Spices Research and Development - An Overview

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Spices contribute substantially to the export earnings of India. During 1998-99 it touched an all time high of Rs. 1650.02 crores. India contributes approximately to 1/3 of the global trade in spices and this is justified to call India as 'Land of spices'. While black pepper, small cardamom are mainly confined to South India, ginger and turmeric are generally grown in many states. Large cardamom is mainly confined to Sikkim. Cumin, coriander and fenugreek are mainly confined to northern states. The varied geographical and agro-climatological conditions that exist confined these crops to different regions.

In the past the research efforts for these crops are not commensurate with the problems that these crops face. The research efforts are only about three decades old and the research funding is abyssmally low compared to the foreign exchange that these crops earn.

Research Organization set up: At present Indian Council of Agriculture research through its main institute, Indian Institute of Spices Research (IISR), Calicut and the All India Coordinated Research Project on Spices (AICRPS) with about 20 centres located in 17 state Agricultural universities, cater to the needs of crop research perse. IISR also operates paid consultancy services to transfer their technologies to entreprenuers. The post harvest research at present is mainly at Regional Research Labs (RRL), Trivandrum and CFTRI Mysore, even though ICAR itself has started its programmes. Quality control for the produce is mainly taken up by Spices Board, Cochin (Ministry of Commerce).

Development: Agriculture being the state subject major efforts of extension are through the state departments of Agriculture and Horticulture. However, substantial funding comes from Ministry of Agriculture, Govt. of India. While the investment by Govt. of India through Central sector schemes was only about Rs.5.74 crores during 1991-92, it was substantial Rs. 125 crores during 1992-97. It was Rs. 30 crores during 1997-98 and 37.5 during 1998-99. During 9th plan period it is estimated to be around Rs. 145 crores.

All these are implemented under Integrated Programme for Development of Spices (IPDS). Production and distribution of planting materials, rehabilitation of replanting black pepper, demonstration of high production technologies programmes through financial support and providing plant protection equipment are some of the developmental activities. An integrated disease management consisting of cultural practices and chemical control for Phytophthora foot rot control was implemented in five districts in Kerala viz., Wyanad, Calicut, Cannanore, Kasaragod and Idukki at a cost of Rs. 28 crores during 1992-1995 with assistance of Ministry of Agriculture, Govt. of India. The impact analysis showed that it was highly effective.

Establishment of Krishi Vigyan Kendras with assistance of ICAR in different parts of the country is providing an impetus to the existing developmental activities,in the country.

The following are the major production constraints:

1. Non availability of quality planting material (disease free)/ seed.
2. Severe crop losses caused due to diseases and pests.
3. Lack of variability for host resistance to major diseases and pests and also to abiotic stress.
4. Non adoption of scientific approaches of cultivation and lack of awareness among the farming community.
5. Vagaries of monsoon which affects the crop growth and productivity substantially.
6. High cost of production.

7. Lack of quality conciousness and poor handling of the commodity during post harvest period.
8. Inadequate extension net work.
9. High price fluctuation of the commodity

The following are the major approaches adopted to overcome the constraints:

1. Development of varieties with high productivity, resistance to biotic (diseases and pests) and abiotic (drought) stress.
2. Streamlining the production of quality planting material/ seed.
3. Standardization of cost effective agrotechnologies for optimum productivity to reduce the cost of production.
4. Eco-friendly crop protection procedures to ensure 'O' pesticide residues in the produce.
5. Popularization of post harvest practices and quality awareness to ensure clean spices that would **meet the international quality control standards.**
6. Value addition through development of various spice products (oils and oleoresins) and production of consumer oriented blends of spices in hygienic and attractive packages to meet the internal. and export demands.
7. Greater participation of industry in R &, D activities.
8. Linkages of both Governmental, public/private industries and NGO'S.

The SWOT (Strength-weakness-opportunities -threat) on these crops indicates an exciting but a challenging future for India to remain as a major player of the spices trade at global level. Rich genetic resources, the research attainments through agro-technology development and diverse agroclimatic zones condusive to various spices are **our strengths.** Lack of high degree of host resistance to biotic and abiotic stress, lack of adequate facilities for production of quality planting materials and inadequate extension network, are the **weakness.** Excellent scope for the value added product production, development of entreprenuers with developed technologies which are commercially viable and infrastructure development and development of human resources are the **opportunities.** High cost of production, severe disease and pest incidence, non availability of quality planting materials and price instability are some of the **threats.**

The projected world trade in spices during 2000 AD is about 6.25 lakhs tonnes valued around US $3 billion. Export of 2.103 lakh tonnes valued US $393.90 by India during 1998-99 is an indication that it can achieve the target for the next millenium.

While the national average productivity of these crops is low, the potential for productivity increase is very high based on the production achieved by the progressive farmers and research station (Table 1). These production gaps need to be bridged through augmented research and developmental efforts.

Table 1. Potential for productivity increase at the national level (kg/ha)

Crop	National	Progressive farmer	Research station	Abroad
Pepper	315	2000	2445	2925 (Malaysia)
Cardamom	154	1625	450	250 (Guatemala)
Ginger	3477	5500	8250	-
Turmeric	3912	6200	10700	-
Coriander	591	-	1900	515 (Morocco)
Cumin	578	-	2000	-

Salient research achievements

CROP IMPROVEMENT:

Germplasm conservation: To check the genetic erosion and to preserve the available variability for the posterity is essential. Conservation of germplasm has been initiated both at IISR and Agricultural Universities through the All India Coordinated Research Project on Spices. Black pepper, cardamom, ginger and turmeric being indigenous, substantial collections have been made. In the exotic spices like clove, nutmeg, allspice, cumin, coriander, fennel and fenugreek, there is a need to introduce germplasm through international collaboration especially for the variability for pest and disease resistance. The latest status of germplasm in spices at IISR and at AICRPS centres are given below.(Table 2 & 3).

Table 2: Germplasm in spices at IISR, Calicut

Spice	Indigenous	Exotic	Wild & related	Total
Black pepper	2716 (2492 + 224)	5	279	2776
Cardamom (Small)	314 (272 + 41)	"	13	286
Ginger	508 (437 + 71)	10	12	459
Turmeric	707 (674 + 33)	6	17	697
Nutmeg	465 (415 + 50)	"	10 (6+4)	421
Clove	217 (212 + 5)	2	1	215
Cinnamon	267 (242 + 25)	14	14 (6 + 8)	262
Allspice	160 (137 + 23)	-	-	137

Table 3: Genetic Resources of spices at AICRPS centres:

Crop/Centre	Indigenous		Exotic	Total
	Cultivated	Wild and related sp.		
Black pepper				
Panniyur	87			87
Sirsi	72	21		93
Chintapalli	27	23		50
Yercaud	106			106
Pundibari	2			2
Dapoli	7			7
Dholi	7	1		8
Small Cardamom				
Pampadumpara	77	15	92	
Mudigere	238	7		245
Large Cardamom				
Gangtok	12	18		30
Ginger				
Pottangi	155	2	3	160
Solan	176			176
Dholi	27			27
Raigarh	18			18
Kumarganj	10			10
Pundibari	11			11
Turmeric				
Pottangi	182	22		204
Jagtial	188			188
Dholi	56			56
Bhavanisagar	124			124
Raigarh	43			43
Kumarganj	27			27
Pundibari	50			50
Solan	185			185

Clove				
Yercaud		13		13
Thadiyankudisai		1		1
Pechiparai		16		16
Nutmeg				
Y'ercaud		15		15
Thadiyankudisai		1		1
Pechiparal		12		12
Dapoli		14		14
Cinnamon				
Yercaud		1 1		1 1
Thadiyankudisai		6		6
Pechiparai		12		12
Coriander				
Jobner		628	105	733
Jagudan		51	17	68
Coimbatore		182		182
Guntur		230		230
Hisar		98		98
Dholi		110		110
Raigarh		13		13
Kumarganj		60		60
Cumin				
Jobner		258	8	266
Jagudan		150	7	157
Kuma.rganj'		7		7
Fennel				
Jobner		170	28	198
Jagudan		173	20	193
Hisar		44		44
Dholi		40		40
Kumarganj		26		26
Fenugreek				
Jobner		308	12	320
Jagudan		64	2	66
Coimbatore		179	179	
Guntur		90	90	
Hisar		82	82	
Dholi		105	105	
Raigarh		11	1 1	
Kumarganj		58	58	

Varietal Improvement: About 62 high yielding varieties have been developed in black pepper, cardamom, cinnamon, ginger, turmeric, coriander, cumin, fennel and fenugreek.(Table 4) through the efforts of IISR and AICRPS.

Table 4. Improved Hybrids and varieties in spices

Spices		Hybrides (H) and varieties (V) released
Black pepper	1 0	Panniyur-1 (H) , Panniyur 2 (V), Panniyur 3 (H), Panniyur 4 (V), Panniyur 5 (V), Subhakara (V), Palode 2 (V), Sreekara (V), Panchami (V), Pournami (V)
Cardamom	6	Mudigere-1 (V), PV.1 (V), CCS-1 (V) ICRI.1(V), ICRI.2(V), ICRI-3 (SKP-14) (V)

Cinnamon	2	IISR Navasree (V) , IISR Nithyasree (V)
Ginger	4	Suprabha (V), Suruchi (V) Suravi (V), Varada (V).
Turmeric	14	Co.1 (m), Krishna (V), Sugandham (V) , BSR. 1 (V), Suvarna (V), Roma (V), Suroma (V), Rajendra Sonia (V), Suguna (V), Sudarshana (V), Ranga (V) Rasmi (V) , IISR Prabha (V) , IISR Prathibha (V).
Coriander	13	Gujarat Coriander-1 (V), Co.1 (V), Co.2 (V), Gujarat Coriander 2 (V), Rajendra Swati (V), RCr.4 (V), Sadhana (V) , Swathi (V), Co.3 (V), CS.287 (V) , Sindhu (V), UD 20 (V), DH - 5 (V).
Cumin	5	S-404 (V), MC-43 (V), Gujarat Cumin. 2 (V), Gujarat Cumin . 1 (V) , RZ- 1 9 (V).
Fennel	4	S-7-9 (V), PF-35 (V), Gujarat Fennel. 1 (V), Co.1 (V).
Fenugreek	4	Co.1 (V), Rajendra Kanti (V), RMt.1 (V), Lam Selection.1 (V).

H - Hybrid, V - Variety, M - Mutant.

The major focus had been to increase the yield levels substantially. Black pepper hybrid Panniyur 1 is still the popular choice of the farmers. Since the disease problems are mainly elusive, soil borne and being virtually killers, especially in black pepper, ginger, turmeric, cumin and coriander, it is essential to target the resistance development with a high priority both through conventional breeding and through need based biotechnological approaches. For single crop like pepper susceptible to Phytophthora, plant parasitic nematodes and pollu beetle, the need is to look for multiple resistance. With the often repeated vagaries of monsoon it is imperative to concentrate to induce abiotic resistance in these crops. Some of the accession in Karimunda have been identified as drought tolerant which need field evaluation.

Multiplication of planting material: In view of the increased demand of

planting materials of these crops agrotechniques have been standardised specially for black pepper (1: 40) cardamom (1:20), nutmeg, cinnamon and clove. (Table 5).

Table 5. Plant propagation methods in spices standardized:

Spices	Method of propagation	Advantages
Black pepper	Single nodded rooted cutting using bamboo method.	Multiplication rate of 1:40 per year. Profuse root systems that ensures high field establishment.
Cardamom	Trench method of sucker production	Multiplication rate of 1:20 per year -
Clove	Inarching on clove seedlings	Earliness, dwarfness and high productivity
Nutmeg	Epicotyl grafting Top working	Female plants are propagated. Conversion of male plants to female plants
Cinnamon	Cuttage , air layering	Rapid multiplication of elite plants per unit area.
Cassia	Air layering, cuttage	Earliness, more plants per unit area
Allspice	Cuttage, layering	True to type plants
Ginger and Turmeric	Disease free rhizomes	Management of rhizome rot.

These would ensure supply of enough quantities of nucleus planting materials and also on commercial scale. In crops like black pepper and cardamom where virus diseases are serious, selection of disease free nucleus planting materials and further confirmation by ELISA techniques becomes crucial to ensure supply of disease free planting materials. Even though field evaluation of tissue cultured cardamom didn't show substantial yield gain, it is ideal to ensure disease free plants. Where seed borne infections are important in crops like cumin and coriander, need based and effective pre harvest fungicidal or biocontrol treatments would be beneficial. This needs intensified research efforts.

In the case of cardamom clones with an average yield of 600 kg/ha and potential realizable yield have been developed. In ginger high yielding, low fibre content variety with an average yield of 22.2t/ha named as Varda has been released. In turmeric high yielding Suvarna, Suguna and Sudarsana with yield potential of 43,60.3 and 54.8t/ha with curcumin content of 4.9 and 7% respectively were released.

Biotechnological approaches: Biotechnological intervention in these crops is very recent and the contributions of IISR, Kerala Agricultural University, Calicut University and Indian Cardamom Research Institute are impressive. Micropropagation protocols have been developed for 31 crops which can be utilized as and when required. Similarly synseed technology standardized for ginger, protoplast technology, cell and embryo culture systems in black pepper are important mile stones in spices biotechnology. Molecular characterization of the germplasm has been initiated. Long term storage and cryo-preservation for some of the spices have been standardized.

CROP PRODUCTION:

While the land being limited, to ensure export surplus after meeting the indigenous consumption, increasing the productivity and reducing the cost of cultivation are the only options to be perused. Considerable varietal improvement has been made for productivity. To consolidate these gains the standardization of cheap and effective agro techniques is the major approach. The low national average productivity and the higher yields obtained at both farmers and research stations points to the efficacy of effectiveness of the crop management. The high production technology (HFIT) developed for black pepper and cardamom were demonstrated in the farmers' field. About 200% increase in yield and reduction of disease to less than 1% has been achieved in the HFIT implemented in farm holdings of black pepper. In cardamom it has been proved through HPIT programme that 460 kg/ha can 'be produced compared to 116kg/ha under average management. Diagnosis and Recommendation Integrated system (DRIS) was developed for black pepper to assess the nutrient balance and yield. An increase in yield by 50% was noticed when irrigation was provided at W/CPE ratio of 0.25 @ 100 1 of water/vine/irrigation at 8-10 days interval.

Rapid method of multiplication of black pepper through single node cuttings and trench method of multiplication in cardamom are the methods standardized to ensure adequate quantities of planting material. Technology has been developed to accommodate 5000 vines/ha by adoption of 2 x lm spacing using dead standards there by increasing the productivity to 5000kg/ha. A fertilizer dose of 140:55:270g of NPK/vine/yr for laterite soils has been developed for black pepper. Slow release fertilizer technology with the numin coated urea increased the yield of black pepper by 51%. Use of mussori/rock phosphate @ 80g P205/vine/yr was found to be as efficient as super phosphate. A fertilizer schedule of 120:120:240kg NPK/ha has been standardised for cardamom. Development of bush pepper technology is a new dimension to increase the production through homestead cultivation. There is a renewed interest in vanilla cultivation and Spices Board is taking lot of initiative to bring in more area under cultivation, by supplying tissue cultured plants to farming community. Processing procedures are being developed at ICRI, Myladumpara.

Cropping systems approach: With the fluctuation of price of the commodity, multiple cropping system which ensures a cushion from the fluctuating prices by offering remuneration price for one or the other commodities of crops of the cropping systems, becomes a practical option to the farmer and is an age old adopted in Kerala and Karnataka. Studies are warranted further to develop remunerative cropping system involving spice crops. The coffee-pepper cropping system is one such example. In the case of Areca-pepper system there is a need to standardize the population of pepper vines to reduce the disease incidence.

Post harvest technologies: Research efforts of post harvest technologies are mainly through CFTRI Mysore and RRL, Trivandrum. Recently, IISR has standardized technology for white pepper production. Panniyur-I, Valiakaniakodan and Balankotta have been identified as suitable varieties for white pepper production. Kottanadan and Aimperian varieties have been identified with high content of oleoresin 17% and 16%, respectively.

Organic spices: In view of greater preference for organically grown spices by the importers, a new momentum has started in India also, specially for black pepper to adopt organic agriculture to obtain pesticide free produce.

Organically grown spices would fetch highly competitive prices. One of the main components of organic farming is recycling of organic residues and vermicomposting has been taken up. Besides biofertilizer programmes using Azospirullies, P solubilizin g bacteria and fungi and also Vesicular Arbuscular Mycorrhiza (VAM) have been initiated and initial indications are encouraging. Combination on Azospirillies, phospho bacteria and VAM showed synergistic effects on growth parameters of black pepper was noticed compared either of them alone. There are international organization like IFOAM, Germany, IOIA, USA, ISO Switzerland and NSC Nagpur for certification of organically grown products. A lot more research efforts are needed on this method of organic cultivation.

Quality: Apart from quantity of spices produced, quality of the spice is most important. Clean spice and not cleaned spices is the watch word in the export strategy. This involves maintenance of high quality standards for the microbial load, extraneous matter, pesticide residues, afflotoxin/mycotoxins, which are adopted rigorously by the importing countries. As such research efforts in post harvest technology are needed right from farm level to the export houses. Particularly mycotoxins have become a greatest hazard. HACCP concept of risk analysis and implementation of ISO 9000 requirements have become hallmark of the spices export.

CROP PROTECTION:

Crop loss due to diseases and pest is the major production constraint in spices production; particularly diseases are soil-borne and virtually killers. Phytophthora foot rot, slow decline in black pepper, capsule rot of cardamom, rhizome rot and bacterial wilt in ginger and turmeric, cumin and coriander wilts still remain as threats to these crops. Viral diseases of cardamom viz., Katte and Kokkekandu caused by poty virus and stunted disease of black pepper caused by cucumber mosaic are debilitating and cause considerable yield loss. Lack of host resistance, diseased nursery stock/seed material, non-adoption of phytosanitation and uncontrollable weather factors particularly high rainfall make these crops more vulnerable to diseases. 'Pollu' beetle and root mealy bug damage in pepper, thrips in cardamom and stem borer in ginger, turmeric are serious insect pests causing substantial crop loss.

Chemical control: For management of pests and diseases, major focus had been the chemical control with insecticides and pesticides, besides cultural practices. Endosulfan and Quinalphos sprays were found effective against 'pollu' beetle. Similarly spray with Monocrotophus, Phosolone, Fenithion were effectice against cardamom thrips and Malathion against stem borer of ginger and turmeric.

Pre and Post monsoon spray with 1% Bordeaux mixture and drench with copper oxychloride were found effective both for foot rot of black pepper and capsule rot of cardamom. Use of systemic fungicides like metalaxyl and phosphonates are highly effective against foot rot in black pepper but apprehensions are expressed about pesticide residues and development of resistance. Similarly seed treatment of rhizomes and selective soil drenching with Mancozeb or metalaxyl Mancozeb has been found effective for rhizome rot of ginger control.

Jntegrated Disease and Pest Management (IDM/ IPM)

An integrated approach of crop protection involving nursery hygiene cultural, chemical and biocontrol coupled with host resistance is the strategy adopted with the available components. Effective botanicals like neem based formulations, microbial pathogens, parasites and predators have been identified for insect pest management. Greater emphasis is for **biological control** as a component of eco-friendly crop protection without or minimal pesticide usage.

Biotechnological Approaches of Crop Protection:
Biocontrol: Vesicular Arbuscular Mycorrhizae (VAM) and Trichoderma harzianum were found effective against Phytophthora and plant parasitic nematodes in black pepper. Efficacy of biocontrol in checking foot rot in black pepper, capsule rot in cardamom and rhizome rot in ginger has been established under farmers' condition. Impact analysis made in black pepper biocontrol programmes in

farmers'field showed that 80% of farmers confirmed its effectiveness. Potassium phosphonate compatible with biocontrol was found effective against foot rot and this becomes major components of IDM.

Botanicals: Neem formulation viz., Neem gold was found effective in 'pollu' beetle management.

Microbials: BT (Bacillus thuringiensis) formulations were effective against stem borer of ginger and turmeric. Pasteuria penetrans, Pacilomyces lilacinens and Verticillium chlamydosporium were effective in suppressing root knot and burrowing nematodes.

Parasites/predators: Potential natural enemies like Chilocorus nigdta against scale insects in pepper have been found. Mass rearing techniques have been developed and the field efficacy in scale insect management has been established. A variety of potential parasites and predators for various pests have been documented.

Host resistance: Piper colubrinum showed multiple resistance to Pcapsici, plant parasitic nematodes and 'pollu' beetle. Since interspecific breeding efforts are not successful, identification of resistance genes and incorporating them into high yielding black pepper through recombinent DNA technology is the long range strategy. Field resistant black pepper type P24 against Phytophthora has been developed. Somaclones tolerant to Phytophthora were developed through tissue culture technology. Root knot resistant variety of black pepper 'Pournami'has been developed. 'Pollu' beetle resistance has been identified in four accessions and are being evaluated for their yield potential in black pepper.

'Katte' clinic: For viral diseases of cardamom phased eradication and replanting with disease free nursery stock is the strategy implemented. 'Katte clinics' at Regional Station of IISR at Appangala are highly successful in appraising the farmer the management of 'katte' disease of cardamom.

National Network of Phytophthora Diseases of Horticultural crops: Since Phytophthora is a major pathogen of plantation crops and spices, to develop effective diseases management through basic and applied studies, a National network of Phytophthora disease of Horticultural Crops (PHYTONET) has been set up with 9 centres throughout the country with IISR, Calicut as its headquarters.

A Repository of microbial biocontrol agents has been set up at IISR, as a facility to develop efficient microbial inoculants that are compatible with agro-chemicals and which can suppress soil-borne pathogens of spice crops and insect pests. Thus the crop protection is aimed through an Integrated Disease and Pest Management programme.

Pepper Technology Mission: Govt. of Kerala launched this programme with a budget outlay of Rs. 221.62 crores for 1 year from 1997-98 onwards to increase the present productivity to 1.2 lakh tonnes /yr through the implementation of available proven technologies on INM/IPM/IDM and also with a thrust on value addition.

Future thrust

The role of micronutrients like Zn, Mo & Bo in increasing the productivity apart from NPK should be looked into. The nutrient buffer concept should be given priority. From the organic spice production intensification of research programmes on biofertilizers is called for.

India would remain as a major player in spice trade at global level with the present pace of its research and developmental efforts. With the stiff competition from other producing countries the Indian production should become competitive. Major effort should target the increased productivity through development of varieties for resistance to biotic and abiotic stress, specially in the case of black pepper and cardamom. While conventional breeding remains as a basic strategy, invoking appropriate biotechnological approaches is of high priority. Development of eco-friendly plant protection measures through IDM and IPM is imperative to ensure clean and '0'pesiticide residue spice produce.

Diagnostics: Since viral problems are on increase and major spices being vegetatively propagated, the diseases are likely to be transmitted vertically to nursery stock. Diagnostic techniques like ELISA and also latest molecular techniques like PCR should be standard for early detection to avoid disease free nursery stock.

Optimising the efficiency of agro-techniques to reduce the cost of production becomes crucial to become internationally competitive. Technologies already developed (Table 6) and recent research achievements at IISR would meet these demands partially. (Table 7).

Table 6. Technologies developed at Indian Institute of Spices Research

Sl. No.	Major constraints	Technology (S)
1.	Phytophthora foot rot in black pepper	Two pre-monsoon sprays with Brodeaux mixture (1%), one dremching copper oxychloride (1%) and phytosoanitary measuress can manage the disease.
2.	'Kokke kandu' viral disease in cardamom	Roughing out diseased plants as and when appear can reduce the incidence
3.	Seedling diseases in pepper and cardamom	Incorporation of VAM and Trichoderma in the nursery re duces incidences.
4.	Stunted disease of black pepper	Viral etilogy is established. Removal of infected vines is recommended
5.	Rhizome rot of ginger	Biological control by Trichoderma sp. is effective.
6.	Nematodes, thrips and root grubs in cardamom	Spot application by phorate @2.5g.s.i per clump, twice a year during April-May and October-November is advo cated.
7.	Nematodes and soil borne diseases in cardamom nurseries.	Soil solarization by mulching with polythene sheets for 40-45 days as a pre-sowing treatment.
8.	Diseases in planting materials of black pepper.	The nursery mixture may be sterilised by soil solarization and fortified with VAM and Trichoderma at the time of rais ing cuttings
9.	Pullu beetle on black pepper	Spraying endosulfan (0.05%) during July (21-30 days af ter setting of berries) followed by three sprays of Neemgold (0.6%) during August, September and October or four sprays of Neemgold (0.6%) during July, August, Septem ber and October is effective.
10.	Shoot borer in ginger and turmeric	Four sprays of Dipel (0.3%) (Bacillus thuringiensis) during July-October at 21 days interval commencing from first symp tom of pest infestation are effective