrgscan: A software for monitoring various training programmes organized by agencies

5.8 Adoption of technologies

Since one of the mandates of the institute is to monitor the adoption of new and existing technologies, this may be taken up on a priority in the next Plan period. The institute may also utilise the services of KVK and ATIC to study the status of adoption of technologies.
The institute has linkages with many national institutions and universities. Many universities have recognized the institute as a centre for post graduate studies. The institute has also linkages with other ICAR Institutes and SAUs and many collaborative research projects have been taken up. Besides, the institute has good linkages with developmental agencies such as Spices Board, Directorate of Arecanut and Spices Development and State Department of Agriculture and Horticulture of Kerala, Karnataka and Tamil Nadu. A few institutions with which the institute has linkages and the nature of linkages have been listed below.

<table>
<thead>
<tr>
<th>Agency</th>
<th>Areas of collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Calicut, Calicut</td>
<td>Centre for Post Graduate studies; Teaching MSc Biotechnology students</td>
</tr>
<tr>
<td>Bharathiyar University, Coimbatore</td>
<td>Centre for Post Graduate studies</td>
</tr>
<tr>
<td>Mangalore University, Mangalore</td>
<td>Centre for Post Graduate studies</td>
</tr>
<tr>
<td>Nagarjuna University, Nagarjunasagar</td>
<td>Centre for Post Graduate studies; Teaching and training MSc Biotechnology students</td>
</tr>
<tr>
<td>Tamil Nadu Agricultural University, Coimbatore</td>
<td>Centre for Post Graduate studies</td>
</tr>
<tr>
<td>National Institute of Technology, Calicut</td>
<td>Teaching and training MTech students in Bioinformatics</td>
</tr>
<tr>
<td>DOEAC Centre, Calicut</td>
<td>Maintenance of institute web-site and office automation</td>
</tr>
<tr>
<td>Indian Agriculture Research Institute, New Delhi</td>
<td>Electron microscopy</td>
</tr>
<tr>
<td>National Bureau of Plant Genetic Resources, New Delhi</td>
<td>Collection and conservation of germplasm</td>
</tr>
<tr>
<td>National Bureau of Agriculturally Important Microorganisms, Mau</td>
<td>Evaluation and conservation of microorganisms</td>
</tr>
<tr>
<td>Project Directorate on Cropping Systems Research, Modipuram</td>
<td>Network project on organic farming</td>
</tr>
<tr>
<td>Central Research Institute for Dryland Agriculture, Hyderabad.</td>
<td>Network project on climate change</td>
</tr>
<tr>
<td>Central Plantation Crops Research Institute, Kasaragod.</td>
<td>Maintenance of germplasm; library networking</td>
</tr>
<tr>
<td>National Research Center for Cashew, Puttur</td>
<td>Library networking</td>
</tr>
<tr>
<td>National Centre for Agricultural Policy, New Delhi</td>
<td>Project monitoring and evaluation</td>
</tr>
<tr>
<td>Centre for Water Resources Development and Management, Calicut</td>
<td>Biosynthesis of pigments</td>
</tr>
<tr>
<td>Kerala Agricultural University, Thrissur</td>
<td>Evaluation of tissue cultured plants</td>
</tr>
<tr>
<td>Spices Board, Kochi</td>
<td>Cardamom and vanilla research; training programmes</td>
</tr>
<tr>
<td>Directorate of Arecanut and Spices Development, Calicut.</td>
<td>Planting material production; training programmes</td>
</tr>
<tr>
<td>Departments of Agriculture/ Horticulture</td>
<td>Transfer of technology; training programmes</td>
</tr>
</tbody>
</table>
The KVK has linkages with several organizations including NGOs and the important institutions with which the KVK has linkages and the nature of linkages have been listed below:

<table>
<thead>
<tr>
<th>Agency</th>
<th>Areas of collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency for Non-conventional Energy and Rural Technology, Trivandrum</td>
<td>Technology of smokeless chula and supply of solar light for demonstration</td>
</tr>
<tr>
<td>SERIFED, Trivandrum</td>
<td>Information on sericulture, supply of mulberry and silkworm seed</td>
</tr>
<tr>
<td>Centre for Water Resources Development and Management, Calicut</td>
<td>Technology on watershed management</td>
</tr>
<tr>
<td>Coconut Development Board, Kochi</td>
<td>Technology on value addition in coconut products</td>
</tr>
<tr>
<td>Kerala Livestock Development Board, Trivandrum</td>
<td>Training of KVK staff</td>
</tr>
<tr>
<td>MANAGE, Hyderabad</td>
<td>Training of KVK staff on extension technology</td>
</tr>
<tr>
<td>Indian Agricultural Research Institute, New Delhi</td>
<td>Technology on Zero Energy Cooling Chamber</td>
</tr>
<tr>
<td>National Institute of Technology, Calicut</td>
<td>Landscaping technology</td>
</tr>
<tr>
<td>State Department of Agriculture</td>
<td>Training programmes, watershed development, selection of beneficiaries under FLD and OFT programmes, implementation of development schemes of KVK</td>
</tr>
<tr>
<td>State Department of Animal Husbandry</td>
<td>Training programmes, animal health camps, campaigns against disease outbreaks in animals, supply of piglets and chicks of improved breeds</td>
</tr>
<tr>
<td>State Department of Fisheries</td>
<td>Training programmes, selection of KVK beneficiaries for fishery related activities, supply of fingerlings</td>
</tr>
<tr>
<td>Kerala Livestock Development Board, Trivandrum</td>
<td>Supply of frozen semen for artificial insemination programme, supply of fodder seeds/sets</td>
</tr>
<tr>
<td>MATSYAFED, Calicut</td>
<td>Financial assistance to KVK beneficiaries</td>
</tr>
<tr>
<td>Farm Information Bureau, Calicut</td>
<td>Organising farmers’ seminars, kisan melas, etc.</td>
</tr>
<tr>
<td>Department of Industries, Govt. of Kerala</td>
<td>Organization of vocational training programmes for handicapped youth</td>
</tr>
<tr>
<td>Govt. Polytechnic College, Calicut</td>
<td>Organization of vocational training programmes for youth</td>
</tr>
<tr>
<td>National Agricultural Board in Agriculture and Rural Development, Trivandrum</td>
<td>Funding of Vikas Volunteer Vahini clubs formed by KVK</td>
</tr>
</tbody>
</table>

In addition the KVK has linkages with local NGOs such as Central for Overall Development, Tharassery; Nehru Yuva Kendra, Calicut; Integrated Development Centre, Thamarassery; National Yuvak Co-operative Society, Calicut; Socio-Economic Unit, Calicut; and Indian Farmers Movement, Calicut.
7 Future Projections and Programmes

7.1 Challenges facing spice industry

Spices and condiments have long been an integral part of the culture and trade of mankind since time immemorial. India held a predominant position in spices production and trade which is fast changing in the last few decades. Several countries like Brazil, Guatemala, Indonesia, Vietnam, Malaysia, Sri Lanka, and China have established their strong presence in international trade of spices. Many countries have even overtaken India in production, productivity and trade. Added to this are the consequences of globalisation and the effects of various international agreements entered into under the GATT/WTO regime. With the steady removal of trade barriers, the challenge is only bound to increase.

India has to make conscious and sustained efforts even to maintain its position as the leading exporter of spices in the world. This can be done only by making available quality spices at competitive prices, trading organic spices, developing market intelligence coupled with aggressive marketing, developing geographical indicators and branding Indian spices.

Reduction of suitable areas and water resources for spices cultivation are also important factors to be taken into consideration. Climate changes have also led to reduced soil fertility and increased disease incidence resulting in reduced yields and quality. This coupled with non-availability of cheap farm labour for cost effective production of spices are challenges being faced by the country.

However, India possesses many innate advantages over all the other spice producing countries - its large area and varied soil and climatic conditions. The major handicaps that Indian spices face in the international market are the high cost of the product and high level of microbial and pesticide contamination. India will need to make concerted efforts for producing clean spices at competitive prices. Considerable efforts will have to be made to improve post harvest processing, value addition and storage systems and educating the farmers and traders in handling the produce hygienically and to make spice farming remunerative.

7.2 Major thrust areas

The major thrust areas identified to overcome the challenges facing spice cultivation and industry include:

- Conventional and biotechnological approaches for development of varieties having high yield and resistance to biotic and abiotic stresses
- Development of integrated pest, disease and nutrient management schedules which are environment friendly and ecologically sound
- Generation of high quality and disease-free planting materials of released varieties and elite genotypes
- Development of production technologies for spices and spices based cropping systems for the production of organic and eco-spices
- Characterization of spices growing soils and assessing soil quality for developing soil based agro-techniques including rhizosphere and water requirement for sustainable spices production
- Value addition through isolation and characterization of bioactive principles in spices and post harvest technology of spices with emphasis on product development and product diversification
- Cost reduction and automation in spice farming
- Concerted efforts to popularize technologies among end users

7.3 Future programmes

- Improving productivity, development and
adoption of integrated pathogen, pest and nutrient management, wholesome post harvest practices coupled with value addition are the three key factors for the future of both domestic and international spice trade and should be the most important goal of spices research and development.

- The institute has the largest germplasm collection of black pepper, ginger and turmeric. It has also been identified as the nodal agency for germplasm exchange as far as spices are concerned. In order to function effectively as the centre for collection, conservation, documentation and exchange of germplasm, the National Repository of Spices Germplasm may be strengthened with sufficient infrastructure facilities. Conservation of germplasm in in vitro repositories is an effective and safe way of conserving vegetatively propagated spices. The In Vitro Gene Bank with sufficient manpower and infrastructure needs to be strengthened on a priority basis. The feasibility of in situ conservation of germplasm should also be explored.

- A large collection of spices germplasm is maintained at a huge cost and workload. A good beginning on molecular characterisation has been made and molecular profiling of about 100 collections each in black pepper, cardamom, ginger, turmeric and about 50 lines of vanilla has been completed. This has to be extended to all the remaining genotypes (about 3,000 in black pepper, 400 in cardamom, 1,000 in turmeric and 800 in ginger). The molecular data for the remaining genotypes at least in black pepper and cardamom should be generated and this coupled with the morphological data already available can be used to short list core collections which should be safely conserved for future utilisation.

- All the released and promising varieties and genotypes with unique characters must be finger printed and registered. Attempts may be made to develop barcodes for important and unique genotypes and species.

- GIS has tremendous potential for genetic diversity estimation and identifying ecological niches for in situ conservation. GIS coupled with remote sensing data also helps in predicting newer areas suitable for spices cultivation. The good beginning made in this direction may be intensified.

- Gene tagging, especially for quantitative trait loci (QTLs), biotic and abiotic stresses, will help in marker assisted selection (MAS). Molecular profiling of about 100 collections each in black pepper, cardamom, ginger, turmeric and about 50 lines of vanilla, 10-20 lines of cinnamon, garcinia, nutmeg and clove has already been done. A mapping population has been developed for preparing molecular maps in black pepper and about 200 polymorphic markers scored. Populations have been assembled for tagging genes by association mapping in black pepper and cardamom. The additional data required may be generated and MAS technology made available for black pepper and cardamom by the end of the XI Plan period.

- Biotechnology has an important role in spices research. It is necessary to strengthen this unit considerably for tackling the problems in black pepper, ginger and cardamom. Sufficient linkages should be built up with other national/international organisations in the field. Though reasonable linkages with a few national laboratories have been established, the institute is handicapped by restrictions in collaboration especially with the best laboratories abroad. This may be relaxed for improving the exposure, calibre and standards of scientists.

- Use of markers for detecting adulteration and standardising geographical indicators is a good approach which need to be taken to its logical end by the end of this Plan period.

- Climatic change is drastically altering the environment including rainfall patterns in all spice growing regions. Some spice crops like black pepper and cardamom grown primarily in forest ecosystems are greatly affected by this climate change. The effect of the changes on performance of genotypes may be monitored
with the objective of identifying better performers in changed climate conditions and adequate facilities may be provided to undertake such studies.

- In view of the changing climate, water will be a limiting factor in future. Studies on drought resistance and tolerance may be given high priority in black pepper and cardamom. Various agronomic practices to mitigate water shortage may be tried to identify cost effective technologies for drought management. Basic studies and evaluation of drought resistance has to be taken up as a priority.

- The demand for organic products is increasing in the western markets at about 20% every year. IISR may strengthen research in organic farming in black pepper, cardamom, ginger and turmeric. Use of vermicompost and farmyard manure/compost/oil cakes/green manure in INM may be encouraged. Linkages may be developed with Spices Board in this aspect since it is the nodal agency to promote organic farming in spices in the country.

- Programmes on biological nutrient management in black pepper may be intensified, especially on microbial diversity and community structure in the rhizosphere and soils of black pepper. This would help in identifying strains of microbes beneficial for enhancing soil nutrient availability for black pepper. It is also important to understand the effects of applied biocontrol agents on populations of indigenous beneficial bacteria, which commonly occur in the rhizosphere. These studies will aid in formulating INM packages utilizing beneficial microbes.

- Mixed cropping systems involving herbal and medicinal plant gardens may be encouraged to increase the income per unit area. In addition this also enhances the role of women in spices cultivation and contributes to enhanced general health of community.

- Quality of produce is one of the most important factors for spices export. Breeding programmes must concentrate on genotypes with high quality parameters, especially high β-caryophyllene in black pepper, high zingiberene and shagoals in ginger, high α-terpinyl acetate in cardamom and high cinnamaldehyde in cinnamon, in addition to yield trait.

- A majority of the spices and their active principles are excellent antioxidant nutraceuticals which play a significant role in the prevention of a number of age-related diseases. IISR may initiate studies on the identification and characterization of these bioactive components in spices, with a long term objective of inclusion of these constituents in various drug formulations. Exploitation of natural food colours in spices is also an area worth exploring. Programmes may be initiated to isolate the natural colour components in potential spice crops.

- Research on post harvest technology and product diversification needs immediate attention. Cost effective primary processing technologies for important on-farm operations like harvesting, grading, packaging and storage which can improve the quality of the produce may be developed in collaboration with CSIR laboratories. Studies on mechanization of farm operations may also be initiated. Equally important is indigenous technology to develop new products.

- The institute has done commendable work on Phytophthora of black pepper specifically on etiology, epidemiology, disease resistance and management. A large collection of Phytophthora isolates from various crops are also available. Infrastructure especially for molecular aspects and also long term storage of cultures need to be established. In view of the importance of the pathogen, international linkages should be established for effective interaction with leading laboratories in the world.

- As a component of integrated pest and disease management of spices, biocontrol is a major input for pesticide residue free product. Though a number of biocontrol agents have been identified against major pests, nematodes and pathogens of black pepper, cardamom, ginger
and turmeric, facilities are not available for their maintenance, mass multiplication and distribution. These biologically important microorganisms are also to be characterised, patented and utilised. Hence adequate facilities for these studies may be built up.

- A good beginning has been made in developing diagnostic kits for identifying a bacteria and viruses infecting spice crops. Concerted efforts may be made to develop reliable and cheaper diagnostic kits for all the major pathogens including nematodes of black pepper, cardamom, ginger and turmeric. The proposed centre for virus diagnostics and quality testing partially funded by DBT is a good beginning in this direction.

- Production and distribution of quality disease free planting material is the most important input in increasing production and productivity in spices. The facility at the institute may be strengthened with funds and inputs from Horticulture Mission. Protected mother gardens of improved varieties need to be built in black pepper and cardamom and scion banks in tree spices. The planting materials should be fortified with efficient biocontrol agents at the nursery level. This programme may be supplemented by encouraging the certified nurseries and biocontrol units in farmer’s fields in different regions.

- The north eastern India provides excellent opportunities for expanding and developing spices cultivation in the region. Production, processing, adoption and marketing constraints of spices in north eastern hill states should be studied critically and promotion programme need to be prepared and executed in the next Plan. Collaboration with Spices Board, ICAR Research Complex at Shillong, CPCRI Research Centers at West Bengal and Assam may help in bridging the gap. Improved varieties of ginger and turmeric may be introduced in larger scale in the region. Arecanut and tea-based cropping systems may be used to introduce black pepper in this region.

- Though the institute has developed many technologies including improved varieties, nutrition management and pest and disease management especially in black pepper, cardamom, ginger and turmeric, information on the extent of adoption of the technologies in various spice growing regions of the country is not available except in a few cases. Since one of the mandates of the institute is to monitor the adoption of new and existing technologies, this may be taken up on a priority in the next Plan period. The institute should utilise the services of KVK and ATIC in popularization of technologies. Front-line demonstrations need to be organized through AICRP centres for effective transfer of technologies. Frequent farm/scientist/industry/development agency interfaces will also help in this regard.

- The research efforts of the institute must be complimented with the efforts of AICRP on Spices, SAUs, DASD and Spices Board. The mandates of each agency should be clearly understood to avoid duplication of work. It is also important to utilise the expertise and resources at RRLs, APEDA, NABARD and National Horticulture Mission and various Departments of Agriculture/ Horticulture in a synergistic effort for aggressive production, product development, market and trade strategies.

- The KVK should focus on the following programmes for overall development of farmers in the district: development of farming system models in farmers fields; promotion of enterprises in agriculture and related fields for self employment and additional income generation; integration of agricultural enterprises for livelihood security for socially weaker sections; dissemination of viable and economically feasible technologies; breed improvement of farm animals including poultry, using frozen semen and embryo-transfer technology; promotion of low-cost feed technologies for adoption of livestock based enterprises; and promotion of technologies for safe disposal of farm and livestock wastes.

- With globalisation and increased
competitiveness in international trade, development of databases and market intelligence become an important input for predictions and directions to obtain remunerative prices.

- In general the motto of next Plan period must be to excel. This requires highest level of HRD at all levels - administrative, technical, and scientific. Phased training programmes need to be obtained in improving the quality of personnel to meet the requirement of globalized and technology savvy world.

- Access to information is an important input in any activity of excellence. The bioinformatics and the library facilities of the institute may be integrated into National Informatics Centre for Spices with state of art facilities. Emphasis may be given for development of a digital library including electronic collection and digitizing the most consulted reference sources for which appropriate softwares and CD-DVD mirror servers may be procured. The library website has to be further developed as a gateway to information resources available in the library. A 'nation wide open access movement' should be developed and linkages strengthened with similar institutes in sharing their institute repositories.
8 Resources and Organisation

8.1 Manpower requirement

The overall research output of the institute is impressive. The institute has proposed numerous ambitious programmes to tackle issues related to improvement of spices especially for pest, pathogen and drought resistance and quality, and various production and management related problems. However, sufficient scientific and technical manpower is needed to fulfil the desired objectives and to achieve the set goals. The sanctioned scientific cadre strength of the institute has remained unchanged at 41 both during IX and X Plan periods.

Though the institute has progressed very well in the field of Crop Improvement and Biotechnology, there is no sanctioned post of Head, Crop Improvement. Hence, there is an urgent need to create the post at the headquarters at Calicut. The QRT also feels that additional manpower is required in Entomology, Plant Pathology, Computer Applications, Bioinformatics and Food Technology/Post Harvest Technology in the grade of Senior Scientist. A post of Instrumentation Engineer in the grade of Senior Scientist is also required at Calicut for maintenance and repair of sophisticated equipments available at the institute. A Principal Scientist position in Plant Breeding/Horticulture is required at Cardamom Research Centre, Appangala, to carry out various research activities envisaged in the next Plan period and also to head the station when it is upgraded as a Regional Station. Similarly, another Principal Scientist position in Plant Breeding/Horticulture would be required when a new Regional Station of IISR is sanctioned in the north eastern region.

In administration also, the institute is managed by an Assistant Administrative Officer and the institute handles a large number of externally funded projects besides regular institute projects. This puts lot of strain on the lone Assistant Administrative Officer and there are no senior positions in administration such as Administrative Officer/Senior Administrative Officer. Hence the QRT recommends sanctioning of two administrative positions, one at Calicut (Administrative Officer) and another at CRC, Appangala (Assistant).

8.2 Infrastructure facilities required

8.2.1 Equipments

The institute has built up excellent instrumentation facilities over the years to cater to the needs of research. Facilities in terms of equipments are comparable with any prestigious institute in the country or abroad. But some of the existing equipments are very old and need replacement and some new equipments are needed to carry out the envisaged programmes. Hence, the QRT recommends the purchase of the following equipments during the next Plan period:

- Autoradiography and radioactive facility
- Herbarium facility
- Automated protein purification unit
- Liquid chromatography mass spectrometer
- Gas chromatograph
- Atomic absorption spectrophotometer with graphite analyser
- Liquid chromatograph mass spectrophotometer
- Atomic absorption spectrophotometer with graphite analyser
- Infra red spectrophotometer
- Spectrofluorimeter
- CHNS analyzer
- Anion analyzer
- Stereomicroscope
- High and ultra speed refrigerated centrifuges-Floor model
- Deep freezer
- PCR / Real Time PCR units
- Microwave digester
- Denaturing gradient gel electrophoretic unit
- BIOLOG System
- Internet connectivity and wide area networking of all three centres
- Computers/servers for office automation at all three centres
• Pre-cleaners, separators and driers for post harvest processing
• Cryo grinding and super critical extraction unit
• Solar water heating system

8.3 Buildings

8.3.1 Calicut

A new building is under construction to house the library at Calicut. There is also a proposal to construct a new administrative building during the XI Plan. As post harvest technology is an emerging area of research, it has to be strengthened. The institute has also identified several antagonists for the management of pests and diseases of various spice crops. However adequate facilities are not available for their mass multiplication, quality evaluation and distribution. Various research laboratories of molecular biology and biotechnology are scattered and congested and have to be integrated into a common unit. The institute also draws considerable visitors such as students, researchers and farmers and adequate space is not available in the ATIC for housing various live and preserved specimens of spices and also exhibits of significant achievements and technologies transferred of the institute.

Hence, the QRT recommends the construction of Post Harvest Technology Block, Biocontrol Production Unit, Molecular Biology and Biotechnology Block and Spice Museum at Calicut. The Project Coordinator’s (Spices) office is also housed in the main laboratory building which is very congested and insufficient to keep records and samples received from centres for analysis. Hence the QRT strongly feels the need for a separate and spacious Project Coordinator’s Office.

8.3.2 Peruvannamuzhi

Residential quarters are under construction at Peruvannamuzhi. A new office building is also coming up at Peruvannamuzhi. Since it is proposed to post more scientists at Peruvannamuzhi for development of the farm, the QRT proposes that additional facilities such as residential quarters and scientists hostel may be provided.

8.3.3 Appangala

Since the entire Kodagu District is of tourist interest, getting satisfactory accommodation becomes very difficult especially during the peak tourist season at Appangala, for scientists and trainees who visit the centre. Hence, the QRT feels the necessity of construction of a Training cum Scientists Hostel at CRC, Appangala.

8.4 Vehicles

The minibus, jeep and staff car available at the headquarters are more than 10 years old leading to frequent repairs and high expenditure for their maintenance. The QRT feels that the existing vehicles should be replaced and a new bus/minibus is essential at the headquarters and also at KVK, Peruvannamuzhi, for comfortable transportation of staff to the farm and farmers for training programmes.

8.5 Human Resource Development

The scientists of IISR are aware of modern research methodologies and techniques and have adopted them for implementation of the project objectives. However, advanced training in reputed laboratories in specific fields would lead to better research output and successful implementation of the envisaged programmes with desired goals. Hence QRT suggests advanced training for scientists in the following institutions:

8.6 Land

8.6.1 At Chelavoor (Calicut)

The present area of the headquarters of the institute at Chelavoor (Calicut) is only 17.4 ha. The institute is facing acute shortage of land for further expansion of physical facilities (laboratory, administrative and other buildings) and for essential field experimentation. The QRT suggests that the ICAR/IISR may approach the Kerala Government to make available at least 25 ha additional land preferably contiguous to the existing land to meet the increased demand.
<table>
<thead>
<tr>
<th>Specific skills and techniques required</th>
<th>Training institutions proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced training in molecular biology</td>
<td>Institute of Plant Biology, University of Zürich, Switzerland; IPGRI, Italy</td>
</tr>
<tr>
<td>Advanced training in conventional and molecular breeding</td>
<td>Department of Molecular and Cell Biology, University of California, USA</td>
</tr>
<tr>
<td>QTL mapping and conventional and map based cloning</td>
<td>University of Texas, University of California, and Cornell University, USA</td>
</tr>
<tr>
<td>Advanced training in molecular sequencing and mapping, transgenic expression tools and techniques</td>
<td>Institute of Molecular Plant Sciences, Leiden University, Netherlands</td>
</tr>
<tr>
<td>Development of crop management strategies; Advanced techniques in conservation and utilization of germplasm</td>
<td>Rothamsted Agricultural Experiment Station, UK</td>
</tr>
<tr>
<td>Advanced training on crop modelling and drip irrigation</td>
<td>Rothamsted Experimental Station, UK; International Water Management Institute, Sri Lanka; Iowa State University, USA; University of Florida, Gainesville, Florida, USA</td>
</tr>
<tr>
<td>Advanced techniques on nutrient and quality analysis</td>
<td>Institute of Plant Nutrition and Soil Science, Braunschweig, Germany</td>
</tr>
<tr>
<td>Advanced techniques on quality analysis and molecular biology</td>
<td>School of Biological Sciences, University of Surrey, UK; Centre for Plant Biochemistry and Biotechnology, University of Leeds, UK; Centre for Plant Cell Biology Riverside, UK</td>
</tr>
<tr>
<td>Advanced training on chromatographic and spectral techniques</td>
<td>Nottingham University, UK; Purdue University, UK</td>
</tr>
<tr>
<td>Advanced training on processing, storage and value addition</td>
<td>Department of Food Science &amp; Technology, University of Reading, UK; Victoria University of Technology, Melbourne, Australia</td>
</tr>
<tr>
<td>Identification, characterization, diagnostics and development of disease management strategies</td>
<td>Scottish Crop Research Institute, Scotland, UK; Natural Resource Institute, UK</td>
</tr>
<tr>
<td>Identification, characterization, diagnostics and development of nematode management strategies</td>
<td>North Carolina State University, Raleigh, USA; Commonwealth Institute of Parasitology, UK</td>
</tr>
<tr>
<td>Development of insect pest management strategies through biological control</td>
<td>International Institute of Biological Control, UK</td>
</tr>
<tr>
<td>Modern statistical tools including GIS</td>
<td>United Nations Statistical Institute for Asia and Pacific, Chiba, Japan; Statistical Science Centre, University of Reading, UK</td>
</tr>
<tr>
<td>Resource economics/optimization</td>
<td>University of Cambridge, UK; University of Vermont, USA</td>
</tr>
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</table>

| 8.6.2 At Appangala                                                                                      |

The present area of CRC, Appangala, is only 17.4 ha. This is inadequate to meet the present requirements since cardamom is raised as an under storey crop under forests and only a fraction of the gross area is available for cultivation. Moreover a duplicate set of germplasm available at Peruvannamuzhi may have to be maintained at Appangala. The QRT suggests that the ICAR/IISR
may approach the Karnataka Government to make available at least 25 ha additional land preferably contiguous to the existing farm to augment the land facilities at Appangala to meet the increased demand.

8.7 Development of IISR Experimental Farm, Peruvannamuzhi

The present area of the farm is 94.6 ha. Almost all the field experiments are laid out in this farm. Presently, 3 scientists (Horticulture and Crop Processing) and 12 technical staff are posted at the farm. The farm is beset with several problems such as constant attack from wild animals, excessive weed growth, poor and uneven crop stand, and inadequately maintained farm roads and buildings. The infrastructure facilities available include an old office, agricultural produce storage shed, canteen, and residential quarters. The farm is 51 km away from Chelavoor and the scientists are expected to visit the farm by the institute vehicle that runs three times a week. To improve the overall condition of the farm the QRT suggests the following:

a. Post at least 3 scientists in the divisions of Crop Improvement, Crop Production and Crop Protection on rotation to the farm. Ensure that all scientists at Calicut visit the farm thrice a week and also stay in the farm when important field operations are in progress. For providing minimum convenience to the scientists, the QRT proposes that ICAR/IISR provide additional facilities such as residential quarters, scientists hostel and recreation facilities at the Peruvannamuzhi Farm.

b. Make concerted efforts to make the farm free of all wild animals which cause widespread damage to experimental fields and seed plots. The institute may take the advice of scientists specialized in Wildlife Management at KFRI, Peechi, and Forestry College, KAU, Vellanikkara, for the same.

8.8 Development of watersheds

Adequate supply of water is essential for the laboratories throughout the year and the experimental fields during the post monsoon and summer seasons. Since the rains are becoming errant year by year it is imperative to develop water harvesting structures and water sheds to meet this growing need. Hence the QRT suggest that suitable measures may be undertaken for the development of water sheds at Calicut, Peruvannamuzhi and Appangala.

8.9 Up-gradation of CRC, Appangala

The Cardamom Research Centre at Appangala which was a Research Centre of Central Plantation Crops Research Institute, Kasaragod, was merged with the National Research Centre for Spices (the present IISR) during 1986. The centre mainly conducts research on cardamom and also to a limited extent on black pepper and tree spices. The centre may be upgraded as a Regional Station with necessary manpower and facilities to intensify research on cardamom and other crops as envisaged in the next Plan period.

8.10 Regional Station at north eastern region

Various spice crops such as black pepper, ginger, turmeric and tree spices are grown in the north eastern region. There is also great potential to increase the area and productivity of these crops. But there are many problems in cultivation and marketing of spices in the region. Hence, there is an urgent need to start a Regional Station of IISR in the north eastern region to overcome the problems in cultivation of these crops and to tap the potential available in the region.
9 Summary and Recommendations

Scientific

Crop Improvement and Biotechnology

9.1 IISR has the largest germplasm collection of black pepper, ginger and turmeric. It is also identified as the nodal agency for germplasm exchange in spices. In order to function effectively as the national centre for collection, conservation, documentation and exchange of germplasm, the National Repository of Spices Germplasm may be strengthened with the following infrastructure facilities: net-houses with e-jet irrigation (for multiplication and conservation of collections), green house with humidity control (for conserving unique collections and high elevation species), and electric fencing of germplasm conservatories (to protect from wild animal attack).

9.2 Most of the black pepper growing areas and forests in South India have been explored so far. However, explorations may be carried out in the following areas that are yet to be explored:

Kerala: Shendurney Wildlife Sanctuary, parts of Kulathupuzha, Goodrical Forest Range, coastal regions of Alleppey District, Perumbavur, Kunnathunadu, Vellidioppara, Arakulam in Ernakulum District, and parts of Kasaragod District.

Karnataka: Karwar, Bababudin hills, Yelapur, Bandipur, Bhadraavati, Kudermukh.

Tamil Nadu: Kolli hills, Kodaikanal, Yercaud and Shevaroy hills.

9.3 Conservation of germplasm in in vitro repositories is an effective and safe way of conserving vegetatively propagated spices. The in vitro gene bank needs to be strengthened with sufficient manpower on a priority. A technical assistant (T3) may be provided on permanent or on contract basis with a contingent funding of Rs 50,000/- per year. The feasibility of in situ conservation of germplasm should also be explored.

9.4 A large collection of spices germplasm is maintained at a huge cost and work load. A good beginning on molecular characterisation has been made and molecular profiling of about 100 collections each in black pepper, cardamom, ginger, turmeric and about 50 lines of vanilla has been completed. This has to be extended to all the genotypes (about 3,000 in black pepper, 400 in cardamom, 1000 in turmeric and 800 in ginger). The molecular data for the remaining genotypes at least in black pepper and cardamom, should be generated and this coupled with the morphological data already available can be used to short-list core collections. This may be undertaken with external/contingent funding and the core collections should be safely conserved for future utilisation.

9.5 All the released and promising varieties and genotypes with unique characteristics must be finger printed and registered. Attempts may be made to barcode important and unique genotypes and species. The crop-wise priority for undertaking this work can be in the following order: black pepper, cardamom, ginger, turmeric, nutmeg, garcinia, clove, cinnamon and vanilla.

9.6 GIS has tremendous potential for genetic diversity estimation and identifying ecological niches for in situ conservation. GIS coupled with remote sensing data also help in predicting newer areas suitable for spices cultivation. The good beginning made in this direction may be intensified.
Gene tagging, especially for QTLs, major biotic and abiotic stresses, will help in marker assisted selection (MAS). Molecular profiling of about 100 collections each in black pepper, cardamom, ginger, turmeric and about 50 lines of vanilla, 10-20 lines of cinnamon, garcinia, nutmeg and clove has already been done. A mapping population has been developed for preparing molecular maps in black pepper and about 200 polymorphic markers scored. Populations have been assembled for tagging genes by association mapping in black pepper and cardamom. The additional data required may be generated and MAS technology made available for black pepper and cardamom by the end of the XI Plan period.

Developing black pepper varieties resistant to Phytophthora, nematodes, pollu beetle and drought, katte and drought resistance in cardamom, rhizome rot resistance and low fibre content in ginger and high curcumin content in turmeric should be given a high priority.

Black pepper cultivars that mature early like Arakulam munda may be used as parents in breeding programmes to develop varieties to reduce the period and time of harvest in black pepper. The cardamom genotypes with synchrony in flowering may also be used in breeding programmes to synchronize the period of flowering and harvesting.

In breeding and developing new varieties, survey and selection should be given a high priority and a core group comprising of breeders, horticulturists, physiologists and plant protection scientists should be constituted to undertake the work.

Developing novel genotypes especially for pest, disease and drought resistance may be given priority. Chloroplast transformation approach may be ideal to avoid gene flow, as spices are native to India.

Biotechnology has an important role in spices research and it is necessary to strengthen this unit considerably. An autoradiographic facility and greenhouse to maintain transgenic plants and virus-free mother plants may be provided. Though most of the instruments needed are available many of them are over 10 years old and need to be replaced. The feasibility of providing a one time grant of about Rs. 50 lakhs may be examined for upgrading the equipments, periodic calibration of all analytical equipments and maintaining them with service contract for next 5 years. This is all the more important to get the laboratories accredited with ISO standards.

Sufficient linkages should be built up with other national/international organizations in biotechnology. Though reasonable linkages with a few national laboratories have been established, the institute is handicapped by restrictions in collaboration especially with the best laboratories abroad. This may be relaxed for improving the exposure, calibre and standard of scientists.

More emphasis may be given to develop short duration varieties in ginger and turmeric. Studies on lack of seed set in the crop may be intensified. Specific recombinant breeding programmes in turmeric may be initiated to bring the characters of interest together which was not attempted so far.

Tree spices need introduction of germplasm from centres of origin. Introducing sweet nutmeg (low myristicin) from West Indies and their evaluation will help the food industry.

Indian nutmegs are rich in myristicin, an anti-carcinogenic compound. This property may be further verified and exploited in collaboration with CSIR laboratories to give value addition to Indian nutmeg.

Garcinia is the source of important anti-
obesity compound, hydroxycitric acid (HCA). Efforts should be made to identify genotypes with higher HCA content and the possibility of isolation and purification of this compound as a major nutraceutical product should be explored.

9.18 Vegetative propagation remains the most effective method of multiplying elite genotypes of tree spices. The efficiency of this method may be enhanced using rootstocks at seedling stage without damaging their tap root system and rootstocks with known drought tolerance.

9.19 The effect of growth regulators in increasing yield may be studied in tree spices. Pruning studies may be undertaken to remove unproductive branches, doctor the canopy and increase flowering.

Crop Production and Post Harvest Technology

9.20 The demand for organic products is increasing in the western markets at about 20% every year. IISR may strengthen research in organic farming in black pepper, cardamom, ginger and turmeric. Use of vermicompost and FYM/compost/oil cakes/green manure in INM may be encouraged. Linkages may be developed with Spices Board in this aspect since it is the nodal agency to promote organic farming in spices in the country.

9.21 IISR has done good work in developing management schedules against black pepper diseases incorporating soil amendments. These studies may be advanced further to determine critical soil pH, soil profiling and soil health levels (including rhizosphere) in black pepper and cardamom especially in organic farming systems.

9.22 Programmes on biological nutrient management in black pepper may be intensified, especially on microbial diversity and community structure in the rhizosphere and soils of black pepper. This would help in identifying strains of microbes beneficial for enhancing soil nutrient availability for black pepper. It is also important to understand the effects of applied biocontrol agents on populations of indigenous beneficial bacteria, which commonly occur in the rhizosphere. Comprehensive studies on these aspects are possible through molecular approaches. This will aid in formulating INM packages utilizing beneficial microbes.

The crop-weather relationship for black pepper established by IISR based on the weather and yield data from Regional Agricultural Research Station (KAU), Ambalavayal, cannot be extrapolated to other regions due to inherent limitations in the statistical model. Hence, similar relationships for different black pepper producing centers may be obtained with the help of SAUs/AICRPS to arrive location-specific conclusions.

9.23 Some of the popular standards of black pepper like *Erythrina* sp. are susceptible to new insect pests resulting in their mortality. Efforts should be made to identify more suitable standards for black pepper. New agro-forestry species need to be evaluated before popularization.

9.24 Climatic change is drastically altering the environment including rainfall pattern in all spice growing regions. Some spice crops like black pepper and cardamom grown primarily in forest ecosystems are greatly affected by this climate change. The effect of these changes on performance of genotypes may be monitored with an objective of identifying better performers in changed conditions. Facilities such as open top chamber / greenhouse with light, temperature and CO₂ control may be provided to undertake such studies.

9.25 In view of the changing climate, water will be a limiting factor in future. Studies on drought resistance and tolerance may be given high priority in black pepper and
Various agronomic practices to mitigate water shortage may be tried to identify cost effective technologies for drought management. Basic studies and evaluation of drought resistance has to be taken up on priority.

Studies on crop phenology will help in planning crop management strategies so as to schedule field operations to enhance the yield with available resources. A programme may be initiated to see the relationship of flowering with yield and curcumin content in turmeric. Leaf area of turmeric may be correlated with rhizome yield in the on-going crop phenology study.

Quality of produce is one of the important factors for spices export. Breeding programmes must concentrate on genotypes with high quality parameters, especially high β-caryophyllene in black pepper, high zingiberene and shagoals in ginger, high α-terpinyl acetate in cardamom and high cinnamaldehyde in cinnamon, in addition to yield trait.

A majority of spices and their active principles are excellent antioxidant nutraceuticals which play a significant role in the prevention of a number of age-related diseases. IISR may initiate studies on the identification and characterization of these bioactive components in spices, with a long term objective of inclusion of these constituents in various drug formulations.

Exploitation of natural food colours in spices is an area worth exploring. Programmes may be initiated to isolate the natural colour components in potential spice crops.

Research on post harvest technology and processing needs immediate attention. Cost effective primary processing technologies for important on-farm operations like harvesting, grading, packaging and storage which can improve the quality of the produce may be developed in collaboration with CSIR laboratories. Studies on mechanization of farm operations may also be initiated. Processing and product diversification are extremely important in spices. Equally important is indigenous technology to develop new products. Establishment of an agro-processing unit at IISR is to be given priority, taking into consideration the recent trends in the field of value addition.

Studies on use of molecular markers for detecting adulteration in spice products that is being undertaken at present may be intensified.

Studies on various factors involved in improving vanillin content through processing and identifying efficient microbes involved in fermentation and conversion should be initiated.

Pesticide residue analysis is mandatory in the area of quality improvement and safety assessment of spices. The QRT recommends that the institute build up the required expertise and infrastructure facilities for the same. The Spices Board's ISO 9002 certified Quality Laboratory may be utilized for pesticide residue and microbiological analysis (particularly for aflatoxin), till such facilities are built up at the institute, as the certificates issued by them are accepted by international trade agencies.

Crop Protection

The institute has large collections of Phytophthora isolates from different hosts including black pepper. Morphological and molecular studies on these isolates have been initiated. The work must be continued to understand the variability existing in different Phytophthora species and for the identification of races. Molecular diagnostics to differentiate species also need to be taken up.

Phytophthora capsici and nematodes
(Meloidogyne spp. and Radopholus similis) are the predominant organisms associated with foot rot and slow decline disease of black pepper. However, in certain areas especially at higher altitudes, occurrence of Fusarium sp. is also reported. Hence the role of Fusarium in slow wilt of black pepper needs to be established and suitable control measures evolved.

The institute has a large collection of biocontrol agents and a few of them which have shown promise against Phytophthora capsici and Meloidogyne spp. have already been commercialized. Besides, several endophytes also have shown promising results against fungi and nematodes. In depth studies on the ecology of these organisms, their efficacy especially multiple efficacy in controlling more than one pathogen and their commercialization needs to be done.

Major spread of the pathogens (viruses, bacteria, fungi and nematodes) takes place through seeds/rhizomes and nursery planting material. Hence it is important to develop and employ sensitive techniques to detect all the pathogens early in the soil/root system. Though the institute has developed ELISA and PCR based diagnostics for certain viruses, bacteria and fungi, they need to be extended to all pathogens infecting spice crops. Wherever possible multiplexing should also be attempted.

Efforts should be intensified to characterize the fungi associated with rhizome rot of ginger and turmeric in various regions and develop strategies for management including development of resistant varieties through conventional and biotechnological approaches.

Unlike cyst and root-knot nematodes, the genes associated with the parasitism/resistance of the endoparasitic nematode R. similis are not clearly understood. There are reports on involvement of phenolics and phenyl propanoid pathway contributing to R. similis resistance in banana. Studies on mode of parasitism may be undertaken to develop resistant black pepper lines.

Changes in nematode community in soil reflect soil and ecological processes. Nematode diversity tends to be greatest in ecosystems with least disturbance, and bacterial-feeding nematodes make the greatest contribution to the decomposer food web in more intensively managed ecosystems. Studies on the role of nematodes in these processes will help in understanding the relationship between plants and soil nematode communities especially in perennial crops.

Infestations of new insect pests such as root mealybugs on black pepper and Erythrina gall wasp on Erythrina sp. have reached alarming proportions in some hilly districts of Kerala and Karnataka. Since adequate manpower is not available in the Entomology Section, research work on these insect pests may be initiated through external funding.

Little information is available on the microbial pathogens affecting insect pests of spice crops. Systematic efforts may be made to document, evaluate and develop mass production technologies for utilizing microbial pathogens for the management of insect pests.

Social Sciences

Agro-ecosystem analysis of spices production in different farming situations, problem prioritization, technology intervention and participatory on-farm assessment of newly developed technologies should be planned and undertaken by the Social Sciences Section of the institute.

A study of the present level of demand and supply of spices, its projection both for
domestic and export, cost of production vs import cost is required to be made on priority.

Extension

9.46 The north eastern India provides excellent opportunities for expanding and developing spices cultivation in the region. Production, processing, adoption and marketing constraints of spices in north eastern hill states should be studied critically and promotion programmes need to be prepared and executed in the next Plan. Collaboration with Spices Board, ICAR Research Complex at Shillong, CPCRI Research centres at Mohitnagar (West Bengal) and Kahikuchi (Assam) may help in bridging the gap. Improved varieties of ginger and turmeric may be introduced in a larger scale in the region. Areca nut and tea-based cropping systems may be used to introduce black pepper in this region.

9.47 The research efforts of IISR must be complimented with the efforts of AICRPS, SAUs, DASD and Spices Board. It is also important to utilize the expertise and resources at RRLs, APPEDA, NABARD, NHM and state agricultural/horticultural departments in a synergistic effort for aggressive production, product development, market and trade strategies. Hence partnership arrangement with these agencies are to be encouraged.

9.48 Production and distribution of high quality and disease-free planting material is the most important input in increasing production and productivity in spices. The facility at IISR may be strengthened and developed as a separate unit with funds from Technology Mission on Horticulture. Protected mother gardens of improved varieties need to be built in black pepper and cardamom and scion banks in tree spices. The planting materials should be fortified with efficient biocontrol agents at the nursery level. This programme may be supplemented by encouraging certified nurseries and biocontrol units in farmer’s fields in different regions. Micro propagation techniques may be used where ever possible for initial bulking up of disease-free stocks.

9.49 Dissemination of information and technologies developed at IISR must be aggressive and effectively involve ATIC, KVK, Spices Board, DASD, state agriculture/horticulture departments and farmers. This should be enterprising, and conducted using modern audiovisual techniques. The institute should also lay front-line demonstrations (FLDs) in major spice growing regions with the help of KVK to demonstrate the feasibility of technologies developed at the institute.

9.50 Impact assessment of technologies transferred is an important input to develop future strategies for the institute. Utilizing the in-house ATIC and KVK facilities, inputs from the departments of agriculture/horticulture may be periodically obtained, documented and analysed for deciding future strategies of the institute.

9.51 ITKs available in spices need to be verified, refined and documented so as to promote them through FLDs in farmers fields for increasing the production.

9.52 The Institute Village Linkage Programme (IVLP) of ICAR implemented by many institutes has been successful in testing and modifying technologies in order to make them most suitable for local conditions of farmers in different regions. This programme has now been discontinued. The QRT recommends to start the IVLP again during the XI Plan and the institute should propose adequate budget for the same.

KVK

9.53 The availability of KVK staff is not
according to norms and all the posts should be filled up on priority. The functioning of the KVK is affected due to the vacant posts of Programme Coordinator and SMSs in Plant Protection, Fisheries and Home Science.

9.54 The SMS (Home Science) should be encouraged to perform the twin role as support personnel for women’s programmes in adoption of improved farming technologies such as dairying and animal husbandry, production of vermicompost and post harvest management of spices, food grains, fruits and vegetables.

9.55 The Scientific Advisory Committee meeting of KVK should be held twice a year regularly. Half yearly achievements of KVK should be reviewed critically and suggestions be made so as to enable KVK to make mid-term corrections in the programme and reorient the same to make it demand driven.

9.56 In the KVK programme emphasis was found tilted towards training and FLDs ignoring the importance of on-farm trials. The annual and five yearly programme of KVK should be reoriented giving equal emphasis on all the four mandates namely, training of farmers, on-farm trials, front-line demonstrations and training of field level extension functionaries.

9.57 The process of collection, documentation and use of field feedback for reorientation of research and extension programmes in the KVK was found to be weak. This needs to be given due importance in the KVK activities.

9.58 The KVK Farm and its demonstration units should be maintained scientifically to have the desired 'demonstration effect' on the visitors. Each demonstration unit should be labeled giving full technological information about the demonstration. On-farm trial plots and FLDs should also be well labeled to give full information about the treatments/interventions.

9.59 All important and critical agricultural operations in the FLDs need to be made in presence of KVK/IISR scientists in order to fully realize the production potential of technologies included as interventions. Only newly released technologies or technologies which are likely to be released in the near future should be the interventions in all FLDs.

9.60 The Dr. Mohan Singh Mehta Committee, while conceptualizing the KVK, suggested to identify innovative/progressive farmers including farm women who should be given comprehensive training and designated as 'key communicators' in the villages. Their services should be utilized for transfer of technologies in the villages. Further, the committee suggested that school drop-outs should be trained in technical knowledge and skills in agriculture and allied fields by them under the close supervision of KVK scientists. This needs to be implemented in selected areas by the KVK.

9.61 Training need analysis should be done by the extension scientists of KVK and IISR in order to uncover training needs of different target groups which should form the basis to develop need-driven training courses for different target groups. Emphasis in KVK/IISR training should shift from quantity to quality. Development of 'lesson plan' for each course is 'sine-qua-non' for imparting quality training. Impact points in 'lesson plan' helps in objective evaluation of training. Every training course need to be evaluated against the specific objectives of the course.

9.62 The programme for capacity building of SMSs of KVK and scientists of IISR specially in the field of participatory training methods and extension techniques requires special attention. Their knowledge and skills should be progressively improved in
these areas. They need training in training need analysis techniques, training evaluation, audio visual aids preparation and use of socio-metric techniques.

9.63 The need and urgency of forging linkages and collaborative functioning of KVK with development departments of the state, SAUs and nearby ICAR institutes need to be recognized and followed by well planned concrete action. The Director, IISR in consultation with the Coordinator of Zone VIII need to do strategic thinking and work out details for establishing working linkages and also guide and assist the KVK to achieve them.

9.64 The following facilities may be provided to the KVK so that it can effectively fulfil all its mandates: biocontrol production unit; information and communication technology laboratory; mobile-agro-veterinary clinic.

9.65 Sufficient funds may be provided to the KVK for development of KVK farm and demonstration units, conducting kisan melas and field days and POL charges for vehicles.

HRD

9.66 Excellence requires highest level of HRD at all levels-administrative, technical, and scientific. Phased training programmes need to be imparted in improving the quality of personnel who understand and meet the requirement of globalised and technology savvy world. The list of institutions where training programmes can be undertaken by scientists have been listed in Chapter 6. The opportunities available with various agencies including international institutes may be utilized for HRD. IISR may encourage utilization of sabbatical leave by scientists for continued education and upgrading of knowledge.

9.67 Access to information is an important input in any activity of excellence. The bioinformatics and the library facilities of the institute may be integrated into National Informatics Centre for Spices with state of art facilities. Emphasis may be given for development of a digital library including electronic collection and digitising the most consulted reference sources for which appropriate softwares and CD-DVD mirror servers may be procured. The library website has to be further developed as a gateway to information resources available in the library. A 'nation wide open access movement' should be developed and linkages strengthened with similar institutes in sharing their institute repositories.

Infrastructure

9.68 As post harvest technology is an emerging area of research, it has to be strengthened. The institute has also identified several microorganisms for the management of pests and diseases of various spice crops. However adequate facilities are not available for their mass multiplication, quality evaluation and distribution. Various research laboratories of molecular biology and biotechnology are scattered and congested and have to be integrated into a common unit. The institute also draws considerable visitors such as students, researchers and farmers and adequate space is not available in the ATIC for housing various live and preserved specimens of spices and also exhibits of significant achievements and technologies transferred from the institute. Hence the QRT recommends the construction of the following:

- Post Harvest Technology Block
- Biocontrol Production Unit
- Molecular Biology and Biotechnology Block
- Spice Museum

9.69 At present, the Project Coordinator's office is housed in the main building which is
very congested and insufficient to keep records and samples received from centres for analysis. Hence the QRT strongly feels the need for a separate Project Coordinator’s office at Calicut.

9.70 The institute has built up excellent instrumentation facilities over the years to cater to the needs of research. However, many of the existing equipments are more than 10 years old and need replacement and some new equipments are needed to carry out the envisaged programmes. Hence, the QRT recommends the purchase of the following equipments during the next Plan period:

- Herbarium facility
- Autoradiography and radioactive facility
- Automated protein purification unit
- Liquid chromatography mass spectrometer
- Gas chromatograph
- Atomic absorption spectrophotometer with graphite analyser
- Infra red spectrophotometer
- Spectrofluorimeter
- CHNS analyzer
- Anion analyzer
- Stereomicroscope
- High and ultra speed refrigerated centrifuge-Floor model
- Deep freezer
- PCR / Real Time PCR units
- Microwave digester
- Denaturing gradient gel electrophoretic unit
- BIOLOG System
- Internet connectivity and wide area networking of Calicut, Peruvannamuzhi and Appangala
- Computers/servers for office automation at Calicut, Peruvannamuzhi and Appangala
- Pre-cleaners, separators and driers for post harvest processing
- Cryo grinding and super critical extraction unit
- Solar water heating system

9.71 Adequate supply of water is essential for the laboratories throughout the year and the experimental fields during the post monsoon and summer seasons. Since the rains are becoming errant year-by-year it is imperative to develop water harvesting structures and water sheds to meet this growing need. Hence the QRT suggest the development of watersheds at Calicut, Peruvannamuzhi and Appangala.

9.72 Since the entire Kodagu District is of tourist interest, getting satisfactory accommodation is very difficult especially during the peak tourist season at Appangala, for scientists and trainees who visit the centre. Hence, the QRT feels the necessity of construction of a Training cum Scientists Hostel at CRC, Appangala.

9.73 Posting of adequate number of scientists is crucial for the overall development of the Experimental Farm at Peruvannamuzhi. Hence the QRT proposes that additional facilities such as residential quarters and Scientists Hostel may be provided at Peruvannamuzhi for the same.

9.74 The minibus, jeep and staff car available at the headquarters are more than 10 years old leading to frequent breakdowns and repairs and demand high expenditure for their maintenance. The QRT feels that all the existing vehicles should be replaced. A new bus/minibus is essential at the headquarters for comfortable transportation of staff to the farm and also at KVK, Peruvannamuzhi for transportation of farmers for training programmes.

9.75 The present area of CRC, Appangala is only 17.4 ha. This is inadequate to meet the present requirements since cardamom is raised as an under storey crop under forests and only a fraction of the gross area is available for cultivation. Moreover a duplicate set of germplasm available at Peruvannamuzhi may have to be maintained at Appangala. The QRT suggests that the ICAR/IISR may approach
the Karnataka Government to make available at least 25 ha of additional land preferably contiguous to the existing farm to augment the land facilities at Appangala to meet the increased demand.

9.76 The present area of the headquarters of the institute at Chelavoor (Calicut) is only 17.4 ha. The institute is facing acute shortage of land for further expansion of physical facilities (laboratory, administrative and other buildings) and for essential field experimentation. The QRT suggests that the ICAR/IISI may approach the Kerala Government to make available at least 25 ha additional land preferably contiguous to the existing land to meet the increased demand.

9.77 The CRC at Appangala under IISR mainly conducts research on cardamom and also to a limited extent on black pepper and tree spices. The centre may be upgraded as a Regional Station with necessary manpower and facilities to intensify research on cardamom and other crops as envisaged in the next Plan period.

9.78 Spice crops such as black pepper, ginger, turmeric and tree spices are grown to a large extent in the north eastern region. There is also great potential to increase the area and the productivity of these crops in this region. Hence there is an urgent need to start a Regional Station of IISR in the north eastern region to overcome the problems in cultivation of these crops and to tap the potential available in the region.

9.79 The institute has proposed numerous programmes to tackle issues related to spices research and development. However, sufficient scientific manpower is needed to fulfil the objectives and to achieve the set goals. The sanctioned scientific cadre strength of the institute has remained unchanged at 43 both during IX and X Plan periods. There is an urgent need to create a post of Head, Division of Crop Improvement and Biotechnology at Calicut. Additional manpower is also required in Entomology, Plant Pathology, Computer Applications, Bioinformatics and Food Technology/Post Harvest Technology in the grade of Senior Scientist.

9.80 A Principal Scientist position in Plant Breeding/Horticulture is required at Cardamom Research Centre, Appangala, to carry out various research activities envisaged in the next Plan period and also to head the station when it is upgraded as a Regional Station. Similarly, another Principal Scientist position in Plant Breeding/Horticulture would be required when a new Regional Station of IISR is sanctioned in the north eastern region.

Administration

9.81 The institute has made tremendous progress in automation of office and is perhaps the only one of its kind in the entire ICAR. Sufficient funds may be sanctioned to provide networking of the headquarters at Calicut with its Experimental Farm at Peruvannamuzhi and Research Centre at Appangala.

9.82 The institute handles a large number of externally funded projects besides regular institute projects. The administration is headed by a lone Assistant Administrative Officer and there are no senior positions in administration such as Administrative Officer/Senior Administrative Officer. Hence the QRT recommends sanctioning of two administrative positions, one at Calicut and another at CRC, Appangala, in the rank of at least Administrative Officer.
The Chairman and members of the Quinquennial Review Team (QRT) wish to place on record their appreciation and gratitude to Dr. Mangala Rai, Director General, ICAR and Secretary, DARE, for providing the opportunity to serve the QRT of Indian Institute of Spices Research, Calicut, including the All India Coordinated Research Project on Spices.

The QRT also wish to thank Dr. H. P. Singh, Deputy Director General (Horticulture), ICAR, and Dr. K. V. Ramana, Assistant Director General (Hort-II), ICAR, for providing their valuable support and guidance.

The QRT is grateful to Dr. V. A. Parthasarathy, Director, Indian Institute of Spices Research, Calicut, who extended all support and facilities for the working of the QRT. The QRT would also like to express their appreciation to all scientific, technical, administrative and supporting staff of the institute for their cooperation and assistance during the visits of the QRT.

Dr. G. Kalloo
(Chairman)

Dr. I. Irulappan
(Member)

Dr. B. N. Choudhary
(Member)

Dr. R. Samiyappan
(Member)

Dr. K. C. Bansal
(Member)

Dr. A. G. Appu Rao
(Member)

Dr. S. Devasahayam
(Secretary)
1 Research achievements and their impact

To examine and identify the research achievements of the institute, KVK, its regional stations and sub-stations and AICRPs operated by them vis-a-vis sectoral programmes since the previous quinquennial review and critically evaluate them. Commensurate with the objectives, mandates and resources of the organization, the socio-economic impact of research on farmers/beneficiaries and transferability of results to farmers through extension should be critically reviewed.

2 Research relevance and budget allocation

To examine the objectives, scope and relevance of the research programmes and budget of the institute for the next 5 years in relation to overall state/regional/national plans, policies and long and short-term priorities. The committee may also draw its attention to the EFC/SFC memo in relation to recommendations of the previous QRT and also the perspective plans and Vision - 2025 document of the institution.

3 Policies priorities and strategies

To examine the policies, priorities, strategies and procedures adopted by the institute and the system in relation to perspective plan in arriving at these decisions particularly the effectiveness of working of the Staff Research Council, Research Advisory Committee and Institute Management Committee as well as the consultative machineries like Grievance Cell and Joint Staff Council.

4 Relationship/collaboration with SAUs and other stakeholders

Whether the research programmes of the past and proposals for future are in harmony with the vision of ICAR and the programme of related centres of research and agricultural universities, State Government, private sector and IARCs.

5 Linkages with clients/end users

To examine the kinds of linkage established with clients and end users of research results, i.e., farmers/fishermen and the extent of interest displayed in conducting 'on farm research' on farmers fields and in organizing demonstrations / training courses for the transfer of technology to extension agencies.

6 Proposed changes in organization, programmes and budget

To examine whether any changes in the organizational set up are called for, to achieve an improved and effective working. The committee may also examine and draw attention to any imbalances in the staffing pattern consistent with the scientific, technical and administrative needs as well as the allocation of research funds towards capital works, establishment and research contingencies. Further the committee may also examine the resource generation efforts and assess the problems and prospects of the same. The progress and problem of implementing project-based budgeting may also be highlighted. While proposing major changes in organization and functioning, their feasibility in relation to ICAR's rules, autonomy, resources, etc. need to be kept in view.

7 Organization and management

Whether the organizational structure of the institute is conducive to efficient functional/working autonomy, decentralization and delegation of authority in day-to-day routine working and whether the Director and senior staff are interested in promoting a collegiate and co-operative method of administration is to be assessed. The committee may also critically examine the status of implementation of O & M reforms as introduced by the Council from time to time and suggest ways and means to implement them at the institute level.
They may also suggest further reforms to be considered by the Council. The suggested staff ratio by the Council may have to be kept in view while reviewing the staff position in the institute.

8 Constraints

To examine constraints hindering the institute in the achievement of its objectives and implementation of its programmes and goals and to recommend ways and means of minimizing or eliminating them.

9 Looking forward

To look forward into any other points considered relevant by the committee or referred to it by the ICAR, Institute Director or the Institute Management Committee in respect of future project development, research prioritization and management changes.

The above terms of reference may be modified at the suggestion of Director of Institute/Management Committee of the Institute/ICAR Headquarters/General Body keeping in mind any specific problems of the institute.
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Date</th>
<th>Institute / Centre</th>
<th>QRT/Director/PC</th>
<th>Officials met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>25.04.2007</td>
<td>ICAR Headquarters, New Delhi</td>
<td>Dr. G. Kalloo, Dr. I. Irulappan, Dr. K. C. Bansal, Dr. V. A. Parthasarathy, Dr. M. Anandaraj</td>
<td>Dr. H. P. Singh, DDG (Hort.), ICAR, Dr. K. V. Ramana, ADG (Hort-II), ICAR</td>
</tr>
<tr>
<td>2.</td>
<td>07.05.2007 - 09.05.2007</td>
<td>II.SR, Calicut; KVK, Peruvannamuzhi</td>
<td>Dr. I. Irulappan, Dr. B. N. Choudhary, Dr. R. Samiyappan, Dr. K. C. Bansal, Dr. V. A. Parthasarathy, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All staff</td>
</tr>
<tr>
<td>3.</td>
<td>09.05.2007</td>
<td>TNAU, Coimbatore (Presentation by Coimbatore, Yercaud and Pechiparai centres)</td>
<td>Dr. I. Irulappan, Dr. B. N. Choudhary, Dr. R. Samiyappan, Dr. K. C. Bansal, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists, Dr. D. Veeraragava Thatam, Dean (Horticulture), Dr. K. Rajamani, Head, Spices &amp; Plantation Crops</td>
</tr>
<tr>
<td>4.</td>
<td>23.05.2007</td>
<td>CRS, Pampadumpara</td>
<td>Dr. I. Irulappan, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists</td>
</tr>
<tr>
<td>5.</td>
<td>24.05.2007</td>
<td>ICRI, Myladumpara</td>
<td>Dr. I. Irulappan, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists, Dr. J. Thomas, Director</td>
</tr>
<tr>
<td>6.</td>
<td>06.06.2007 - 07.06.2007</td>
<td>CCSHAU, Hisar (Presentation by Hisar and Solan centres)</td>
<td>Dr. G. Kalloo, Dr. R. Samiyappan, Dr. A. G. Appu Rao, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists, Dr. V. C. Katyal, VC, Dr. B. S. Chillar, DR, Dr. Jit Singh, ADR</td>
</tr>
<tr>
<td>7.</td>
<td>10.07.2007-11.07.2007</td>
<td>NDAUT, Kumarganj (Presentation by Kumarganj, Pundibari, Dholi and Raigarh centres)</td>
<td>Dr. G. Kalloo, Dr. I. Irulappan, Dr. B. N. Choudhary, Dr. R. Samiyappan</td>
<td>All scientists, Dr. V. C. Gautam, Prof. (Vegetables), Dr. D. S. Yadav, Prof. &amp; Head (Vegetables)</td>
</tr>
<tr>
<td>8.</td>
<td>23.08.2007</td>
<td>ANGRAU, Guntur (Presentation by Guntur, Chintapalle, Jagtial and Pottangi centres)</td>
<td>Dr. I. Irulappan, Dr. B. N. Choudhary, Dr. R. Samiyappan, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists, Dr. Yellamanda Reddy, ADR</td>
</tr>
<tr>
<td>9.</td>
<td>23.09.2007</td>
<td>RAU, Jobner (Presentation by Jobner and Jagudan centres)</td>
<td>Dr. I. Irulappan, Dr. B. N. Choudhary, Dr. R. Samiyappan, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists</td>
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<tr>
<td>10.</td>
<td>24.09.2007</td>
<td>NRCSS, Ajmer</td>
<td>Dr. I. Irulappan, Dr. B. N. Choudhary, Dr. R. Samiyappan, Dr. S. Devasahayam, Dr. M. Anandaraj</td>
<td>All scientists, Dr. B. B. Vashishtha, Director</td>
</tr>
<tr>
<td></td>
<td>Date</td>
<td>Location</td>
<td>Presenters/Staff</td>
<td>Organizer/Contact</td>
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<td>11</td>
<td>15.10.2007</td>
<td>DASD, Calicut</td>
<td>Dr. I. Irulappan&lt;br&gt;Dr. B. N. Choudhary&lt;br&gt;Dr. R. Samiyappan&lt;br&gt;Dr. S. Devasahayam</td>
<td>Dr. Tamil Selvan, Director</td>
</tr>
<tr>
<td>12</td>
<td>16.10.2007 - 17.10.2007</td>
<td>CRC, Appangala&lt;br&gt;<strong>Presentation by Mudigere and Saklespur centres</strong></td>
<td>Dr. I. Irulappan&lt;br&gt;Dr. B. N. Choudhary&lt;br&gt;Dr. R. Samiyappan&lt;br&gt;Dr. V. A. Parthasarthi&lt;br&gt;Dr. M. Anandaraj</td>
<td>All scientists</td>
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<td>13</td>
<td>18.10.2007</td>
<td>KAU, Panniyur&lt;br&gt;<strong>Presentation by Panniyur, Dapoli and Sirsi centres</strong></td>
<td>Dr. I. Irulappan&lt;br&gt;Dr. B. N. Choudhary&lt;br&gt;Dr. R. Samiyappan&lt;br&gt;Dr. M. Anandaraj</td>
<td>All scientists</td>
</tr>
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<td>14</td>
<td>19.10.2007</td>
<td>IISR, Calicut</td>
<td>Dr. I. Irulappan&lt;br&gt;Dr. B. N. Choudhary&lt;br&gt;Dr. R. Samiyappan&lt;br&gt;Dr. A. G. Appu Rao&lt;br&gt;Dr. V. A. Parthasarathy&lt;br&gt;Dr. S. Devasahayam&lt;br&gt;Dr. M. Anandaraj</td>
<td>All staff Members of IMC</td>
</tr>
</tbody>
</table>
List of Scientific and Technical Personnel (2002-06)

Annexure III

Headquarters, Calicut

Managerial
Dr. V. A. Parthasarathy, PhD
Dr. Y. R. Sarma, PhD
Dr. P. N. Ravindran, PhD
Dr. K.V. Ramana, PhD
Dr. M. Anandaraj, PhD

Scientific
Dr. K. Narayana Kurup, PhD
Dr. B. Chempakam, PhD
Dr. S. Devasahayam, PhD
Dr. B. Krishnamoorthy, MSc (Ag)
Dr. M. S. Madan, PhD
Dr. T. John Zachariah, PhD
Dr. B. SasisKumar, PhD
Dr. J. Rema, PhD
Dr. T. K. Jacob PhD
Dr. K. Johnson George, PhD
Dr. C. K. Thangamani, PhD
Dr. R. Dinesh, PhD
Dr. R. Suseela Bhai, PhD
Dr. A. Ishwara Bhat, PhD
Dr. R. Ramakrishnan Nair, PhD
Dr. P. Rajeev, PhD
Dr. K. S. Krishnamurthy, PhD
Dr. K. Kandianman, PhD
Dr. Santhosh J. Eapen, PhD
Dr. N. K. Leela, PhD
Dr. K. V. Saji, PhD
Dr. A. Kumar, PhD
Dr. V. Srinivasan, PhD
Dr. A. Sharmila, PhD
Dr. K. M. Abdulla Koya, MSc (Ag)
Dr. K. N. Shiva, PhD
Dr. T. E. Sheeja, PhD

Technical
Dr. Johny A. Kallupurackal, PhD
Dr. Hamza Stambikkal, PhD
Sri. P. Azgar Sheriff, MLib
Dr. Utpala Parthasarathy, PhD
Sri. M. M. Augusthy, BSc
Sri. K. Jayarajan, MSc
Sri. M. Vijayaraghavan
Sri. K. T. Muhamed
Sri. V. Sivaraman, BA
Dr. C. K. Sushamadevi, PhD

Director
Director (up to 31.05.2002)
Project Coordinator (Spices) (up to 30.04.2002)
Project Coordinator (Spices) (up to 25.01.2005)
Project Coordinator (Spices)

Principal Scientist (Statistics) & Acting Head (Social Sciences) (up to 30.06.2006)
Head (Crop Production and Post-harvest Technology)
Principal Scientist (Entomology) & Acting Head (Crop Protection)
Principal Scientist (Plant Breeding) & Acting Head (Crop Improvement and Biotechnology)
Senior Scientist (Agricultural Economics)
Senior Scientist (Biochemistry)
Senior Scientist (Plant Breeding)
Senior Scientist (Horticulture)
Senior Scientist (Entomology)
Senior Scientist (Genetics & Cytogenetics)
Senior Scientist (Agronomy)
Senior Scientist (Soil Science)
Senior Scientist (Plant Pathology)
Senior Scientist (Plant Pathology)
Senior Scientist (Genetics & Cytogenetics)
Senior Scientist (Agricultural Extension)
Senior Scientist (Plant Physiology)
Senior Scientist (Agronomy)
Senior Scientist (Nematology)
Senior Scientist (Organic Chemistry)
Senior Scientist (Economic Botany)
Senior Scientist (Plant Pathology)
Senior Scientist (Soil Science)
Senior Scientist (Biochemistry)
Scientist (SG) (Entomology) (up to 30.06.2006)
Scientist (Senior Scale) (Horticulture)
Scientist (Senior Scale) (Biotechnology)

Technical Information Officer (T9)
Technical Officer (Laboratory) (T7-8)
Technical Officer (Library) (T7-8)
Technical Officer (T6)
Technical Officer (Statistics) (T5)
Technical Officer (T5) (Workshop)
Technical Officer (T5) (Farm)
Technical Officer (T5) (Farm)
Technical Officer (T5) (Library)
Experimental Farm, Peruvannamuzhi

Scientific

Sri. P. A. Mathew, MSc (Ag)  Principal Scientist (Horticulture) & Scientist in Charge (Farm)
Smt. E. Jayashree, MSc (Ag)  Scientist (Senior Scale) (AS & PE)
Dr. K. Abirami, PhD (Hort)  Scientist (Fruit Science)

Technical

Sri. V. K. Abubacker Koya  Farm Superintendent (T7)
Sri. N. A. Madhvan  Technical Officer (T5) (Farm)
Sri. K. Kumaran  Technical Officer (T5) (Farm)

Cardamom Research Centre, Appangala

Scientific

Dr. M. N. Venugopal, PhD  Principal Scientist (Plant Pathology) and Scientist in Charge (CRC)
Dr. S. J. Anke Gowda, PhD  Senior Scientist (Physiology)
Dr. R. Senthil Kumar, PhD  Senior Scientist (Horticulture)
Dr. D. Prasath, PhD  Scientist (Senior Scale) (Vegetable Science)

Krishi Vigyan Kendra, Peruvannamuzhi

Sri. P. A. Mathew, MSc (Ag)  Training Organiser (up to 09.12.2002)
Dr. T. K. Jacob, PhD  Training Organiser
Sri. P. S. Manoj, MSc (Ag)  Technical Officer (Horticulture) (T-7) (on study leave from 10.10.2006)
Dr. S. Shanmughavel MVSc  Technical Officer (Veterinary) (T-7)
Sri. K. M. Prakash MSc (Ag)  Technical Officer (Agronomy) (T-7)
Dr. S. Ravi MVSc  Technical Officer (Animal Husbandry) (T-5)
## List of Research Projects

#### Annexure IV

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the project</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
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<tbody>
<tr>
<td></td>
<td><strong>CROP IMPROVEMENT AND BIOTECHNOLOGY</strong></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Mega project: Collection, conservation, characterization and cataloguing of germplasm of spice crops for yield and other economically important characters</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1.</td>
<td>Gen. I (813) : Collection, conservation, cataloguing and evaluation of black pepper germplasm</td>
<td>•</td>
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<tr>
<td>2.</td>
<td>Gen. IX (813) : Collection, conservation, cataloguing and evaluation of cardamom germplasm</td>
<td>•</td>
<td>•</td>
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<td>3.</td>
<td>Gen. II (813) : Collection, conservation cataloguing and evaluation of germplasm of ginger and turmeric</td>
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<td>4.</td>
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**CROP PRODUCTION AND POST HARVEST TECHNOLOGY**

**Mega project : System approach for sustainable production of spices**

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8. Agr. XXV (813) : Evaluation of legumes as intercrops in black pepper plantation

9. Agr. XXVII (813) : Enhancing the productivity in black pepper by intercropping

10. Technology Mission on Black Pepper

11. SSC II. Nutritional requirement of improved varieties of spices

Mega project : Production physiology of spice crops

1. Phy. VII (813) : Physiological and biochemical basis for productivity in black pepper

2. Phy. V (813) : Characterization of drought tolerance in black pepper

3. Phy. VI (813) : Characterization of drought tolerance in cardamom

4. Phy. VIII (813) : Mechanism of drought tolerance in cardamom and black pepper

5. ICAR Cess Fund : Impact, adaptation and mitigation of climate change effects on growth and productivity of plantation crops with special reference to coconut and black pepper

6. ICAR Cess Fund : Development and evaluation of soil and water conservation measures and land use system for sustainable crop production in Western Ghats of coastal region

7. Biochem II (813): Characterization of turmeric germplasm for curcuminoids

8. ICAR Cess Fund : Chemical characterization of Cinnamomum germplasm

9. ICAR Cess Fund : Elucidation of biosynthetic pathways of curcumin in turmeric (Curcuma longa L.)

10. Biochem I (813): Biogenesis of pigment in spice crops

Mega project : Value addition and post harvest processing of spices

1. PHT. III (813) : Studies on drying and storage parameters in black pepper, ginger, turmeric and nutmeg

2. PHT. IV (813) : Evaluation for physical and biochemical quality of spices

3. KSCSTE : Production of white pepper through fermentation technology

4. ICAR Cess Fund: Prevention and management of mycotoxin contamination in commercially important agricultural commodities

5. DBT : Determination of purity of powdered market samples of major spices using PCR techniques, protein profiling and/or HPLC techniques

6. PHT V (813) : Studies on the nutraceutical properties of bioactive compounds in a few spices

7. ICAR Cess Fund: Development of chilli (Capsicum annuum L.) hybrids for paprika (oleoresin) production

8. PHT I (813) : Quality evaluation in spices
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Mega project: Production of nucleus planting materials of improved varieties of spice crops

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CROP PROTECTION

Mega project: Identification, characterization and development of diagnostics against pests, pathogens and nematodes of spice crops

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<td>Nema. III (813) : Investigations on the nematodes associated with spices crops</td>
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Mega project: Conventional and molecular approaches for developing pest, pathogen and nematode resistance in spice crops

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#### 8. Crop Prot. II (813) : Mechanisms of resistance to pests and pathogens in spice crops

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List of Publications

Research articles


Bimi G B, Anandaraj M, Kumar A, Heartwin Amaladhas

Annexure V


Hareesh P S, Madhubala R & Bhat A I 2006 Characterization of Cucumber mosaic virus infecting Indian long pepper (Piper longum L.) and betel vine (Piper betel L.) in India. Indian J. Biotech. 5: 89-93.


Kandiannan K, Chandaragiri K K, Sankaran N,


Review articles


Presentations in Conferences/Symposia/Seminars


Babu K N 2002 Conservation of genetic resources and crop improvement in black pepper. Workshop on Radiation-Induced Mutations for Black Pepper Improvement, Breeding and Biotechnology, 9 December 2002, Matale, Sri Lanka.

Babu K N 2002 Studies on black pepper cultivars, species and their inter-relationships using chemo taxonomic, morphometrics, numerical and principal component analysis. Workshop on Radiation-Induced Mutations for Black Pepper Improvement, Breeding and Biotechnology, 9 December 2002, Matale, Sri Lanka.

Babu K N 2002 Biotechnological tools for improvement of black pepper. Workshop on Radiation-Induced Mutations for Black Pepper Improvement, Breeding and Biotechnology, 9 December 2002, Matale, Sri Lanka.

Babu L, Mathew P A & Krishnamoorthy B 2002 Biodiversity in cinnamon germplasm—a qualitative


Bhai R S, Joseph Thomas & Solomon J J 2002 Mosaic disease of vanilla (Vanilla planifolia, Andrews) - the first report from India. IPS Southern Zone Meeting, 10-13 December, Calicut.

Bhai R S & Sarma Y R 2003 In vitro effect of fluorescent Pseudomonas on capsule rot of cardamom (Elettaria cardamomum Maton) caused by Phytophthora meadii. 6th International Workshop on PGPR, 5-10th October 2003, Calicut.


Ravindran P N, Johny A K & Nirmal Babu K 2002 Spices in our daily life, 56th All India Ayurvedic Congress, Kottakkal, Kerala.


Thankamani C K & Ashokan P K 2002 Influence of drip irrigation on yield and moisture extraction pattern of bush pepper grown in coconut garden. National Symposium on Soil and Water Conservation Measures and Sustainable Land Use Systems with Special Reference to Western Ghats Region, Old Goa.


Thankamani C K, Anandaraj M, Diby Paul & Kandiannan K 2003 Compatibility of Pseudomonas fluorescens, VAM (Glomus fasciculatum), Trichoderma harzianum and pesticides on establishment and growth of black pepper under nursery condition. 6th International PGPR Workshop, 5-10 October 2003, Calicut.


Spices, 24-26 October 2002 Calicut.


Books and chapters in books


List of Publications


**Technical publications**


List of Publications


<p>| 10.4 | <strong>Research on chilli:</strong> While paprika is an IISR mandated crop informally, chilli is treated as a vegetable crop by ICAR and not as a spice crop. This is an anomaly. In fact, Government of India and SB treat chillies as a spice crop. This QRT strongly recommends that red pepper R and D be done by the IISR and in tandem with the SB. If the ICAR accepts this recommendation, the ICAR may transfer the scientists working on red pepper in the various institutions at IIHR Bangalore, IARI New Delhi, AICRPV and IIVR, Varanasi to IISR/AICRPS (Paras 3.24 to 3.27). | Not agreeable. The recommendation of QRT that research work on chilli should be carried out by IISR was considered and it was decided that the spice part will be handled by IISR and vegetable part will continue to be handled by IIVR. | IISR is conducting research work on chilli (spice portion), particularly on paprika. |
| 10.5 | <strong>Research on large cardamom:</strong> Large cardamom (<em>Amomum aromaticum</em>) is a major crop of the eastern Himalayas of Sikkim and Bengal. The ICAR Research Complex for NEH Region’s Regional Station in Gangtok, Sikkim did some work on this crop earlier in plant and variety improvement for about 10 years, until about 5 years ago. Presently, SB is the only agency researching on this crop. The IISR does not have a presence in this region to carry out large cardamom research. The SB with its 2 farms at Panghang and Penlong, located about 10 and 15 km from Gangtok in Sikkim, and 2-3 scientists and some other staff is working on selected aspects of this crop. The SB is also doing a good deal of development work. The QRT recommends that IISR may join hands with SB and the ICAR Research Complex Regional Station, Sikkim under a Partnership Arrangement to conduct R &amp; D work on large cardamom (Paras 3.29 - 3.31). | Director, IISR may initiate this process of partnership with SB in the selected areas of research work on large cardamom, where IISR has an edge over SB. | Director, IISR, has written to the Director, ICAR Research Complex, Sikkim, for developing modalities for partnership programmes. A team of experts from IISR also visited Sikkim during September 2003 to study the problems facing cultivation of large cardamom in Sikkim and suggest remedial measures for the same. A scientist represented the team from ICAR Research Complex for NEH Region. |
| 10.6 | <strong>Regional research project on large cardamom:</strong> South and south east Asia is rich in the genetic resources of all the spices. Several species are used in this region as flavoring agents and in native systems of medicines. The QRT recommends that the IISR may at a later stage initiate a multi-country regional research project for large cardamom covering India, Bhutan and Nepal by seeking funding from the UNDP, ADB, FAO or SAARC. In the second phase of this programme, the IISR may extend the scope of this programme to cover south and | Spices are the major export commodity. It is therefore, not advisable to expose valuable germplasm and technological know-how to any foreign country in suggest international approach. | No action needed. |</p>
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<th>Sl. No.</th>
<th>Recommendations</th>
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<td>10.1</td>
<td><strong>Mandate crops</strong>: Presently the IISR is researching on black pepper, small cardamom, ginger, turmeric, cinnamon, clove and nutmeg. It is also stated to be working on allspice, garcinia, paprika and vanilla and to a limited extent like collecting some genetic material from a few sources (Paras 2.5, 3.38). The SB is mandated to work on the developmental activities of all the spices grown in the country (Appendix-9) and research on cardamom (both small and large) vanilla and herbal spices.</td>
<td>Agreed.</td>
<td>No action needed.</td>
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<td>10.2</td>
<td>In the interest of doing comprehensive and meaningful spices R and D work, the QRT recommends that the ICAR may mandate the IISR also to research on all the major crops on which the SB is presently working on (Para 3.18). This will necessitate the IISR to take up research on all the major condiments (coriander, cumin, fennel, fenugreek and red pepper).</td>
<td>Not agreeable. Research on seed spices is the mandate of NRCSS, Ajmer.</td>
<td>No action needed.</td>
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<td>10.3</td>
<td><strong>NRC on Seed Spices</strong>: It was the recommendation of the QRT of CPCRI and AICRPSC in 1983 that led to the establishment of National Research Centre for Spices (NRCS) and AICRPS in 1986. This QRT had also recommended setting up a regional station in Rajasthan/Gujarat to conduct research on condiments. This suggestion was not followed up then. At the same time, the AICRPS continued to coordinate research on condiments through its network of centres in various states of India (19 centres). In 1998, the ICAR has set up a NRC on Seed Spices in Tabij, near Ajmer. Presently, 3 scientists including Director are in position. The Centre has made a modest start in setting up basic facilities for condiments research. As the crops dealt with at NRC on Seed Spices at Tabij are the mandated crops of IISR, this QRT recommends that this Centre may be merged with IISR and redesignated as Regional Station of the IISR. This is a policy decision to be taken by ICAR (Para 3.22).</td>
<td>Not agreeable.</td>
<td>No action needed.</td>
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<td>10.10</td>
<td><strong>Vanilla research</strong>: The SB is doing some research on vanilla. It plans to expand the area under vanilla to 5000 ha during the X Plan. The IISR may develop a vanilla research programme jointly with the SB under the Partnership Arrangement (Para 3.37).</td>
<td>Agreed.</td>
<td>A group meeting of researchers of vanilla of IISR and SB was held to discuss the research priorities and to avoid duplication of research. IISR will continue its programme on vanilla evaluation with a special focus on disease resistance.</td>
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<td>10.11</td>
<td><strong>Research on allspice and garcinia</strong>: The IISR and SB may arrange a consultation of all the interested agencies on garcinia and allspice, to develop a R and D programme (Para 3.38).</td>
<td>Agreed.</td>
<td>A group meeting of researchers on tree spices was held and it was decided that as marketing of allspice is a major problem, less emphasis may be given for this crop, and in garcinia the on-going programmes may be continued.</td>
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<td>10.12</td>
<td><strong>Production of seed and planting material</strong>: Non-availability of quality planting material in black pepper, cardamom, ginger and turmeric is a prime constraint in increasing their production. The IISR along with SB should develop training programmes to encourage private agencies to take up the responsibility for producing quality planting materials and making them available to farmers in time. A system of licensing such agencies may also be introduced. The QRT feels that the present recommended nursery practice in black pepper of raising its planting material in split bamboo pieces has apparently outlived its utility and it has become one of the important methods of spreading infection of nematodes and certain other pathogens. The Institute may quickly develop and adopt alternate methods of rapid multiplication such as micropropagation and using single node cuttings with/without hormones (Para 3.39).</td>
<td>Agreed.</td>
<td>Training programmes on production of planting material in black pepper were organized through the KVK and in collaboration with SB. Alternative methods to produce disease-free black pepper rooted single node cuttings using serpentine method have already been developed and is being adopted on a large scale.</td>
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<td>10.13</td>
<td><strong>Climate changes</strong>: There is a lack of unanimity on the nature and direction of climatic changes taking place. Some of the spice crops like black pepper, cardamom and ginger are grown primarily in the forest ecosystems as understorey crops. The QRT recommends that the IISR may set up 2 permanent plots for black pepper and cardamom (being perennial crops) using 5-10 most standard varieties/land races in each and monitor the</td>
<td>Agreed.</td>
<td>The effects climate change on black pepper was studied in different regions in Kerala, Karnataka and Tamil Nadu. The data on climate change and productivity of black pepper for the last 20 years showed that rainfall was decreasing and temperature increasing in all the regions. The productivity of black pepper also showed no change or a decreasing trend in these regions. Studies</td>
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south east Asia to take up a survey and collection of all the genera and species that are related to ginger, turmeric and large cardamom (Para 3.29).

| 10.7 | Establishing IISR’s presence in north east India: The QRT feels that IISR’s/AICRP’s presence in the region is absent/weak, with only a fledgling Centre attached to the UBKVJ Jalpaiguri. Since spices hold considerable promise in the region, this is considered inadequate. The QRT therefore recommends that the ICAR may consider transferring to the IISR one of the 2 Research Centers of CPCRI Kasaragod in this region, viz., Mohitnagar (Jalpaiguri district, West Bengal) or Kaliukuchi (in Guwahati, Assam), if the CPCRI is agreeable to this (Para 3.32). | Dialogue between two institutes may be initiated for this purpose. | A letter was written to Director, CPRCI, Kasaragod regarding the issue. |
| 10.8 | Imparting earliness in ginger and turmeric: The present ginger and turmeric varieties take 7-10 months to mature. In the context of the emerging water deficiency and cropping system scenario, the overall duration of the crop may be got reduced by 4-8 weeks. This could be done by studying the rhizome bulking physiology in a range of varieties, and actively making selections for earliness. The QRT feels that it will be possible to achieve this in about 5-10 years time if sustained and systematic work is done as has been achieved in tuber crops in India (Paras 3.35). | Agreed. | The three ginger varieties released by the institute namely, Varada, Mahima and Rejatha take 200 days for maturity if harvested for dry ginger. However, they can also be harvested for vegetable ginger at 180 days maturity. The two turmeric varieties released by the institute namely, Suguna and Sudarshana are short duration varieties taking about 180 days to reach maturity. In the ongoing varietal evaluation trials with new lines this aspect of earliness is taken into consideration. For studying the rhizome bulking physiology, different sowing dates were tried to examine if there is any difference in photosynthetic accumulation pattern and early translocation to rhizomes for early harvesting. However, the duration of harvest could not be reduced. |
| 10.9 | Reducing harvesting period in black pepper and cardamom: The flowering and harvesting in black pepper and cardamom extend over several months (3-5, even 6). Deliberate efforts may be made to reduce and synchronize the period of flowering and harvesting in these 2 crops, to complete the harvesting in 3 (maximum 4) pickings as against the presents 6-8 pickings in cardamom. This could be done by taking 2 approaches: (a) by | Agreed. | As a rain-fed crop flowering is completed in the first two months in black pepper and only one picking is done. Two lines namely, HP 728, and OPKM that come to flowering by May itself have been identified. Trials were conducted using hormonal sprays such as NAA, but uniform maturity was not achieved. In cardamom genotypes that can be harvested in 4 pickings were |
| 10.17 | **Quality control:** The importance of quality produce, especially of spices exported is emphasized by every one. There are no common characters and parameters on the quality of different spices. The perceptions of producers, scientists, SB and traders are quite at variance. In the export trade homogeneity, and freedom from physical impurities, insecticidal residues and moulds are alone considered. In the Institute, there is a misplaced overemphasis on quality factors such as oleoresin and essential oil content. This needs to be corrected. Also, since IIISR will not have the resources (material and manpower) to set up a quality laboratory (and besides, it is likely to be underutilized also). Setting up a quality and/or residue laboratory by the IIISR is not supported. The IIISR and AICRPS can make use of SB Quality Laboratory (Para 3.6). | Agreed. | The quality evaluation programme is mainly a support to characterization and breeding programmes. Hence more emphasis was given for evaluation of oil, oleoresin and pungent principles. Programmes to analyze the intrinsic quality of spices through HPLC and GCMS are in progress. A network project on aflatoxins is also in progress. Evaluation of pesticide residue levels, as and when required, is being done with the help of SB laboratory. |
| 10.16 | **Partnership arrangements:** A Partnership Arrangement may be worked out for doing R and D work with 3 agencies; the SB (R and D on all the spices and specifically on small cardamom for Kerala and large cardamom, vanilla, and herbal spices); ANGRAU (for red pepper) and ICAR Research Complex for NEHR and Regional Station, Gangtok (for large cardamom) (Paras 3.42 - 3.47). | Director, IIISR may explore the possibility. | Four externally funded projects on network mode involving SB, KAU, RGC, APAU, IIIVR and UAS, Dharwad for paprika are in operation. Collaborative programmes with SB on small cardamom have also been initiated. |
| 10.19 | **Increasing the competence of scientists:** Presently, a number of programmes and opportunities are available in the country for scientists to go overseas. They are funded by the DBT, DST, INSA and MHRD and also by the outside agencies; British Council, USEFI, DAAD, etc. The ICAR also has made a provision for granting sabbatical leave to scientists. The Institute may actively encourage scientists to apply for these programmes. The ICAR presently provides a certain budget to the Institutes for HRD development. The IIISR may develop a policy to make this fund available to the scientists for attending international meetings; workshops, etc. This will encourage the scientists to produce better quality work and for presenting of better quality papers (Paras 3.86 -3.88). | Agreed. | The opportunities available for IIISR Scientists for deputation abroad are very limited as compared to other institutes due to policy issues. |
effects of climatic changes on their performance (growth and yield), even while closely recording both the general climate and microclimate. With data accumulated over a long period (say from 8-10 years), it may become possible to predict the effect of climate changes on yield using refined statistical methods. Efforts should also be made to develop appropriate cultural practices to suit the changing weather/climate (Para 3.73).

| 10.14 | **Field tolerance in varieties to be released:** Since pests and diseases are major factors limiting production and productivity of spice crops and there is no high source of resistance to these problems, in future, all varieties to be released by the IISR should be the result of deliberate and directed hybridization work, or in the alternative, and/or using cytogenetical or biotechnological approaches. Further, in all the crops while releasing a variety, it should be ensured that it possesses a minimum level of tolerance to the most important biotic stress/problems affecting the concerned crop, for e.g.: *Phytophthora* foot rot disease in black pepper, rhizome rot and/or bacterial wilt in ginger, rhizome rot in turmeric and virus diseases in cardamom (Para 3.59). | Agreed. IISR has already undertaken work in the suggested areas. A project on ‘Breeding of black pepper for yield, quality, drought and resistance to pests and diseases’ was initiated incorporating crosses involving parents resistant/tolerant to *Phytophthora*, pollu beetle, nematodes and drought with high yield. In cardamom, *katte* and rhizome rot tolerant varieties are included as parents in breeding programmes. While releasing the variety it is ensured that it possesses a minimum level of tolerance to the most important biotic stress. The ginger varieties Varada is field tolerant to rhizome rot, Rejatha is tolerant to root knot nematode and the black pepper variety Thevam to *Phytophthora*. |

| 10.15 | **New standards for black pepper:** In the last 2 decades, several new agroforestry species have been introduced and popularized. It may be worthwhile to relook at the standards being used in black pepper. An ideal standard for black pepper may be an evergreen or non-deciduous species; provide only moderate shade; posses ideally well developed root system; is fast growing, and preferably nitrogen fixing (Para 3.60). | Agreed. Trials with various standards for black pepper such as *Erythrina indica*, *E. lithosperma*, *Ailanthus malabarica*, *Glyricidia maculata*, *Garuga pinna*ita, *Artocarpus heterophyllus*, *A. hirsuta*, *Mangifera indica*, *Macronelia peltata*, *Leucaena leucocephala*, *Swietenia mahogani* and *Caesalpinia sapon* have been initiated in the field. |

<p>| 10.16 | <strong>Use of multi-lines:</strong> Cardamom and black pepper being perennial in nature and more sensitive to weather changes and biotic stresses, the Institute may consider using multilines and/or mixtures of 4-6 near-identical land races/varieties in these crops to provide an insurance or buffer to face the uncertain and unpredictable environmental changes (Para 3.69). | Agreed. IISR advocates growing more than one variety of any spice crop to check the horizontal spread of diseases and pests. |</p>
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<th><strong>10.24 Crop Production Programmes</strong>: The programmes in Crop Production require complete revamping. Generally they lack direction and focus. It may not be worthwhile to continue many of the ongoing programmes e.g: studying the influence of long term storage of black pepper on secondary metabolites. In commerce, it will not be considered economically feasible to extend storage period usually beyond one year (rarely, 2 years). Likewise the programme in biopesticides lacks a clear perspective, in the choice of the materials. This programme may be closed forthwith and the entire work done in this Division may be got reviewed. On some recommendations work has not been initiated without assigning any reason. E.g: 11.28: the possibility of incorporating nor/nif gene in black pepper for uniform ripening. The progress made on some of the recommendations in the earlier QRT reports appears to be inadequate: that a good start has been made in developing transgenics in black pepper using osmotin/chitinase/glucanase. This QRT was not presented with any data on this though this work is supposed to be underway for 5-8 years as per the ATR (Paras 4.6 to 4.8).</th>
<th>Agreed.</th>
<th>The work in organic chemistry has been reviewed. The existing project on biopesticides has been terminated. One of the research programmes in this project related to bioactive compounds has been shifted to the Mega project IX: “Development of integrated pest and disease management strategies in spice crops”. A compound possessing fungicide properties has been identified from Chromolaena odorata and efforts are being made to patent the same. The scientist in organic chemistry has been assigned work on characterization of germplasm of spices also.</th>
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<td><strong>10.25 Listing and naming of projects</strong>: The IISR may follow up the ICAR system for numbering of research projects. The QRT is not sure if the numbering system that is now being followed is in consonance with them in the case of long-running projects (e.g.: germplasm), after giving the general project title, the work proposed to be done in the next 5 years may be indicated as a byline. For example: In the Project, “Collection, conservation, evaluation and cataloguing of black pepper germplasm” if the work proposed in the next 5 years is collection from the remaining unexplored regions, and then this may be given as a byline. (Para 5.2 to 5.5).</td>
<td>Agreed.</td>
<td>The suggestion will be taken care of. At present IISR is following a numbering system as recommended by ICAR.</td>
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| 10.20 | **Developing specialization of horticultural scientists:**
The ISIR has 3 scientists in this discipline. All the scientists have been so far working mainly on vegetative propagation, grafting and related aspects. The QRT has already proposed (Chapter 3) that this programme could be pared off after a review. At the most, part time of one scientist will be adequate for completing the ongoing programmes. The scientists consequently released should be encouraged to develop programmes in crop physiology or improvement, where their services could be made use of more effectively. This point has been discussed elsewhere (Para 3.83). | Agreed. | The project on vegetative propagation of tree spices was closed in 1997. The scientists in horticulture, are also involved in various other research programmes under Crop Improvement Division like collection, conservation, cataloguing and evaluation of germplasm, developing and releasing improved varieties, production of quality planting materials, etc. |
| 10.21 | **Lead Centres:** Keeping in view the greater importance of cardamom, black pepper, turmeric and ginger (also red pepper), the Institute may consider developing Lead Centres, and ‘Advanced Programmes’ in these crops using one SAU for each crop for this purpose. Such Centres may be provided with additional scientific and technical staff and also more funding to carry out their work. Each of these Centres will be expected to arrange one or 2 training programmes in their respective crops for AICRPS scientists and, act as holding centres for germplasm and carry out quality testing for the AICRPS Centres (Para 3.89). | This pertains to AICRPs. Recognizing new centers with additional manpower and funds has also no provision in the Xth Plan. | No action needed. |
| 10.22 | **Follow up action on QRT reports:** The last QRT (1998) had pointed out that the ATR/ follow up action on the earlier QRT report (1993) was inadequate. The present QRT also reiterates this point. The replies furnished on several items did not enable the QRT to assess the progress. They were in the form of well-worn clichés like “in progress” “work initiated”. No explanations were provided where no action has been taken. Some replies either fail to throw adequate light on the progress or were difficult to accept. In future the Institute annual reports may include a section indicating action taken on the previous QRT report also. This should be reviewed also in the RACs (Paras 4.2 to 4.3). | Agreed. | The recommendation of QRT is seriously taken care of. ATR on QRT has been included in the Annual Reports and are being reviewed in the SRCs and RACs also. |
| 10.23 | The ISIR/ICAR is not obliged to accept all the recommendations of a QRT. It is free to indicate so, but after | Agreed. | The recommendation of QRT are seriously taken care of. ATR on QRT has been included in the Annual Reports |
| 10.29 | **Naming of varieties**: The improved varieties developed by IISR have been named fancifully. In future, when a new variety emanates as a selection from an already existing landrace of the crop, say Karimunda or Uthirankotta in black pepper, the name given to the selection may reflect that it is a selection from a particular landrace. For the rest, the IISR may use a common prefix such as 'Kufri' being used for potato varieties by the CPRI Shimla; and 'Arka' for all crops released by IHR. The variety names may consist of one or two syllables only consistent with the general practice (Para 5.22). | Agreed. | At present we follow the system of naming varieties prefixing IISR. |
| 10.30 | **Research on tree spices**: In case of the tree spices, clove, nutmeg, cinnamon, cassia and allspice, it is difficult to envisage that India can develop international trade in these crops. Hence the Institute may therefore limit its programmes to make the country self-sufficient in its requirements of these spices. However, the IISR may arrange a consultation about this aspect with all the interested development agencies. The IISR has been working on vegetative propagation from its inception in 1975 with 1-3 scientists working at different periods. In the Achievements Chapter of the 1998 QRT report, it is stated that “efficient vegetative propagation methods were standardized for clonal propagation in black pepper, cardamom, nutmeg, cloves, cinnamon, cassia and allspice” (pp.22-23). No such conclusive statements are made in the present Research Highlights document (2002). The IISR may now carry out a comprehensive review of the entire vegetative propagation work done till date and decide about the need for continuing this programme at the present level (Paras 5.24 to 5.26). | Agreed. | A comprehensive review of vegetative propagation of tree spices has been submitted. The final report of the projects on 'Vegetative propagation of tree spices' was submitted in 1997. |
| 10.31 | **Work on Piper colubrinum**: *P. colubrinum* is reported to be resistant to major pathogens of black pepper. The IISR has been working on this species since 1996 to use this species as a rootstock for black pepper. Grafting black pepper on *P. colubrinum* is stated to give moderately good success (about 60%-70% after 2 years), but no data has been provided to indicate its effect on black pepper scion yield. The report also states at some point that *P. colubrinum* can withstand water | Agreed that any further work needed to be done may be decided after making a comprehensive assessment of the results obtained so far. | Grafting of black pepper in *Piper colubrinum* has been standardized and these grafts were evaluated in farmers' fields and in the farm at Peruvannamuzhi. The oldest trial is 10 years old and the grafted pepper gave an average yield of 3 kg green berries/vine with a highest yield of 7 kg green berries/vine. |
| 10.26 | **Germplasm studies:** The Institute has made good advances in the collection of genetic resources of all the major crops. However, there is a drop in the number of accessions being maintained in *in vitro* condition in the 2003 report as compared to the 1998 report. The current reports do not indicate that evaluation, and cataloguing have gone on pace with the collection programme. Therefore, the IISR may use the next 5 years primarily for evaluation, conservation and cataloguing of all the available genetic resources. The IISR may use the IPGRI descriptors wherever available. Otherwise, it may develop its own descriptors. As and when these data are generated, a revised edition could be brought out subsequently. This is the only way that IPR and patent protection can be ensured for the native genetic resources of the country (Paras 5.5 to 5.10). | Agreed. | IISR has catalogued 750 accessions in black pepper and 100 accessions in cardamom using IPGRI descriptor. For the rest cataloguing has been completed based on minimum descriptors. A dozen promising accessions of various spices have been registered with NBFG, New Delhi. |
| 10.27 | No reports were made available to indicate that the IISR has carried out adequate checks to ensure the genetic integrity of the germplasm being maintained *in vitro* (medium term) by using the protocols developed by the Institute. If this has not been done, the Institute may initiate studies both at the biochemical and molecular levels (in addition to of course at the traditional morphological level) to verify this. Till this is satisfied, the *in vitro* system of germplasm maintenance may be kept in suspense. As and when this is done, the Institute may conserve one set of germplasm in this condition also (Para 5.11). | Regular checking of fidelity of *in vitro* germplasm is being conducted in cardamom, ginger and vanilla. | Studies were taken up to check the genetic integrity of germplasm maintained in the *in vitro* gene banks. Molecular profiling by randomly selected *in vitro* materials of cardamom, ginger and vanilla had proved their genetic integrity after 5-6 years of culture. Work is in progress in all other crops also. Random checking of fidelity of *in vitro* maintained germplasm was done regularly as a part of DBT funded project. |
| 10.28 | The present manner of conserving germplasm in the open or permanently in the juvenile phase is considered both unscientific and unsatisfactory. The IISR may therefore give very high priority to developing insect-proof net houses with artificially provided shade for maintaining germplasm of these crops (Paras 5.11, 5.12). In a permanent arrangement the IISR may conserve its entire germplasm in controlled environment glass houses. A duplicate set should also be maintained at Appangala. | Not manageable and adding huge cost of operation. | With a collection of over 3000 accessions of black pepper, it is difficult to maintain them in insect proof net houses as it requires a large area under insect proof conditions and huge recurring costs. Black pepper germplasm is conserved in bamboo splits, with is the only solution available at present to minimize the losses of genetic resources, and is used to augment and not to replace the field gene banks. Ginger and turmeric accessions are harvested each year, stored separately and replanted in cement tubs in duplicates. A set of select black pepper germplasm is also being maintained at CPCRI Regional Station at Kidu. |
| 10.34 | The work distribution among scientists working in biotechnology seems to be skewed. One of the scientists has been involved in nearly 9 projects. They are mostly externally funded and cover diverse areas such as cryopreservation, genetic transformation, marker assisted selection, and micropropagation. The maximum number of externally aided projects be restricted to 2 per scientist and all the scientists may specialize on a particular aspect of biotechnology (Para 5.35). | Agreed. | The number of projects being handled by a scientist is now restricted to 3. |
| 10.35 | The biotechnology laboratory has excellent facilities. However, many equipments were never or sparingly used. For example, gene gun and cryopreservation equipment. Dilution of the work can be further exacerbated by one of the scientists guiding as many as 10 PhD students (Para 5.36). | Agreed. | In view of lack of continuous supply of liquid nitrogen facilities at IISR and else where, this equipment is used only to develop protocols at present. The number of PhD students per scientist is now restricted to a maximum of five. |
| 10.36 | The number of PhD students/scientists must be curtailed to a maximum of 5 for senior members and 2 for junior/middle level scientists. All the plant breeders and cyto geneticists have taken a fascination for biotechnology at the expense of their discipline, while posts of biotechnologists lie vacant (Para 5.36). | Agreed. | The number of PhD students/guide is 5 at present. Dr. T. E. Sheeja, Scientist (Sr. Scale) (Biotechnology-Plant Sciences) has joined in the vacant post of Biotechnologist. |
| 10.37 | **DNA marker technologies for fingerprinting:** The spice germplasm collections have to be characterised by using PCR based techniques. A large number of primers may be screened and the informative RAPD markers may then be converted into SCAR markers which are more robust and highly reproducible (Para 5.38). | Agreed. | Conversion of the RAPD markers linked to important agronomic characters to SCAR markers are in progress. Molecular characterization of cardamom (106 lines), black pepper (100 lines), vanilla (20 lines) and ginger (96 lines) was done using RAPD (about 50 primers), ISSR and RFLP-PCR techniques. |
| 10.38 | **Molecular mapping in black pepper:** Molecular genetic map consisting of only molecular markers of useful traits such as disease resistance, early or late maturity etc., may be developed which could be used in marker-assisted selection and breeding. A good segregating population is a prequisite to identifying such linked markers. The application of molecular technologies in black pepper would benefit through easy access to cloned genes of agronomic importance. The generation of partial cDNA sequence information (ESTs) derived from cDNA clones (especially differentially expressed genes) provides fast and | Agreed. | Two mapping populations with good segregation for various agronomic characters were already prepared and are being used. So far about 150 markers were screened in the mapping population (Panniyyur I and Subbakara). Segregation of resistance to *Phytophthora* was recorded in this population and the work is in progress. |
logging, but black pepper is hardly cultivated in such situations, and hence this cannot be considered an advantage. The QRT therefore feels that if any further work is needed to be done, this may be decided only after making a comprehensive assessment of the results obtained so far. The QRT recommends the suspension of this work (Para 5.27).

| 10.32 | **Cytogenetical studies:** The results presented in the reports do not indicate either new data or new approach, especially in the last 5 years. Much of the information presented in the Research Achievements (pp.18-20) is restatement of information already known such as chromosome number, chromosome morphology, data on sterility, etc. The work in the cytogenetics may be confined to studying the remaining aspects of flowering and sterility in ginger and turmeric, with a view to enhancing fertility and hybridization. This should include also embryological and genetic aspects (Para 5.29). | Agreed. | A project on 'Investigations on the reasons and solutions for absence of seed set in ginger' was initiated in 2005. Cytological studies on turmeric seedling progenies alone is being carried out. |

| 10.33 | **Biotechnology:** The work done in this area has been presented (Appendix 6). Successive QRTs have been emphasizing on the need to utilize biotechnology tools to tackle problems in spices. The results presented cover a wide ground but the results are meandering and descriptive in nature; hardly any results are presented, and merely stating that a particular work has been done. Several aspects have been touched upon and no detailed progress is reported on any aspect (Para 5.29). | Agreed. | The Biotechnology programmes have been reorganized to augment conventional breeding programmes in the field of micropropagation, in vitro conservation, molecular profiling, identification and cloning of candidate genes for foot rot resistance and transgenic research. RAPD and ISSR profiling of most of the crops has been done. Five putative transgenics in black pepper were multiplied for disease and drought screening. Molecular profiling of cardamom (106 lines), black pepper (100 lines), vanilla (20 lines), ginger (96 lines), turmeric (100 lines), nutmeg (10 lines), garcinia (10 lines), clove (10 lines) and cinnamon (15 lines) was completed and their relationship studied. Mapping populations are being developed to tag resistant genes for *Phytophthora*, poliu and Caryophyllene content. On farm evaluation of tissue cultured plants in 100 ha have been taken up. Protocols for large scale multiplication of large cardamom, ginger and turmeric have been sold to commercial laboratories like TERI, New Delhi and Cargi Biotech, Pune. |
early as in 1999 for various crops. The group working on pepper tissue culture deserves appreciation by the QRT. This protocol should be put to use in evolving transgenic cardamom lines. Protoplast technology research has been stopped in many crops including rice due to its laboriousness. In the absence of any immediate and stated goals, protoplast research on cardamom may be stopped. Cardamom tissue culture research may be continued in Appangala. There is no concerted effort to evolve somaclones of ginger expressing resistance to major diseases and to test them under sick plot conditions or under artificial conditions. There is also no planned effort to achieve transformation goals in ginger. It is surprising why tissue culture protocols could not be exploited in the pepper transformation. This needs to looked into (Paras 5.47 to 5.50).

**10.42 Integrated plant nutrient management**: The earlier reports (1998, 1999) indicate that several fresh approaches were under trial in IISR, such as DRIS, IPNM, HPT (high production technology), etc. But no results are reported further on these except some results on the IPNM. The results presented on the major (NPK) and the important micronutrients (Zn, B, Mo) are repetitions and also show marginal variations (NPK requirements of black pepper are broadly given as 140, 55 and 260 kg/ha in the 1998 report; as 150, 60 and 270 and 150, 40 and 280) kg/ha in the 2002 report). So also for Zn, B and Mo. In future, at least for the major nutrients, the recommendations may not be based solely on manurial trials carried out with graded doses of N, P and K; Instead, they may be based on nutrient removal studies taking into account the nutritional status of the soil and targeted yields. Efforts should be strengthened on INM and organic farming work (Paras 5.54 to 5.56).

**Agreed.**

**Experiments on nutrition removal studies in black pepper; ginger and turmeric are included in the current research projects taking into account the nutritional status of soil and plant uptake, thereby targeting the yield, so that a need-based recommendation for major nutrients can be made.**

On micronutrients, studies on obtaining the critical levels and also target-based application are in progress in black pepper, ginger and turmeric.

**10.43 Biofertilizers**: The QRT suggest taking up a detailed and objective review on the feasibility and effects of using *Azospirillum*, *Azolla*, phosphobacteria and VAM in spice crops. The possibility of building up the population of these soil amending organisms on a sustainable basis, their population build up in the soil and their ability to develop in 'soil crops' may require attention (Paras 5.59 to 5.60).

**Agreed.**

**Studies on Azospirillum application on black pepper indicated that it is beneficial for enhancing the yield when applied along with inorganic N, P, K and Mg. The population of bacteria also increased substantially due to its application.** Populations of *Azospirillum* and phosphobacteria are being monitored under different maangeemnt systems.
<p>| 10.39 | Major emphasis is to be given for identification and cloning of resistance genes and improving the efficiency of conventional and molecular breeding in black pepper through functional genomics approach. Under these circumstances, it is desirable to impart training to one or two of the scientists on the following aspects: (a) Identification of conserved motifs and primer design (for isolation of specific genes); (b) Isolation and cloning of full length cDNAs; and (c) Subcloning of genes in expression vectors and functional characterization of proteins (Para 5.40 to 5.44). | Agreed. | Already a research programme funded by DBT is in progress for identification and cloning of resistant genes in black pepper to improve the efficiency of conventional breeding. Genomic and DRRT PCR approaches are used. An ICAR Ad-hoc project ‘Full length sequencing of cDNA corresponding to resistance and defense genes’ was sanctioned. A part of the resistance gene from <em>Piper colubrinum</em> was sequenced. |
| 10.40 | Transgenic research: Recombinant DNA (transgenic research) could be done only under the direction of an Institutional Biosafety Committee (IBSC) as per the safety guidelines. A perusal of the Annual Reports indicates that there was no organized effort to perform transgenic research on spices. The equipment was not in working condition since 12.10.1998. Antibiotic sensitivity of black pepper has been reported to be checked with different antibiotics which is unnecessary. The necessity of checking sensitivity of a callus line to hygromycin or kanamycin is decided by the construct used in transformation studies. It is enough to do sensitivity studies after deciding the type of construct to be used. In 1996-1997, the threshold of kanamycin was reported to be 250 mg/ml while in 2001-2002, it was 100 mg/ml. Further, the quantities of kanamycin tried are abnormally high. Normally, it is 100 or 250 mg/l of the medium. There was no transgenic spice plant evolved and the results reported in most Annual Reports are repetitive. The QRT recommends that a through review of the Biotechnology work may be done and fresh directions given by interacting with the organizations mentioned earlier in the text (Para 5.45 to 5.46). | Agreed. | <em>Agrobacterium</em> mediated transformation method is adopted in monocots. The earlier report of threshold of Kanamycin @ 100 and 250 mg/ml was a typographically error which was actually microgram/ml. While the mature tissues from the field grown plants showed resistance up to 250 microgram/ml Kanamycin, the juvenile tissues from somatic as well as zygotic embryos are more sensitive at 100 microgram/ml. The programme was reviewed by RAC. The IBSC was reorganized and activated. It has met once in six months and ratified the transgenic and other related works on Biotechnology. Five putative transgenics of black pepper with osmotin were planted and PCR screening indicated the presence of osmotin. Preliminary screening indicated that one of them gave tolerant reaction to <em>Phytophthora</em>. Twenty five more putative black pepper transgenics of osmotin were also produced. |
| 10.41 | Tissue culture: A perusal of the Annual Reports pertaining to this QRT period indicates a reproducible tissue culture protocol based on direct/indirect embryogenesis has been achieved as | Agreed. | Work on black pepper transformation is in progress. About 200 somaclones in ginger were screened for disease resistance for <em>Pythium aphanidermatum</em> and |</p>
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<th>10.46</th>
<th><strong>Organic farming:</strong> Organically produced produce (including foods, spices and condiments) fetch 30%-50% premium price. In India, the APEDA has taken some steps to promote the production of organically produced food materials for export. They have identified the SB as the nodal agency to promote organic farming in spices. The IIHR may take up some work in this area in nonperishable products like black pepper, cardamom, turmeric, etc. The IIHR may strengthen its programmes through encouraging vermicompost, INM including FYM/compost. India has a tremendous scope in organic farming specially on spices where the use of inorganic fertilizers and chemicals is limited (Para 5.55).</th>
<th>Agreed.</th>
<th>The institute has started projects on organic cultivation of black pepper, ginger and turmeric by following standardized practices of using composts/bioagents. An ICAR network project is also is progress to develop packages for organic farming in major spice crops.</th>
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<td>10.47</td>
<td><strong>IPM technologies for Phytophthora</strong> foot rot of black pepper, rhizome rot of ginger and cardamom, ‘pollu’ beetle of black pepper, and shoot borer in ginger and turmeric have been developed and recommended. Some of the areas, which need attention are as follows (Para 5.78 to 5.81): 1. Host-parasite interactions at different stages of disease development. 2. Standardization of methods for early detection of the pathogens. 3. Variability observed in <em>P. capsici</em> should be further characterized and their distribution studied. 4. Extensive screening of the germplasm using molecular marker for identifying resistant/tolerant lines. 5. Accession P-24, is tolerant to <em>P. capsici</em>, and should be used in breeding programmes. 6. Trials may be undertaken for evaluating the performance of identified resistant rootstocks in black pepper, and search for desirable rootstocks should continue.</td>
<td>Agreed.</td>
<td>1. Activation of defence enzymes such as PAL, 1-3, glucanases and chitinases has been studied in <em>P. capsici</em> - <em>P. nigrum</em> pathosystem. 2. Standardized ELISA and PCR based methods for detection of various pathogens in planting materials of black pepper, vanilla and ginger. 3. Molecular and morphological characterization of <em>P. capsici</em> isolates revealed variability in virulence. rDNA analysis further revealed that the isolates shared the characters of both <em>P. capsici</em> and <em>P. tropicus</em>. 4. Sequence Characterized Amplified Region (SCAR) markers have been identified for Marker Assisted Selection for <em>P. capsici</em> tolerance in black pepper. 5. P-24 (IIHR-Sakht) is being used in the breeding programmes and the segregating progenies are being evaluated for <em>Phytophthora</em> resistance. 6. Trials are in progress to evaluate the performance of <em>P. colocrymmum</em>. Various other species of <em>Piper</em> are being evaluated for their resistance.</td>
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<td>10.48</td>
<td><strong>Black pepper</strong> is affected by phylloyd disease, which causes malformation of flowers and spikes. The vector and alternate hosts of this malady may be identified and appropriate measures may be developed to check the spread of this disease to other growing areas (Para 5.82).</td>
<td>Agreed.</td>
<td>Two species of plant hoppers were observed to be consistently associated with phylloyd affected vines. Etiology of the phylloyd has been confirmed and the pathogen has been identified by analyzing 16s rDNA sequence.</td>
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10.44 **Drought tolerance:** The findings on drought tolerance given here are descriptive in content and preliminary in nature and well known in literature. Basic work on drought resistance and breeding efforts should be made to mitigate/minimize the adverse effect of drought through agronomic/cultural manipulations such as suitable mulching, pruning, training, etc. The 2 scientists available in Plant Physiology, and possibly, 1-2 currently doing Horticulture work (vegetative propagation) may work full time or most of their time in this area. Presently, crop physiology research is largely overlooked. The following lines of work are suggested to begin with: (a) monitor the effects of climatic change in selected crops, especially, those grown as understorey crops; (b) Climate change: In the selected crops, 4-6 most popular varieties may be grown in permanent observation plots; then, both the microenvironment and weather and growth and productivity may be monitored closely for 8-10 years. The crops may be given the same inputs every year (much like the permanent manorial trials). From this, it may be possible to predict the effect of impending climatic changes on yield of crop; (c) Light requirements: The understorey spice crops are known to prefer partially shaded conditions for optimum growth and performance. But, no reliable data are available on the actual light requirements of these crops. Hence the IIISR may study the effects of different levels of shade/light on growth, development and production in these crops (black pepper, cardamom, ginger) using controlled conditions of shade. Alongside, if possible, the effect of moisture stress may also be monitored. Characters such as disposition and number of leaves, water potential of leaf effect of epidermal wax, and such other characters may also be monitored (Paras 5.61 to 5.62).

Agreed.

The germplasm of black pepper and cardamom have been screened for drought tolerance. The tolerant accessions identified in cardamom (APG 244, CL 893 and APG 298) and black pepper (Accs. 1495, 931 and 813) have been included in breeding programmes. Soil conservation techniques such as mulching and provision of contour staggered trenches have been suggested to protect the crop. The light requirement has already been worked out and 50% filtered light was optimum. Photosynthesis was worked out using artificial light at varying light intensities and light intensity of 500-800 μ was optimum.

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10.45 **The detrimental effects of plant protection chemicals are well known.** A scientist in IIISR has been working on naturally occurring plant products but no definitive leads have been obtained. Even the choice of plants used in such studies has been done without a proper rationale; for instance, use of *P. colubrinum*, *Pimenta*, etc. It is felt that it may not be worthwhile to continue this work. Further, the IIISR may assess the work so far done in the Organic Chemistry (Para 5.65).

Agreed. New programmes will be formulated.

The work on organic chemistry was revised with the advise of RAC. The scientist in Organic Chemistry is also working on characterization of spice germplasm.
management of major insect pests. 4. Identify useful botanicals for their potential application in pest and disease management. This will be useful for organic farming. 5. Identify agrochemicals effective against major pests and diseases for use in crisis management and develop methods for detecting their residues, so that, if a pesticide is recommended for use, a safe limit can be maintained. 6. Investigation should be taken up for determining safe limit of various pesticides used for managing pests and diseases of black pepper. 7. Work needs to be initiated on post-harvest processing, packaging and storage for checking residues and maintaining minimum microbial load meeting WTO/SPS related requirements.

project titled “Development of consortium of bioinoculants for management of pests, nematodes and pathogens in spice crops” was initiated during 2004 to intensify research on this aspect. 2. Potential bio-agents of insect pests, nematodes and pathogens of spice crops have been identified and mass multiplication methods standardized for most of them. 3. In view of the non-availability of adequate number of scientists in the Entomology Section a project on ‘Identification, characterization and evaluation of pheromones against pollu beetle of black pepper’ was submitted to DBT for funding. 4. Extracts of various plant species and commercial plant products have been evaluated against pollu beetle of black pepper among which, leaf extracts of Strychnos nux-vomica and Chromolaena odorata and seed extract of Annona squamosa were promising. Among the commercial products, Neemgold was effective and was recommended for the management of the pest. Various plant products have been evaluated against scale insects among which neem oil 0.3%, Neemgold 0.3% and fish oil rocin 3% were promising. Evaluation of plant products against root mealybug indicated that extracts of Azadirachta indica, Vitex negundo, tobacco extract 3% and custard apple seed extract 2% were promising. Aqueous extract from Chromolaena odorata was inhibitory to Phytophthora capsici and is being characterized for possible patenting. 5. Chemicals such as metalaxyl-mancozeb, copper oxychloride, potassium phosphonate and Bordeaux mixture are routinely being used whenever the diseases reaches an epidemiotic proposition. Evaluation of new agrochemicals is in progress against root mealybug of black pepper and shoot borer of turmeric. 6. Pesticide residues are being determined in other laboratories and are recommended only if they are below the safe limits. 7. Pesticide residues levels in the produce are being determined and chemicals are recommended only when the residues are below permissible limits. 8. Studies on post-harvest processing,
<p>| 10.49 | The slow decline disease of black pepper is reported to be caused by feeder root damage by <em>P. capsici</em>, <em>R. similis</em> and <em>M. incognita</em> either individually or by combined infections. The following items of work are suggested (Para 5.81): Methods should be developed and used for keeping nurseries free of nematode infestation. Nursery plants should be tested for freedom from nematodes before they are supplied to growers. This will also help in checking the inadvertent spread of nematodes. Investigation on biological control of nematodes need to be intensified. | Agreed. One externally funded project is in operation. | Nursery mixture is solarized to get rid of the resident nematode inoculum. The solarized potting mixture is fortified with biocontrol agents like <em>Trichoderma</em> and promising rhizobacteria. Chemical control measures such as application of phorate is resorted to if nematode infestation is noticed in nurseries. All the nurseries are periodically inspected and random samples collected to check for the presence of nematodes. Nematode status of all the existing nurseries was ascertained through systematic sampling. Rapid multiplication of black pepper through bamboo method is discouraged as nematode problems are severe in such nurseries. Research on biological control of nematodes was intensified through institute projects, externally funded projects and student projects. The promising organisms short-listed through greenhouse trials are evaluated first in black pepper nurseries. A new externally funded project titled ‘Endophytic bacteria for the biological system management of <em>Radopholus similis</em>, the key nematode pest of black pepper’ funded by DBT, New Delhi was taken up during this period. |
| 10.50 | Major and minor insect pests have been documented and management strategies evolved for them. The following items of work are suggested (Para 5.84). 1. ‘Pollu’ beetle is recognized as a major pest. The identified sources of resistance must be used to develop resistant varieties using conventional breeding and marker aided selection. 2. Biology, including population dynamics of virus vectors should be investigated. This will help in developing managements practices. | Agreed. | 1. The identified sources of resistance in black pepper against pollu beetle are being utilized to develop resistant varieties by using both conventional and molecular aided selection programmes. 2. The biology and population dynamics of aphids and mealybugs that are vectors of viral diseases of black pepper was studied. |
| 10.51 | The QRT suggests the following strategies for integrated pest and disease management in black pepper (Para 5.58 to 5.80): 1. Develop effective biocontrol technology for various pests and diseases and integrate them for different black pepper growing areas. 2. Document identified biocontrol agents and standardize procedures for mass rearing of potential biocontrol agents and their utilization in the field. 3. Identify pheromones for use in the | Agreed. | 1. Field trials have already been conducted for bio-control of <em>Phytophthora</em> root rot disease and integrated with other methods of control. These strains are being supplied to growers for field application as well as to entrepreneurs for mass production. Field trials were undertaken with biocontrol agents for the management of nematodes and rhizome rot disease of ginger. A new |
| 10.55 | Ginger rhizome rot caused by <em>Pythium</em> spp. and wilt caused by <em>Ralstonia solanacearum</em> are the two major disease problems in ginger. Although management practices are evolved the QRT suggests the following programme for developing effective strategies (Para 5.93 to 5.96): 1. Techniques should be developed for simultaneous detection and monitoring of all soil-borne pathogens. 2. Integrated management of soil-borne pathogens needs to be developed. 3. Critical factors leading to rhizome rot (as well as bacterial wilt) need to be determined. 4. Etiology and interaction of pests and pathogens associated with rhizome rot should be determined. | Agreed. | 1. Standardization of simultaneous detection of <em>Pythium myriotylum</em> and <em>Ralstonia solanacearum</em> from soil and rhizomes by molecular method is underway. 2. Integrated management schedules involving clean seed, fungicide and biocontrol agent application, rhizome treatment and strict phytosanitation was standardized. 3. The critical factors leading to rhizome rot (as well as bacterial wilt) was studied. The study led to the understanding of the role of planting material in the dissemination of pathogens in ginger growing areas. 4. The etiology of rhizome rot complex of ginger was studied and the causal organisms identified. |
| 10.56 | The QRT is of the firm view that the most effective method of managing the disease is to use completely disease free planting material. This recommendation may be got validated through the AICRP, and after this, the recommendations may be widely publicized. The QRT is of the view that recommending the use of infected seeds after solarization treatment is fraught with several risks. | Agreed. | Seed rhizome treatment by solarization and hot air treatment was effective against bacterial wilt. These methods can be exploited for production and section of disease free seed rhizomes. The technology would be recommended only after confirming that the technique is safe and effective. |
| 10.57 | The QRT was further informed that a new programme on this malady is being initiated. The QRT could not see the details of the project. It may be premature to go in for molecular approaches even for disease detection at the present stage of the work. The scientist would be advised to review the literature on this pathogen when affecting other vegetatively propagated crops. | Agreed. | The scientist has made a review and contributed a chapter on 'Bacterial diseases of ginger and their management' in a monograph on Ginger-the Genus Zingiber, CRC Press. |
| 10.58 | The QRT was informed of several emerging diseases in various spice crops-anthracnose and stunting in black pepper, chlorotic streak and mosaic in ginger, <em>kokke kandu</em> disease in small cardamom, chirkey and furkey disease in large cardamom, mosaic in vanilla and so on. With the present very limited manpower resources, the QRT does not feel prudent to recommend any research programmes on them. Needless to say, the Plant Protection scientists may like to keep a vigil on the situation to ensure that the IISR is not caught napping if and when an epidemic breaks out. | Agreed. | Etiological studies on anthracnose and stunted disease of black pepper has been carried out and causal agents have been identified, characterized and management strategies have been developed. Three viruses associated with vanilla also identified, characterized and sensitive detection methods developed. |</p>
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<td>10.52</td>
<td>DAC project on foot rot management covered 58% of the area under black pepper in Kerala, it should be considered a very major initiative at the national level for any disease management in any crop. Since the work was completed in 1997, the IISR may undertake a major field survey to study the residual impact of the project in the state to determine the extent of adoption. The IISR may also arrange a consultation of all the interested agencies to develop a harmonized set of recommendation for the malady and to identify weaknesses in the existing recommendations for further study (Para 5.77 to 5.80).</td>
<td>Agreed.</td>
<td>The Social Science Section is undertaking a project to assess the impact of various technologies developed by the institute including management of foot rot. Consultation with various developmental agencies are regularly held to identify weaknesses in the existing recommendations for further study.</td>
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<td>10.53</td>
<td>The Plant Protection and Crop Improvement divisions of IISR may undertake a programme to screen of 100,000 seedlings (both OP and hybrids) annually for their disease reaction and develop a schedule for screening 4-6 vegetative generations for their disease resistance and economic performance. A decision may be taken that in future no black pepper variety would be released unless it possesses a minimum level of resistance. The Plant Protection Division may undertake systematic studies to understand the exact nature and mechanism of resistance to the disease with a view to using biotechnological techniques in <em>Phytophthora</em> foot rot breeding programmes (Para 5.80).</td>
<td>Agreed.</td>
<td>One of the on-going long term programmes is to screen promising accession for <em>Phytophthora</em> resistance. OP seedlings are being raised and evaluated for resistance. A disease tolerant progeny was released as IISR-Shakthi. Progenies were raised from this OP tolerant line and evaluated for <em>Phytophthora</em> resistance and one progeny (F2) was moderately resistant. Also identified three hybrid progenies having moderate resistance to <em>Phytophthora</em>. The nature and mechanism of disease resistance have been studied using molecular methods.</td>
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<td>10.54</td>
<td>One of the major production constraints in cardamom is the occurrence of viral diseases. Although <em>kutte</em> resistant line has been developed and released, the QRT suggests that viruses causing diseases in cardamom should be characterized at molecular levels and virus specific antisera be produced for use in identifying sources of resistance to specific viruses and their use in developing virus resistant lines. The QRT also suggests that management practices be refined and search for resistant genotypes intensified (Paras 5.90 to 94).</td>
<td>Agreed.</td>
<td>Cardamom mosaic virus associated with <em>kutte</em> disease has been characterized at molecular level with the help of Madurai Kamaraj University. The virus showed high level of divergence among the geographical isolates of cardamom. Efforts are on to characterize the causal agents associated with <em>kokke kanu</em> disease. Management practices refined by including early detection of virus in planting material and recommending resistance varieties (IISR Vijetha) for cultivation. Further many <em>kutte</em> and <em>kokke kanu</em> resistant lines are under evaluation.</td>
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<td>10.61</td>
<td><strong>Production of pathogen-free planting material:</strong> The major pathogens causing foot rot and slow decline in black pepper are reported to be carried inadvertently from nursery to the main field. Hence protocols for producing quality, pathogen-free planting material must be standardized and implemented. An approach for this purpose was recommended by the previous QRT; this needs to be implemented with suitable modifications based on current knowledge and technologies. A standard should be developed for quality testing of plants before these are supplied to the growers (Para 5.58 to 5.61).</td>
<td>Agreed.</td>
<td>Methods have been standardized for production of disease-free planting material along with detection methods for viruses and soil borne pathogens. A committee has been constituted to ensure production and distribution of quality planting materials free from pests, pathogens and nematodes. The committee has formulated protocols for testing and certifying the quality of planting material.</td>
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<td>10.62</td>
<td><strong>Adoption of the technologies:</strong> No data was produced on the extent of adoption of the technologies developed except in the case of foot rot management. One of the mandates of IISR is “to monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of the farming community” The KVK should also be used effectively for adaptive research and field testing of technologies developed by the institute (Paras 6.12, 6.13).</td>
<td>Agreed.</td>
<td>A project on ‘Adoption, diffusion and impact of varieties of major spice crops, scientific technologies as well as institute services’ has been initiated. The technologies developed at the institute are being demonstrated to the farmers through KVK.</td>
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<td>10.63</td>
<td>The IISR has released 18 improved varieties of spice crops over the years. No information or data is however available on the extent of spread and popularity of these varieties and also determine the farmers’ perceptions about them. The IISR may undertake jointly with the respective SAUs and DASD periodical consolidation of data say, once in 5-10 years, to assess the extent of spread of the released varieties and farmers’ perceptions about them (Para 6.1).</td>
<td>Agreed.</td>
<td>Studies on the extent of spread and popularity of released varieties and the farmers’ perceptions about them is in progress. The project follows an indicator approach to assess the survey data and data collected from secondary sources of information. A survey questionnaire has been prepared and pre-tested before field survey.</td>
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<td>10.64</td>
<td><strong>Interactions and linkages:</strong> The QRT Report 1998 included a very comprehensive list of 28 institutions and agencies within the country with which the IISR has established linkages. No evidence to indicate that IISR had any fruitful interactions with most of these was made available. It is felt more prudent to short-list the number of institutions and then establish durable and effective linkages with fewer organizations such as AICRPS, SB, CSIR, DFRL Mysore, UPASI Coonoor, PDBC Bangalore, NBPG New Delhi, NRCs for Plant Biotechnology</td>
<td>Agreed.</td>
<td>The number of institutions with which linkages are to be maintained was short-listed to develop durable and effective linkages with these organizations.</td>
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<td>10.59</td>
<td>In spices such as black pepper, cardamom, ginger and turmeric soil borne diseases are production constraints. The IISR has done good work in developing management methods for containing pepper wilts and also in identifying good soil ameliorants. In fact, this may be even considered as one of the major accomplishments of the Institute. The QRT feels that to advance these studies further to more critical levels, the IISR will benefit by having a scientist specialized in soil microbiology. The field experience of farmers should also be documented and used for developing practical management practices (Para 5.58 to 5.61).</td>
<td>Agreed.</td>
<td>There is no post of soil microbiologist in position at IISR, Calicut. However in various externally funded projects, SRFs and RAs are recruited for the purpose of conducting soil microbiology related experiments. The indigenous technical knowledge (ITK) available with the farmers is being documented through the Krishi Vigyan Kendra (KVK) and relevant information will be made use of after validation.</td>
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<td>10.60</td>
<td>IPM practices should be developed to manage diseases, nematodes, insect pests and weeds (Para 5.58 to 5.101). 1. Stress should be given to biological control. 2. Predators and parasites of shoot borer and rhizome scales should be identified for use in biocontrol. 3. Studies should be undertaken on the use of pheromones and their application in controlling the pests like shoot borer. 4. Comprehensive pest and disease forecasting systems should be developed. 5. Studies on storage pests and diseases need to be taken up on priority, for their management and minimizing myco-toxin contamination.</td>
<td>Agreed.</td>
<td>Institute projects are formulated in order to develop IPM strategies for various pests and pathogens of spice crops. 1. Adequate stress is being given for biological control of pests and pathogens. A new project entitled “Development of consortium of bioinoculants for management of pests, nematodes and pathogens in spice crops” was initiated during 2004 to intensify research on this aspect. 2. Predators and parasites of shoot borer and rhizome scale of ginger were documented and potential species identified for use in the biocontrol programmes. 3. Studies on pheromones and their application in management of shoot borer would be undertaken when adequate manpower is available in Entomology Section. 4. The economic threshold level of pollu beetle infestation on black pepper and a sequential sampling strategy as a guidance for initiating control measures has already been developed for shoot borer of ginger. The weather factors conducive for occurrence of Phytophthora foot rot and spike shedding in black pepper has been studied. 5. The insect pests occurring in stored ginger have been documented. Screening of dry ginger rhizomes of various ginger/turmeric accessions for locating resistance sources was undertaken. Further detailed studies would be undertaken when adequate number of scientists are available in Entomology Section. Studies on post-harvest processing, packaging and storage for minimizing microbial contamination is being undertaken through an ICAR Network Project.</td>
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<td>10.68</td>
<td>The present contacts of IISR with SB are good, but need to be made more effective and enduring. The existing system should be structured by providing a regular six monthly/annual documented feedback from the SB to IISR indicating the relevance of the newly developed technologies and a feedback with respect to the specific constraint in adopting recommended technologies. Similarly the IISR should share their experience on the outcome of some new technology under process of development. IISR and SB has good relations with the traders on plantation crops but the relationship with the seed spices trade, which is located more in northern part of the country is weak. This needs to be strengthened (Para 7.12).</td>
<td>Agreed.</td>
<td>Scientists of IISR are being invited to chair various sessions in the SRCs of ICRI (SB). Similarly scientists of ICRI are also invited to attend and chair various sessions of workshops of AICRPS. Collaborative programmes on cardamom and vanilla is being undertaken with ICRI.</td>
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<td>10.69</td>
<td><strong>Linkages with KAU:</strong> The KAU is represented in the IMC of IISR, but there is no reciprocal representation of IISR in any of the bodies of KAU. It is felt advantageous to strengthen linkages to complement the efforts of each other (Para 7.13).</td>
<td>Agreed.</td>
<td>Noted.</td>
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<td>10.70</td>
<td><strong>Research extension linkages:</strong> KVK, Peruvannamuzhi is presently the main source of extension activities of IISR. The mandate of IISR is restricted to the research on spices whereas the KVK has the responsibility for the overall training on all the crops, fisheries, livestock and home sciences. The staff at KVK needs to get regular training and updated information. It is therefore essential to develop a structured relationship between the KVK and KAU (Para 7.14).</td>
<td>Agreed.</td>
<td>KVK is maintaining active collaboration with KAU and other ICAR institutes in extension programmes. The staff of KVK attended training programmes conducted by ICAR institutes, NAARM, TNAU, KAU, etc. The KVK staff also get updated information from KAU, and other research institutes.</td>
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<td>10.71</td>
<td>The KVK has 20 ha of land out of which only 5 ha has been developed and is under use. Necessary funds should be provided for developing additional 5 ha land. The functioning of KVK is seriously suffering for want of staff, specially a regular Training Officer. A Principal Scientist (Hort.) of IISR is in charge of the Experimental farm and also the KVK. This seriously hampers functioning of KVK which needs a fulltime head. The posts of other technical staff lying vacant may also be filled up (Para 7.15 to 7.17).</td>
<td>Director, IISR Calicut take necessary action.</td>
<td>The vacancy positions have been informed to the Council and advertised. At present a Senior Scientist is exclusively looking after the KVK activities. Three training associates one each in Home Science, Plant Protection and Fisheries were appointed for six months on contract basis and a regular Stenographer has been appointed to KVK.</td>
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& DNA Fingerprinting, both at New Delhi, IARI New Delhi and SAUs, where AICRPS Centers are located, ICAR Research Complex for North East India, DASD Kozhikode, BIS, Directorate of Marketing, APK, Kottayam and Spices Exporters Forum, Cochin (Para 7.1, 7.2).

| 10.65 | **AICRPS:** The relationship between AICRPS and IISR should be strong and sound. Both the Director and the PC will need to appreciate their respective responsibilities clearly in this regard. The HDs of the IISR may act as Resource Persons of the AICRPS. Though it is a policy matter, this QRT feels that to ensure smooth and effective function of PCs, both the technical and administrative charge of the AICRPs may be vested with the Director (Para 7.3). | Agreed. | The relationship between AICRPS and IISR is of mutual cooperation. All scientists of IISR are invited for the workshops of AICRPS and act as resource persons of AICRPs. |
| 10.66 | The IISR may establish a continuing relationship with the SAUs where the Centres of AICRPS are located. The DRs of these SAUs may be invited to attend the annual meetings of the SRCs, Workshops of the AICRPS, and so on (Para 7.4). | Agreed. | The DRs of SAUs are invited to attend the SRC, Workshops of AICRPS, etc. |
| 10.67 | **Linkages with Spices Board (SB):** The ICRL, Myladumpara of SB has been identified as one of the 8 Voluntary Centres of the AICRPS. But its participation (like that of all other VCs) in the CP work has been minimal. The research wing of SB has a complement of about 50 scientific staff besides other categories of staff. Their laboratories and field facilities are reasonably good. The ICAR is presently not doing research on large cardamom. In the interest of promoting spices research, the IISR and SB may work out a Partnership Relationship for research on spices. This will benefit particularly the research programmes in small cardamom, large cardamom, vanilla, herb spices, and chillies. The IISR should initiate research on the regionally important crop of large cardamom. This may be done with Partnership Arrangement with SB (Para 7.5 to 7.11). | Agreed. | Collaborative research programmes between IISR and SB has been initiated in cardamom and vanilla. |
| **10.77** | **Linkages with commodity/trade associations:** The QRT suggests that IISR may develop working relationships with organizations such as UPASI, Association of Spices Exporters, Cochin, etc for mutual benefit (Paras 7.32-7.34). | Agreed. | IISR has developed working relationships with organizations such as UPASI for mutual benefit. |
| **10.78** | **Additional land at Appangala:** The present land area of Appangala is inadequate to meet its present requirements. Further this Station may also need to maintain a duplicate set of germplasm of black pepper, and ginger, also. Hence, the ICAR/IISR may approach the Karnataka Government to make available 50 ha additional land contiguously with the present land to augment the existing land facilities at Appangala to meet the increased demand (Para 9.5). | Agreed. | IIHR was approached for getting additional land for establishing duplicate germplasm of black pepper at Chetahalli. |
| **10.79** | **Additional land at Chelavour:** The IISR is at present facing acute shortage of land for conducting further expansion of physical facilities and for conducting essential field experimentation. About 20 ha vacant land lying on either side on the approach road to the main building at Chelavour may be get acquired. The ICAR may approve the proposal (Para 9.6). | Proposal will be looked into when received. | The proposal to acquire additional land will be included in the XI Plan. |
| **10.80** | **IISR Experimental Farm, Peruvannamuzhi:** Presently 2 scientists and 13 technical staff are based in Peruvannamuzhi Farm. Although in existence for 28 years, the Farm is beset with several serious problems. The QRT suggests that all the scientists having field experiments (especially in crop improvement, horticulture, crop protection, and crop production) may stay on the Farm or spend at least 3 days every week even during the so-called off-season period. The necessary infrastructure such as quarters, canteen and guest house may be developed for this (Para 9.5 -9.6). | Agreed. | Three farm trips are arranged every week and most of the scientists spend three days in the farm to carry out the field experiments. |
| 10.72 | The Institute should regularly discuss the feedback provided by the KVK. Priorities based on the nature and extent of the problem and the action will be planned only on those selected problems, which can be successfully carried out with the resources available. | Agreed. | The institute decides the priorities based on feedback provided by KVK. |
| 10.73 | **Interaction with CSIR**: Two CSIR institutions of CFTRI Mysore and RRL Trivandrum are working on post harvest technology of spices. About 20 years ago, the ICAR and CSIR used to have a Joint Research Committee with the two DGs acting as Co-Chairmen and 2-3 Directors from each organization as members. The purpose of this body was to identify areas of national interest that the 2 organizations could jointly work on a partnership basis. The ICAR may consider reviving this programme, at least until such time that the ICAR is able to build up its own facilities in food science and technology (Paras 7.23 to 7.25). | Agreed. Director, IISR to initiate exploring the possibility. | Director, IISR will initiate exploring the possibility of interaction with CSIR institutions for jointly working on identified areas of national interest on a partnership basis. |
| 10.74 | **Interaction with ICAR institutes**: The successive QRT reports have been emphasizing the need for the IISR to strengthen collection and conservation of spices genetic resources jointly with the NBPGR. IISR has its own research programmes and priorities. As India is a primary and/or secondary center of diversity of several spices, it is important and necessary for the IISR to streamline its germplasm research programme (Paras 7.24 to 7.25). | Agreed. | IISR in collaboration with NBPGR, is making several germplasm collection programmes very systematically. |
| 10.75 | The last QRT emphasized that IISR should develop strong ties with NRCs on Plant Biotechnology and DNA fingerprinting to advance spice biotechnology research. No evidence of any such collaborative work was evident. The IISR will have to bear the brunt of the biotechnology research on spices largely on its own. However, need-based co-operation with these 2 Centres is proposed also with Project Directorate on Biological Control, Bangalore (Para 7.28). | Agreed. | We have collaboration with NRC on Plant Biotechnology and gene osmotin was given subsequent to collaboration. We have also obtained a gene (glucanase and chitin) from Coffee Board and UAS Bangalore. We are negotiating with MKU for a new construct. In addition network programme in Spices Biotechnology is in operation involving RGCB, SB and KAU. |
| 10.76 | The IARI Plant Pathology Division has a research station at | Agreed. | Studies on viral diseases of large cardamom have been |
| 10.81 | **Additional staff requirements**: When the erstwhile NRC for Spices was upgraded as an Institute, the staff strength was not increased. As per the ratio fixed by the Council, the strength of the technical staff may be increased. The previous QRT has recommended the creation of administrative posts. During IX Plan, 13 administrative posts had been sanctioned. Shortage of administrative staff is seriously hampering the work of the IISR. The scientific staff strength of the IISR is 41. This number has remained stationary from the time of inception of the IISR as NRCS in 1986. Keeping in view the value and role of spices in the lives of the people and to the national economy, especially, by way of export earnings, the scientific staff strength may be increased by 6 to cope up with the work load. In addition, funding support may be obtained from the Ministry of Food Processing Industries to create a Food Science and Technology Division with 7 scientists. Hence the ICAR may sanction the creation of the already sanctioned 13 posts to enable the administration of the Institute. Further the ICAR may depute the work study unit to objectively determine the staff requirements of the IISR. | Present position will be analysed for doing the needful. | Additional posts were proposed for in the X Plan and sanctioned. |