INDIAN INSTITUTE OF SPICES RESEARCH - IN PURSUIT OF EXCELLENCE IN SPICES RESEARCH

V.A. Parthasarathy,
T.K. Jacob,
B. Krishnamoorthy
Indian Institute of Spices Research,
Marikkunnu P.O., Calicut-673 012, Kerala
e-mail: parthasarathy@spices. res.in

Spices are high value, export-oriented commodities, which yield aromatic and pungent principles commonly used for flavoring and seasoning of food and beverages. Some of the spice products form the essential ingredients in ayrvedic medicines. India is the centre of origin and diversity for major spices like black pepper and cardamom. Spices played a significant role in Indian history and attracted many explorers and traders since ancient days including Vasco da Gama who landed at Calicut in 1498 in search of black pepper. India occupies a pre-eminent position in production and global trade of spices and foreign exchange earnings. During the year 2008-09, the spices export quantity has touched an all time high of 4,70,520 tones, valued at Rs. 5300.25 crores.

The Indian Institute of Spices Research (IISR) has a humble beginning as a regional station of Central Plantation Crops Research Institute, Kasaragod at Calicut on 10th November 1975. It has been upgraded to National Research Centre for Spices (NRCS) in 1986 by merging the Cardamom Research Center at Appangala (Karnataka) to it to intensify research on spices. The centre was further elevated to a national institute, the Indian Institute of Spices Research (IISR) on 1st July 1995. The All India Coordinated Research Project on Spices (AICRPS) is also housed at the institute. The institute is conducting basic and applied research on various aspects of spices like black pepper, cardamom, ginger, turmeric, vanilla, paprika and tree spices (nutmeg, clove, cinnamon, allspice and garcinia). The institute is bestowed with the following mandates:

1. Mandate:

- To extend services and technologies to conserve genetic resources of spices as well as soil and water of spices agro ecosystems.
- 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 up gradation 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.

2. Current Research programmes

- The institute meticulously plans its programmes under various research projects to achieve the aims and objectives fixed for it. The projects are carried out under the following 13-mega projects:
- Collection, conservation, characterization and cataloguing of germplasm of spice crops for yield and other economically important characters.
- Breeding improved varieties of spice crops for yield, quality, drought and resistance to pests and diseases.
- System approach for sustainable production of spices.
- Production physiology of spice crops.
- Value addition and post harvest processing of spices.
- Production of nucleus planting materials of improved varieties of spice crops.

- Investigations on nutraceutical and pharmagokinetic aspects of spices.
- Identification, characterization and development of diagnostics against pests, pathogens nematodes of spice crops.
- Conventional and molecular approaches for developing pest, pathogen and nematodes resistance in spice crops.
- Developing integrated pest and disease management strategies in spice crops.
- Economics, statistics and modeling.
- Extension and training
- Developing customized software and expert systems on spices.

The institute has made several significant achievements in the above fields since its inception. The achievements are briefly described below:

A. Conservation of genetic resources

The institute holds the world's largest germplasm collection of spices, which are being utilized for evolving newer varieties having high yield and quality, coupled with resistance/tolerance to biotic and abiotic stresses. The collections include 2300 black pepper (besides more than 1400 hybrids and 150 open pollinated progenies), 416 cardamom, 665 ginger, 924 turmeric, 484 nutmeg, 225 clove, 408 cinnamon including cassia, 116 garcinia, 180 allspice, 130 paprika, and 79 vanilla accessions.

B. Release of spice varieties

The Institute has developed and released several varieties of spices with high yield and quality with great impact on the production and productivity of spices in the country.

- In black pepper, 4 high yielding and high quality varieties viz., Sreekara, Subhakara, Panchami and Pournami were released in early 1990s. Pournami is also tolerant to root knot nematode infestation. PLD-2, a variety Suitable for both plains and higher elevations was released in 2006. Recent releases include four more varieties viz., IISR Shakthi and IISR Thevam (tolerant to Phytophthora), IISR Girimunda and IISR Malabar Excel suitable for high elevation tracts. The details of the varieties are furnished in table 1.
- In cardamom, 3 varieties viz., Suvasini- a high yielding variety suitable for high density planting, Avinash- a variety resistant to rhizome rot disease and Vijetha, a variety resistant to katte disease were released. The details of the varieties are given in table 2.
- In ginger, 3 varieties with high yield and quality, viz., Varada, Rejatha, and Mahima were released. The details of the varieties are given in table 3.
- In turmeric, 7 high curcumin and high yielding varieties namely Suvarna, Sudarsana, Suguna, Prabha, Prathibha, IISR Kedaram and IISR Alleppey Supreme were released for cultivation. The details of the varieties are given in table 4.
- In cinnamon, 2 high quality varieties namely, IISR Navashree and IISR Nithyashree were released for cultivation. The details of the varieties are given in table 5.
- In nutmeg, one variety with high yield and mace quality namely, IISR Viswashree (3122 kg dry seed/ ha and 480 kg mace/ha at 8th year) was released. The salient features of the variety are given in table 6.

Table 1. Black pepper varieties released from Indian Institute of Spices Research

Variety	Av. Yield (dry, Kg ha^{-1})	Salient Feature
Sreekara	2677	Suitable for all pepper growing regions including high elevations as well as for intercropping, medium maturity, gives high quality pepper with 5.1% piperine, 13.0% oleoresin, 7.0% essential oil and 35.0% dry recovery.
Subhakara	2352	Wide adaptability to all pepper growing tracts. Suitable for intercropping as well as for high elevations, high quality, medium maturity line, piperine 3.4%, oleoresin 12.4%, 6.0% essential oil and 35.0% dry

		recovery.
Panchami	2828	High yielding, spikes twisted, late maturing, suitable for high elevations, excellent fruit set, piperine 4.7%, oleoresin 12.5%, 3.4% essential oil and 34.0% dry recovery.
Pournami	2333	Tolerant to root knot nematode and shade. Medium maturity, suitable for intercropping with arecanut and banana. Piperine 4.1%, oleoresin 13.8%, essential oil 3.4% and dry recovery 31.0%
IISR Thevam	2437	Stable yielding, grow vigorously, field tolerant to Phytophthora, medium maturity, suitable for high altitude areas of South India up to 3000 ft MSL in coffee and tea estates under rainfed conditions Piperine 1.6%, oleoresin 8.15%, essential oil 3.1% and dry recovery 32.5%.
IISR Malabar Excel	1453	Recommended for rainfed condition including coffee & tea plantation. Oleoresin 11.7%, piperine 2.4%, essential oil 2.8%, dry recovery 32.3%. Suitable for high elevations & plains
IISR Girimunda	2880	Recommended for rainfed conditions including tea and coffee estates. A medium maturity group. Piperine 2.2%, oleoresin 9.65%, essential oil 3.4% and dry recovery 32.0%.
IISR-Sakthi	2020	Tolerant to P. capsici, piperine 3.3%, oleoresin 10.2%, essential oil 3.7% and driage 43.0%.
PLD -2	2475	Late maturity high quality cultivar, contains piperine 3.0%, oleoresin 15.45%, essential oil 4.8%. Suitable for plains and higher elevations.

Table 2. Cardamom varieties released from Indian Institutue of Spices Research.

Variety	Av. Yield (dry, Kg ha^{-1})	Salient Feature
Avinash	847	OP progeny of CCS-1. A (rhizome rot tolerant variety.
Vijetha-1	643	A selection from field resistance plants . Resistant to Kattedisease
IISR Suvasini	745	Early maturing, suitable for high density planting, long panicle, high % of bold parrot green capsule (89), tolerant to rhizome rot, thrips, shoot/ panicle/ capsule borer, essential oil 8.7%, 1, 8 cineol 42.0%, terpenyl acetate 37.0%, dry recovery 22.0%.

Table 3. Ginger varieties released from Indian Institute of Spices Research, Calicut

Variety	Av. Yield (dry, Kg ha^{-1})	Salient Feature
IISR Varada	22.6	High yielder, high quality bold low fibre content (3.29% to 4.50%), essential oil 1.7%, 6.7% oleoresin and 19.5% dry recovery, tolerant to diseases, maturity 200 days.
IISR Rejatha	22.4	High yielder, plumpy and bold rhizome, 2.36% essential oil, 6.3% oleoresin, 4.0% crude fibre, 20.8% dry recovery, maturity 200 days.
IISR Mahima	23.2	High yielder, plumpy bold rhizomes, 1.72% essential oil, 4.5% oleoresin, 3.26% crude fibre, dry recovery 23.0%, maturity 200 days. The variety

		is resistant to nematodes. (M. incognita and M. javanica)

Table 4. Turmeric varieties released from Indian Institute of Spices Research, Calicut

Variety	Av. Yield (dry, Kg ha^{-1})	Salient Feature
Suguna	29.3	Short duration type (190 days), curcumin 4.9%, oleoresin 13.5%, essential oil 6.0% and dry recovery 20.4%, field tolerance to rhizome rot.
Suvarna	17.4	Bright orange coloured rhizome with slender fingers. Maturity 200 days, field tolerant to pest and diseases Curcumin 4.3%, oleoresin 13.5%, essential oil 7.0% and dry recovery 20.0%.
Sudharsana	28.8	High yielding variety, short duration type (190 days). Field tolerant to rhizome rot. Curcumin 5.3%, oleoresin 15.0%, essential oil 7.0% and dry recovery 20.6%.
IISR Prabha	37.47	High yielding variety, curcumin content 6.5%, oleoresin 15.0%, essential oil 6.5% and dry recovery 19.5%, crop duration 205 days.
IISR Prathiba	39.12	High quality line, 6.2% curcumin content with high yield, 16.2% oleoresin, 6.2% essential oil, 18.5% dry recovery, crop duration 225 days.
IISR Alleppy Supreme	35.4	Shows tolerance to leaf blotch disease. Rhizomes contain 5.55% curcumin, 16.0% oleoresin, 19.0% dry recovery, crop duration 210 days
IISR	34.5	Tolerant to leaf blotch disease,
Kedaram		Rhizomes contain 5.5% curcumin, 13.6% oleoresin, maturity 210 days and 18.9% driage.

Table 5. Cinnamon varieties released from Indian Institute of Spices Research, Calicut

Variety	Av. Yield (dry, Kg ha^{-1})	Salient Feature
IISR-Nithyashree	200	Good regeneration capacity, bark and leaf oleoresin contents are high. Good bark recovery with good aroma and taste. Bark oil 2.7%, leaf oil 3.0%, bark oleoresin 10.0%, bark recovery 30.7%, cinnamaldehyde in bark oil 58.0%, cinnamaldehyde in leaf oil 14.0%, eugenol in bark oil 5.0%, eugenol in leaf oil 78.0%.
IISR-Navashree	200	High quality line, good bark recovery with good aroma and taste, grow well in plains and high elevations. Bark oil 2.7%. High cinnamaldehyde content (73%) in bark oil, medium quality. Leaf oil 2.8%, bark oleoresin 8.0% bark recovery 40.6%, cinnamaldehyde in leaf oil 15.0%, eugenol in bark oil 6.0%, eugenol in leaf oil 62.0%.

Table 6. Nutmeg variety released from Indian Institute of Spices Research, Calicut

Variety	Av. Yield (dry, Kg ha^{-1})	Salient Feature
Viswashree	1000 fruits	Bushy and compact canopy, low incidence of fruit rot. Nut recovery 70.0%, mace recovery 35.0% and nut oil

		7.14%, mace oil 7.13%, oleoresin in nut 2.48% and mace 13.8% respectively, nut butter 30.9% myristicin, in nut 12.48% and mace 20.03% respectively

C. Development of technologies

The institute has developed several feasible and economically viable technologies for large-scale adoption by the farming community. The major farmer and user-friendly technologies developed and released at the institute are listed below:

- Technologies for vegetative propagation of high quality planting materials of elite lines of black pepper and cardamom were standardized. In black pepper, a low cost serpentine layering technique with a production efficiency of 1:60 cuttings per year has also been evolved.
- Production technology of bush pepper for homestead gardens in urban areas.
- High production technologies in black pepper and cardamom were developed and popularized in the farmers' fields.
- Integrated nutrient management including organic farming technologies were standardized in black pepper. Optimum fertilizer schedules for obtaining higher yields from black pepper and cardamom were developed.
- Agronomic practices in black pepper and cardamom plantations such as irrigation schedules and technologies for mixed cropping systems involving black pepper, cardamom, ginger, turmeric, clove and nutmeg in coconut, areca nut and coffee plantations were developed.
- Integrated disease management strategies in black pepper, involving cultural practices, chemicals, biological control and use of resistant varieties was developed for the effective control of Phytophthora foot rot caused by Phytophthora capsici and slow decline caused by nematodes Radopholus similis and Meloidogyne incognita.
- Integrated management strategies against pollu beetle (Longitarsus nigripennis) in black pepper, thrips (Sciothrips cardamomi) in cardamom, shoot borer (Conogethes punctiferalis) in ginger and turmeric were developed.
- Technology for large-scale production of Pochonia chlamydosporia, an effective bio-control agent for the management of root knot nematodes in black pepper was standardized. Two crystalline compounds with nematicidal activity on the second stage juveniles of Meloidogyne incognita were isolated and identified from the leaves of Piper colubrinum. A repository of bio-control agents including bacteria, fungi and nematodes effective against the pests of spice crops has been established. The details of biocontrol agents recommended for management of major diseases in spice crops are furnished in table 7.
- Post harvest technologies for production of white pepper and salted ginger were standardized and suitable cultivars were identified.
- Technologies for drying of black pepper, ginger, turmeric, nutmeg and mace have been developed and standardized.

Table 7. Bio-control agents recommended for management of major diseases in spices.

Crop	Disease	Casual organism	Bio-control agents
Black pepper	Phytophthora foot rot	Phytophthora capsici	Soil application of VAM, Trichoderma spp.
	Slow decline	Radopholus similis, Meloidogyne incognita P.capsici	Soil application of VAM, Trichoderma spp.
Cardamom	Damping off	Pythium vexans	Trichoderma spp. in solarized nursery beds
	Rhizome rot	P.vexans, Rhizoctonia solani	Soil application of Trichoderma spp.
	Capsule rot	Phytophthora meadii P.nicotiane var nicotiane	Soil application of Trichoderma spp.
Ginger	Rhizome rot	Pythium aphanidermatum P. myriotylum	Soil solarization and application of Trichoderma spp.
	Ginger yellows	Fusarium spp	Soil solarization and application of Trichoderma spp.

D. Biotechnological interventions in spices research

The institute has an excellent team of biotechnologists and the biotechnological tools were successfully employed for solving many of the spice production-related bottlenecks. The major achievements in biotechnological front are given below:

- Tissue culture protocols for 52 spices have been developed. Micro propagation (micro rhizome) technologies for production of disease free nucleus planting materials in ginger and turmeric have been standardized.
- Technology for estimation of genetic fidelity of micro propagated black pepper using RAPD and ISSRs was developed. The Department of Biotechnology (DBT) accredited the IISR Laboratories for virus diagnostics and quality testing.
- Technologies for in vitro conservation and cryo-conservation were developed for black pepper, ginger, turmeric, vanilla and cardamom.
- Studies on molecular characterization of spices germplasm are in progress to protect the bio wealth of spices. Molecular markers like RAPD, AFLP, PCR - RFLP and ISSR polymorphism, involving over 100 genotypes, were used for assessment of genetic variability, characterize important cultivars, varieties, related species to develop finger prints, identification of hybrids and to study the inter relationships in black pepper, cardamom, vanilla, ginger, turmeric, Garcinia, cinnamon, clove and nutmeg. The studies on identification of core collections are in progress.
- Male parent-specific RAPD and AFLP markers were developed to identify hybrids in black pepper and vanilla.
- A mapping population has been developed for preparation of genetic map of black pepper with the objective of tagging important genes of interest for marker aided selection and thus to reduce breeding time.
- RAPD and SCAR markers to tag Phytophthora resistance in black pepper were developed and are in the process of validation.
- A PCR based method has been developed for detection of adulteration and to identify different grades of commercial products of cardamom, black pepper and turmeric.
- Technology for genetic transformation of black pepper for disease resistance was developed. Similar studies are in progress in ginger and cardamom for disease resistance.
- Isolation of the part (internal region) of the resistance gene sequence (252 bp fragment corresponding to 84 amino acids) from Piper colubrinum was achieved by targeted gene amplification using degenerate primers.
- The soil microbial community structure in the rhizosphere of agroforestry trees-black pepper systems was investigated using PCR-RFLP involving primers for multi-copy targets.
- Twelve databases and 10 software programmes on spice, many of which are accessible over the Internet were designed and developed.

E. Indexing of spice crops against viral diseases

Diseases, especially of viral etiology have crippled the successful cultivation of spices crops. Two of the mandated crops of the institute, namely, black pepper and vanilla severely suffer from the incidences of virus diseases. The studies carried out at the institute in containing the virus diseases are briefly described below:

- Based on cloning and sequencing of coat protein gene, the Cucumovirus, Potexvirus and Potyvirus infecting vanilla were identified as strains of Cucumber mosaic virus (CMV) and Cymbdium mosaic virus (CymMV) and Bean common mosaic virus, respectively.
- A DAS-ELISA, RT-PCR and PCR based methods have been developed for indexing black pepper plants for CMV and PYMoV Stunted disease. A single tube multiplex RT-PCR was also developed for the combined detection of both the viruses in a single reaction. The method has been highly useful in indexing and certification programme.

- DAS-ELISA and RT-PCR based methods were developed for indexing vanilla planting materials against major virus diseases.
- Based on coat protein and 3' untranslated region sequence studies, the cardamom katte virus has been placed as a new member of the genus, Macluravirus of family, Potyviridae.
- Studies on isolation of Coat protein gene, cloning and sequencing of different viruses infecting black pepper, cardamom and vanilla are in progress.
- Serological and RT-PCR methods have been developed and available for detection of the virus in cardamom plants.
- Kokke Kandu disease in cardamom is of relatively recent origin and has become a threat to cardamom cultivation in a few endemic pockets of Karnataka. The disease is reported from Kodagu, Hassan, Chickmagalur, Shimoga and North Canara districts of Karnataka. This disease may occur either singly or mixed infections with katte. Unlike katte disease, the plants affected with this disease decline rapidly with yield reduction upto 62-84% in the first year of peak crop.

F. Extension and Training

The Institute disseminates the technologies developed by it to the end users for wider adoption. The Agricultural Technology Information Centre (ATIC) at the institute plays an important role in transfer of technology by way of consultation, organizing training, exhibitions, seminars etc., and publication of books, leaflets and pamphlets. Quality planting materials are also sold through the ATIC. The Krishi Vigyan Kendra, Calicut attached to the institute is also in the forefront of transfer of technologies developed at the institute to the farming community. The institute also organizes short and long term training programmes for various categories of users for better adoption of technologies.

The institute has been recognized as a centre for Ph.D studies by Mangalore University, University of Calicut and University of Kannur in all subjects and, by Bharathiar and Nagarjuna Universities in Botany and Biotechnology, respectively. Currently 25 scholars are pursuing their Ph.D at the institute. The institute also offers project work for M. Phil and M.Sc students in different subjects and Post M.Sc training to candidates who have completed M.Sc and want to have hands on experience. Every year, students from various parts of the country avail the facility at the institute for carrying out their project work.

Future line of Work

The major thrusts in research programmes are oriented towards the following for increasing productivity of spices.

- Conservation of genetic resources and bar-coding of genotypes
- Raising the productivity of spices to the targeted levels using improved varieties with high yield, quality traits and disease/ pest resistance
- Increasing quality planting material production, crop management and replanting and rejuvenation of old gardens, good agricultural practices, INM and organic farming
- Increasing productivity of spices - to raise the production levels through IDM/ IPM
- Developing simple and cost effective tools and machines to offset labour shortage
- Chemo profiling and identification of new flavour compounds, bio active principles for patenting - to identify superior varieties with excellent flavour, identifying newer compounds for increasing the industrial use.
- New market oriented technologies for value addition, processing, product development - to increase the acceptability, demand and value of spices and new markets
- Development of data bases, prediction models, production strategies and market intelligence - use of GIS & Bio informatics tools in spices cultivation, marketing and trade

•••