भाकृअनुप
ICAR

RESEARCH HIGHLIGHTS

अनुसंधान के मुख्य अंश

2020-2021

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान
कोषिक्कोड, केरल

ICAR-Indian Institute of Spices Research
Kozhikode, Kerala

Editors
R Praveena
Lijo Thomas
D Prasath
R Dinesh

Guidance
AK Singh (DDG, Horticultural Science)
Vikramaditya Pandey (ADG, Hort.Sci. -I)

Correct Citation
Praveena R, Lijo Thomas, Prasath D and Dinesh R (Eds.) (2021) Research Highlights 2020-21, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India, 24p

Publisher
Director
ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India

December 2021

Cover Page Photos
IISR Vajra, *M. pingshaense* conidia, Ginger conservatory, *Garcinia andamanica,*
Sporulated cadaver of *C. punctiferalis* infected by *M. pingshaense, Garcinia rubro-echinata*

Cover Design & Printing
Compix Design & Printing Studio, Kozhikode

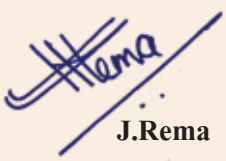
PREFACE

It is a great honor to present the research highlights from ICAR-Indian Institute of Spices Research, Kozhikode, Kerala for the year 2020-21. As a national institute with a mandate on comprehensive development of several important spice crops, we continued to play a catalytic role for the betterment of all the stakeholders. Our prime objective and focus remains firmly fixed on helping farmers in enhancing the efficiency and profitability of spice cultivation through development and adoption of cutting-edge technologies and products. The range of varietal and non-varietal technologies developed by the institute are designed to enhance spice output and farm income in a sustainable manner. Focus on resource conservation, environment quality, food safety and economic viability are ingrained in the crop production and plant health management strategies developed by the institute. The ITMU-BPD harnesses these technological innovations and fosters spicepreneurship among the startups and entrepreneurs. Our vision is to relentlessly strive to enhance spices productivity and make India the global leader. In this quest, we constantly strive to seamlessly integrate national priorities in our products, programs and activities, all of which ultimately contributing to the Government of India's vision of doubling farmer's income.

The year 2020-21 was extraordinary in every sense due to the Covid 19 pandemic. But our diligent efforts in research managed to hold its course even with the pandemic as an omnipresent backdrop. The institute leveraged the digital connectivity platforms to remain more connected than ever. In fact, the outreach capability of our training programs and advisory services witnessed an increase through judicious use of technology and institutional partnerships across the country. It has made us more committed to improving the quality of life and supporting livelihood programs for the socially, economically and geographically disadvantaged sections. The enhanced reach and the specific design of the outreach activities has raised our visibility and reputation among the client stakeholders. The current times being as such, we also charted a different course by discussing and debating public health,policies and the other issues we face as societies. Of course, we did execute all the Covid Guidelines issued by the Central and State Governments. The institute provided proactive support to the state administration in fighting the pandemic by providing its infrastructure and research facilities for greater public cause.

In spite of the limitations imposed by the pandemic, significant advancements in research and development were made during the year. A new ginger variety, IISR VAJRA was released, a ginger conservatory (Garden of Gingers) was established, eleven technologies were commercialized by the ITM-BPD unit and MSME recognised ICAR-IISR as Host Institute to setup/establish Business incubation.

While we are proud of our achievements, we remain aware of the need to adapt quickly to the changes happening around and are fully prepared to deliver sustainable spice production. For this, I am extremely thankful to the ICAR for the unrelenting support and wholeheartedly thank Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for his guidance and encouragement. I am also highly grateful to Dr. A.K. Singh, Deputy Director General (Horticultural Science) and Dr. Vikramaditya Pandey, Assistant Director General (Hort-I) for their constant support, guidance and motivation. Special thanks to the editors for their tireless efforts.



J.Rema

Kozhikode

December 2021

CONTENTS

Black Pepper..... 01

Cardamom..... 03

Ginger..... 04

Turmeric..... 06

Tree Spices..... 08

General..... 09

Economics..... 11

Tribal Sub Plan and Special Component Plan..... 12

ATIC and Extension Services..... 13

ICAR- AICRP on Spices..... 13

Krishi Vigyan Kendra..... 13

ITM-BPD Unit..... 13

Human Resource Development..... 14

RESEARCH
HIGHLIGHTS
अनुसंधान के मुख्य अंश

RESEARCH ACHIEVEMENTS 2020-21

BLACK PEPPER

Genetic resources

Around 3467 accessions are being maintained at Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala. The field genebank at CHES, Chettalli, Karnataka holds 627 accessions. A unique black pepper accession with extra-long spike of 34.5 cm was collected from Tata Coffee, Madikeri, Karnataka. Nine accessions of *Piper spp viz., Piper pedicellosum, P. miniatum, P. wallichi, P. sarmentosum and P. betle* were collected during the joint germplasm exploration program to Andaman and Nicobar Islands conducted by ICAR-NBPGR, Thrissur, Kerala and ICAR-IISR.

Characterization

Eighty two germplasm accessions collected from Karnataka, Kerala, Goa and Maharashtra were characterized for 17 quantitative and 12 qualitative traits. Wide range and high coefficient of variation (CV) were recorded for dry berry weight, fresh berry weight and number of spikes vine^{-1} whereas, lower CV was observed for berry size.

Breeding

Eighteen black pepper genotypes were characterized for pericarp thickness, dry recovery and biochemical constituents and grouped into thin and thick pericarp groups. Berries of IISR Malabar Excel had the thickest pericarp, while the berries from Agali and Nedumchola had the thinnest pericarp. Pericarp contained 0.38 to 0.66% and 1.60 to 4.35% of piperine and oleoresin, respectively. Piperine content in the pericarp was higher in the thick pericarp genotypes such as IISR Malabar Excel while oleoresin was high in Kalluvally. Protein content in pericarp varied from 5.5 to 18.3%. Higher percentage of protein was found in Nedumchola and IISR Malabar Excel. Phenols in pericarp ranged from 1.15 to 6.22 %. Reducing sugars ranged from 2.74 to 9.90 %, IISR Shakthi recorded the maximum followed by Narayakodi. In pericarp, starch varied from 11.76 to 28.52%. High starch in pericarp was found in Narayakodi and Chumala. Thin pericarp group comprised of eight genotypes, while thick pericarp genotypes comprised of 10 genotypes.

Black pepper berry hybrid transcriptome assembly

The de-novo transcriptome sequencing of berry samples (IISR Thevam) was done using Illumina and Oxford Nanopore sequencing platform. The hybrid transcriptome assembly was done using IDP-denovo Assembler- and submitted to NCBI (Bio Sample accession: SAMN13981803).

Development of fertigation schedule

Drip fertigation schedules for three black pepper varieties IISR Thevam, Girimunda and Shakthi were standardized for yield and quality. Required quantities of recommended dose of fertilizers were mixed with irrigation water through dosing pumps and applied at 24 splits/40 splits from September to May. Maximum yield was noticed in IISR Girimunda (2.55 kg dry/vine) followed by IISR Thevam (2.01 kg dry/vine).

Chemo-diversity

Quality analysis of berries from 35 black pepper genotypes was completed for essential oil, oleoresin, piperine, total soluble sugar, starch and total phenolics. Genotypes that showed higher percentage of essential oil, oleoresin and piperine are presented in the table 1.

Table 1. Chemo-diversity of black pepper genotypes

Quality parameters	Accession number
Essential oil (>3%)	959,1090,1207,6648,6660,6690,6691
Oleoresin (>10%)	1090,1207,2445,5755,5757,6690,6691
Piperine (>6%)	1090,1207,2445,5755,5757,6648

The total phenolic content and starch content of genotypes ranged from 1.43-7.89 mg GAE/g and 31.14 - 55.0 % respectively. The genotypes Acc. 2436, Acc. 5762, Acc.6619, Acc.6622, Acc.6649, Acc.6714, Acc.6730, Acc. 7272, Acc. 7376 showed more than 50% starch content.

Best management practices (BMP) for black pepper grown as intercrop in coconut gardens

- If the soil pH is < 6.0, apply 500 g dolomite lime + 500 g gypsum at the base during May-June at the onset of monsoon, every year. For the soil pH > 6.0, this may be applied during alternate years.
- Apply NPK based on soil test values: 150 g urea, 150 g factamfos and 420 g muriate of potash in two equal splits (rates based on NI of Kozhikode District).
- Enrich 100 kg of FYM: Neem cake mixture (mixed in 9:1 proportion) with *Trichoderma asperellum* or *Pochonia chlamydosporia* formulation @ 1-2 kg/ 100 kg and apply enriched mixture @ 5-10 kg to the basin of black pepper vines at the onset of monsoon.
- Remove and destroy completely dried vines and drench the basins with copper oxy chloride (0.3%) with the onset of monsoon.
- Apply foliar spray of IISR Black pepper micro nutrient mixture @ 5 g/litre of water, twice, first during the flowering stage and second during the berry development stage.

This BMP showed an Incremental Benefit Cost Ratio (IBCR) of 1.98.The yield was enhanced by 36.6% through adoption of the site specific nutrient management technology

Staining procedure for *Phytophthora* nuclei to ascertain ploidy level

Staining procedure for visualizing *Phytophthora* nuclei was standardized using SYBR green and propidium iodide dyes (Fig.1).Propidium iodide based staining procedure was standardized to ascertain the ploidy level.

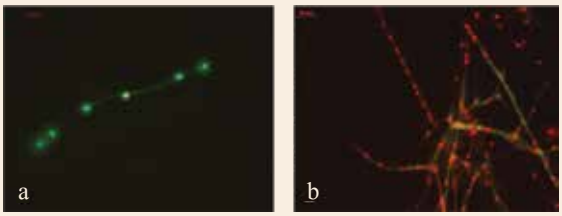


Fig.1 *Phytophthora* mycelium stained using (a) SYBR green and (b) propidium iodide

Multiplex PCR assay for simultaneous detection of *Phytophthora*, *Pythium* and *Fusarium*

A multiplex PCR assay was developed for simultaneous detection of *Phytophthora, Pythium* and *Fusarium* at genus level along with a plant internal control gene, 18s rRNA. The assay could successfully detect the pathogens both singly and in combinations and does not show any cross reaction with other fungal pathogens of black pepper (Fig. 2).

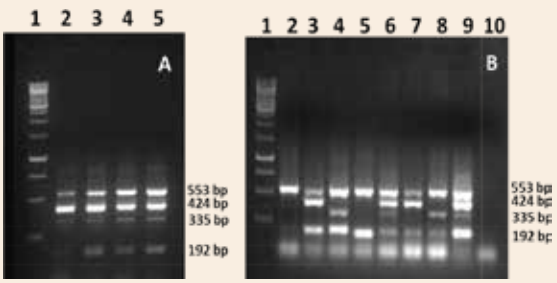


Fig. 2 Multiplex PCR assay detection (a) Lane 1. 1 Kb DNA ladder, Lane 2-5. Amplification of 18s rRNA region of black pepper (553 bp), ITS region of *Pythium* (424 bp), *Phytophthora* (335 bp) and *Fusarium* (192 bp) (b) Multiplex PCR detection of *Pythium*, *Phytophthora* and *Fusarium* from artificially inoculated root samples of black pepper

New disease

In black pepper, collar rot associated yellowing was observed in Kerala and Tamil Nadu During post-monsoon season, which aggravated during February to March. General decline in plant health and flaccidity of leaves were the other associated symptoms. In advanced stages, the entire vine exhibited yellowing (Fig. 3a) leading to wilting. The symptoms manifested on collar region included formation of necrotic regions beneath the bark (Fig. 3b) which later extended both up and downwards leading to disintegration of affected tissues. The isolates were morphologically characterized based on colony conidial and chlamydospore characteristics. Based on morphological and molecular analysis the pathogen was identified as *Fusarium solani.*

Fig. 3 Manifestation of yellowing in black pepper under field conditions (a) yellowing (b) necrotic tissues of collar region

Influence of temperature and relative humidity on the symptom expression of piper yellow mottle virus-infected black pepper

Asymptomatic piper yellow mottle virus (PYMoV) infected black pepper plants of 19 varieties were subjected to varying temperature and relative humidity (RH) under polyhouse conditions.A set of control plants were maintained under constant temperature and RH conditions. Based on the percentage of plants expressing symptoms, varieties Arka Coorg Excel, Panniyur 2 and Panniyur 6 were grouped into high symptom expression category (DI ranged from 0 to 100%), whereas Panniyur 1, Panniyur 3, Panniyur 4, Panniyur 5, Panniyur 7 and Panniyur 8, Vijay, PLD 2, IISR–Shakthi, Panchami, Subhakara, IISR–Girimunda and Sreekara were grouped into medium symptom expression category (DI ranged from 0 to 59%). But the varieties namely, IISR-Malabar Excel, Panniyur 9 and Pournami were grouped into low symptom expression category with DI ranging from 0 to 9 %. Only 0–2% of plants of different varieties kept under controlled condition expressed symptoms. Analysis of the data indicated a positive correlation with DI and afternoon maximum temperature (T-Max) and maximum relative humidity (RH Max).

Screening of new generation insecticides against pollu beetle

Three green labelled low risk insecticides (chlorantraniliprole, flubendiamide and spinetoram) at two doses (0.3 ml/L and 0.5 ml/L) along with quinalphos (2 ml/L) were evaluated for their efficacy against pollu beetle *(Lanka ramakrishnai)* under field conditions. Among the insecticides, chlorantraniliprole was effective in controlling the pest at all the doses tested maintaining the plants free of infestation followed by flubendiamide and spinetoram.

Growth response of black pepper cuttings to arbuscular mycorrhizal fungi (AMF)

Single node cuttings of black pepper (Sreekara) were grown in the presence and absence of AMF, *Rhizophagus* sp., for 150 days under polyhouse. The inoculum of AM fungus, prepared with vermiculite as the carrier, contained 100 propagules per gram of the inoculum in the

form of spores, hyphae, and mycorrhizal roots. Rooted cuttings inoculated with AMF had significantly higher root length, shoot length and dry biomass when compared to uninoculated control at 30, 60 and 90, 120 and 150 days after AM inoculation (Fig 4).

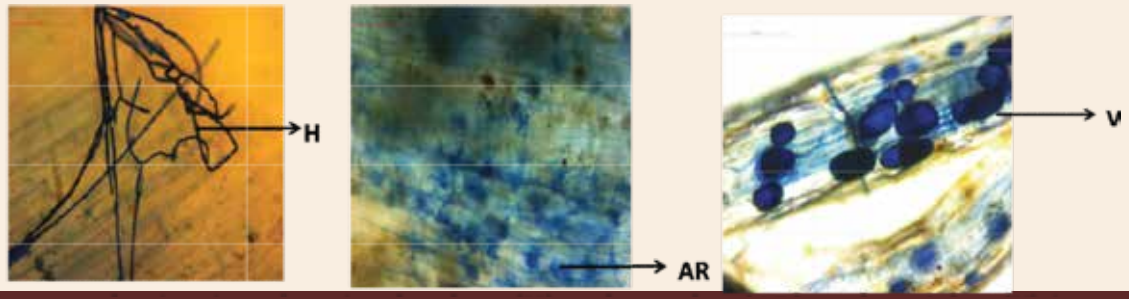


Fig.4 AM root colonization showing hyphae (H), arbuscules (AR) and vesicles (V) in black pepper roots

Root colonization by *Pochonia chlamydosporia*

A greenhouse study was conducted with rooted cuttings of black pepper (var. Sreekara) to assess the root colonizing ability of nematode antagonistic fungus, *P. chlamydosporia.* Very high population of *P. chlamydopsoria* (2.8 – 3.0 $\log_{10}$ CFU/g of root) was observed 7 and 14 days after inoculation. There was asteady increase in colonization from 7th to 28th day post inoculation indicating the endophytic colonization of *P. chlamydosporia* in black pepper roots.The endophytic colonization of *P. chlamydopsoria* was further confirmed through RT-PCR assay. *P. chlamydosporia* DNA was detected in roots at intervals of 7, 14, 21 and 28 dpi and the Ct values in root samples ranged from 32.7 to 33.37 at 21 and 28 dpi.

CARDAMOM

Genetic resources

Around 622 accessions are being maintained in the field gene bank which consists of 423 accessions from Appangala, 102 accessions from Pampadumpara, 41 accessions from Mudigere and 56 accessions from Sakleshpura. In addition to the cultivated types, six allied genera viz., *Amomum aculeatum, Amomum pterocarpum, Hedychium coccineum, Hedychium flavescens* and two *Alpinia* spp. are also being maintained.

Evaluation of farmer's varieties of cardamom

Observations on morphological and yield parameters were recorded from CVT on farmers varieties of small cardamom viz., Arjun, Wonder Cardamom, Panikulangara, Thiruthali, Elarajan, Pachakai, Pappalu, Njallani, PNS Gopinath and check variety Appangala1. Yield contributing traits viz., number of bearing tillers, number of panicles and panicle length (cm) and yield were found to be highest in Pappalu followed by Thiruthali.

Evaluation of elite cardamom accessions for drought tolerance

Six genotypes (IC 349537, IC 584058, GG×NKE-12, IC 584078, CL 668, HS 1, IC 584090) with one check (Appangala 1) were evaluated for drought tolerance. Dry capsule yield (kg/ha) ranged from 314.58 (CL 668) to 542.3 (IC 584078) in control and in stress, it ranged from 159.7 (Appangala 1) to 231.5 (GG x NKE-12). Accession IC 584090 recorded 61.86% 8mm bold capsules followed by IC 584058 (57.90%). Essential oil ranged from 8.05% (IC 584078) to 8.97% (IC 584058) and under stress, it ranged from 8.37% (IC 584058) to 9.18% (IC 584078).

Variation in yield and essential oil constituents with reference to abiotic stress tolerant traits

Variation in yield and essential oil constituents with reference to abiotic stress tolerant traits was recorded in genotypes, Appangala-1, PV-1, ICRI-2, FGB-34, PV-2 and Green Gold. Green Gold recorded more dry capsule yield (673.8 kg ha^{-1}) followed by Appangala-1 (576.4 kg ha^{-1}). Physiological attributes like photosynthetic rate, stomatal conductance, epicuticular wax and total chlorophyll content were also higher for Green Gold closely followed by Appangala-1. Both Appangala-1 (43.9%) and Green Gold (40.8 %)reported higher concentration of 1, 8-cineole. Other genotypes PV-1 and ICRI-2 had higher quantity of α-terpinyl acetate (41.6 % and 40.3 % respectively). Volatile oil of PV-2 and FGB-34 possessed higher proportion of α-terpinyl acetate (37.9 % and 37.9 % respectively) and linalool (11.1 % and 7.1 %, correspondingly).

Economic optimum for fertilizers

Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations. The economic optimum in terms of profitable response for money invested was found to be up to Rs. 3.61/clump for N, Rs. 9.6/clump for P and Rs. 15.4/clump for K. It implies that an economic response can be expected up to fertilizer dosage of 340 kg N, 230 kg P_2O_5 and 540 kg K_2O per ha (Fig. 5) for a population of 1100 plants per ha.

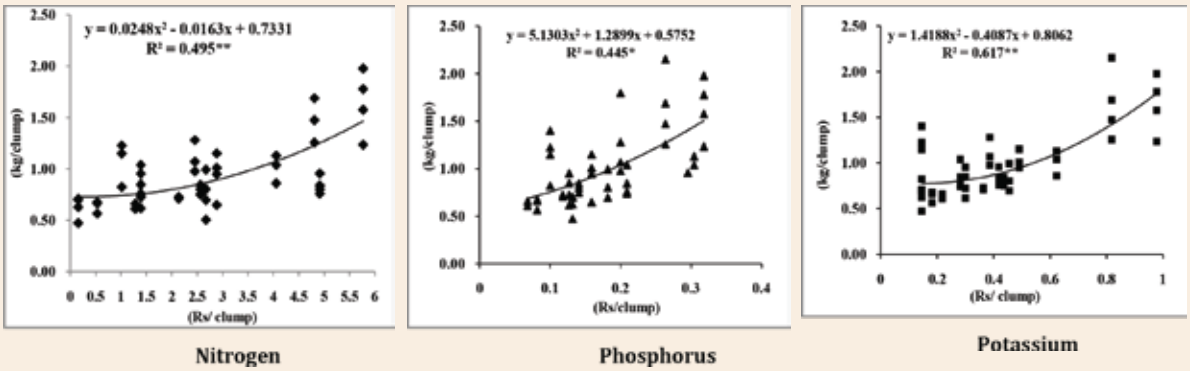


Fig. 5 Response curves for cost of NPK vs Yield (kg/clump) for working economic optimum in cardamom

Viral diseases

Development of isothermal based diagnostic assays for the detection of cardamom vein clearing virus (CdVCV)

Two isothermal molecular assays viz. reverse transcriptase loop-mediated isothermal amplification (RT-LAMP) and reverse transcriptase recombinase amplification (RT-RPA) were developed to detect CdVCV. Detection limits of both assays were determined and compared with conventional RT-PCR and SYBR Green-based real-time RT-PCR. RT-LAMP was found 10000 times more sensitive than RT-PCR and one-tenth that of real-time RT-PCR. RT-RPA was found 1000 times sensitive than RT-PCR and one-hundredth that of real-time RT-PCR Both assays were specific, rapid, and sensitive for detecting CdVCV. Compared to real-time RT-PCR, these assays are economical and can be employed in large scale screening against CdVCV.

GINGER

Genetic resources

668 accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with four ginger and nine *Zingiber* sp. from Andaman Islands. A new conservatory (Garden of Gingers) was established at ICAR-IISR under the DBT funded project for conserving unique ginger and turmeric genotypes (Fig.6).

Fig. 6 View of Conservatory-Garden of gingers

Characterization

Quality characterization of 10 exotic accessions showed that the Acc. 869 (2.44%), recorded the highest essential oil content followed by Acc. 393 (2.42%). Acc. 869, Acc. 874, Acc. 873 and Acc. 393 recorded higher oleoresin content of 5.88%, 5.63%, 5.34% and 5.28%, respectively. The exotic genotypes such as, Acc. 607, Acc. 736 and Acc. 393 recorded lower crude fibre content (<5%), whereas Acc. 869 recorded higher crude fibre content (7.85%). The principal compound identified in essential oil was α- zingiberene and it was highest in Acc. 393 (30.49%) followed by Maran (30.32%).

A total of 40 land races of ginger collected from NE states were characterized for different quality characters which resulted in identification of a superior red ginger genotype with high essential oil (4.3%) along with high pungent principles, gingerol (1.92%) and shogaol (0.55%).

Molecular characterization

From RNASeq assembled contigs obtained through Illumina paired end sequencing, 16,790 EST-SSR loci from 78987 unigenes, and 4597 SSR loci from predicted 76929 coding sequences (CDS) were identified. The 12 flanking EST-SSR primers designed were used for validation in 48 genotypes from NE India and different eco-geographical adaptations by PCR amplification and allele sizing through capillary electrophoresis.Twelve EST-SSR primers generated a total of 111 alleles with an average of 9.25 alleles per locus and allele sizes ranging between 115-189bp.

Breeding

New variety released

IISR Vajra, a clonal selection (Acc. 247) was released during the XXXI All India Coordinated Research Project on Spices (AICRPS) Group Meeting held at ICAR-IISR, Kozhikode in 2020. The characteristic features of the variety are bold and plumpy rhizomes with high yield potential (26.38 t/ha), fibre (5.67%), essential oil (2.15%), oleoresin (7.26%),zingiberene (29.83%) and dry recovery (20.7%). The variety is suitable for Kerala, Karnataka, Odisha and West Bengal.

Polyploid breeding

Systematic examination of the induced tetraploids (0.1/48/3 and 0.1/48/5) revealed significant morphological differences in leaves, pseudostems, and rhizomes. Tetraploid lines exhibited larger plants, leaves, and pseudo stems than their diploids. Moreover, average rhizome thickness of the tetraploid mutants was significantly higher than that of the diploids. In brief, the tetraploid IISR Rejatha exhibited some superior agronomic characteristics that include more vigour and bigger rhizome characters.

Differential expression of potential micro RNAs in bacterial wilt resistant and susceptible gingers

The assembled mRNAs (transcriptome data from ginger-*Ralstonia solanacearum* interactions*)* were utilized to generate miRNA targets and miRNAs. Based on the alignment results, a total of 2926 potential miRNA targets were selected, out of which 1551 were upregulated and 1419 were downregulated. In case of mango ginger, out of 2145 potential miRNA targets, 1506 were upregulated and 1594 were downregulated (Fig. 7). In the resistance interactions with mango ginger, 1068 unique target genes were upregulated when compared to control. Gene Ontology (GO) analysis of differentially expressed target genes showed highest enrichment in response to cold, chloroplast and ATP binding in biological, cellular and molecular functions respectively. Nine target genes and their corresponding miRNAs were experimentally validated, which shows significant difference in expression with ginger-*Ralstonia solanacearum* interactions.

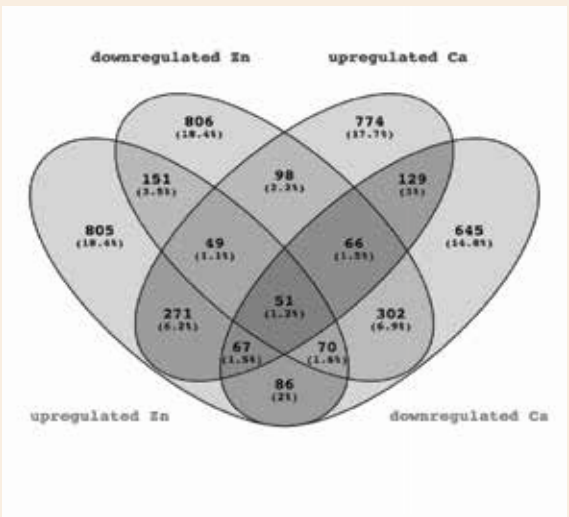


Fig.7 Venn diagram of differentially expressed target genes in response to bacterial wilt in two ginger species (ginger: Zn and mango ginger: Ca)

Soft rot disease management

Evaluation of efficient bacterial antagonists

Under glasshouse conditions, the most efficient bacterial antagonists *Bacillus safensis* (IISR TB4) and *B. cereus* (IISRGB7 (3)) were evaluated against the soft rot pathogen, *Pythium myriotylum* and foliar pathogens, *Colletotrichum gloeosporioides* and *Exserohilum rostratum* of ginger. The results indicated significantly higher sprouting in treatments with PGPR treatments compared to the chemical method . Both the PGPR exhibited significant ($P < 0.05$) suppression of all the three pathogens compared to the chemical method. In case of *P. myriotylum,* the PDI was 92.45 in the control and 53.04 in the treatment with metalaxyl-mancozeb, which decreased significantly to 12.05 *(B. safensis* alone*)*, 14.22 *(B. safensis* + *B. cereus*) and 21.30 (*B. cereus* alone). Likewise, in case of foliar diseases, the PDI was lower in PGPR treatments than in chemical method and control.

Development of RT-LAMP and RT-RPA assays for the detection of two novel viruses infecting ginger

Our previous studies have shown the association of two novel viruses namely, ginger chlorotic fleck-associated virus 1 (GCFaV-1) (Family: Tombusviridae) and ginger chlorotic fleck-associated virus 2 (GCFaV-2) (Family: Closteroviridae) with chlorotic fleck disease of ginger. Two isothermal assays, RT-LAMP and RT-RPA assays were developed and validated for the quick detection of GCFaV-1 and GCFaV-2 (Fig. 8). Based on the cost-effectiveness and duration, RT-LAMP and RT-RPA assays can be suggested for the rapid detection of both viruses.

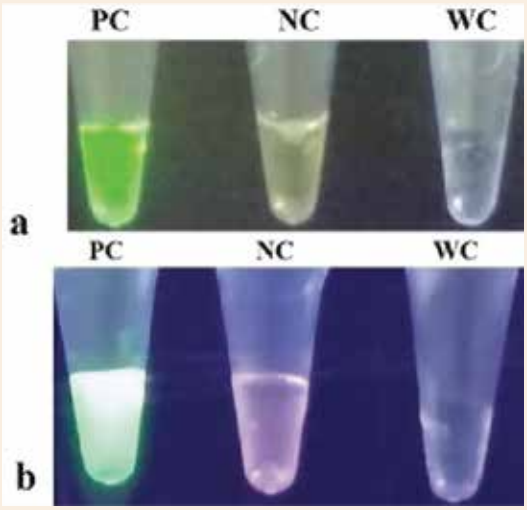


Fig.8 Visual detection of reverse transcription loop-mediated isothermal amplification (RT-LAMP) products under UV light (a) ginger chlorotic fleck-associated virus 1(GCFaV-1), (b) ginger chlorotic fleck-associated virus 2 (GCFaV-2). PC, infected ginger (positive control); NC, healthy ginger (negative control); WC, water control.

TURMERIC

Genetic resources

1404 accessions are being maintained in the field gene bank.The germplasm conservatory was enriched with three *Curcuma long*a and five *Curcuma* sp. from Andamans.

Characterization

Characterization of 200 accessions was carried out based on different morphological traits. A total of 12 quantitative and 10 qualitative characters were recorded for each accession. A total of 155 accessions, eight varieties and four GIs (Erode turmeric, Sangli turmeric, Waigon turmeric and Kandhmal haldi) were characterized for different quality parameters. The curcumin content varied from 0.6 to 5.2%. Investigation of detailed curcuminoid profile revealed three groups, genotypes with equal quantity of bisdemethoxy curcumin (BDMC) and demethoxycurcumin (DMC), BDMC greater than DMC and DMC greater than BDMC.

Breeding

Maintenance of seedling progenies, hybrids and inbreds of turmeric

First generation seedlings (204), mother genotypes (20), second generation seedlings (432), third generation seedlings (47), first generation inbreds (839), second generation inbreds (11), third generation inbreds (402), fourth generation inbreds (367) and inter-varietal hybrids (36 Nos), 117 F2 hybrids of H1 (36), H2 (81), and nine open-pollinated progenies of high curcumin line SLP 389/1 are being maintained. Additionally, intercross hybrids (29), back cross hybrids (7), OP progenies of two inter-varietal hybrids (30) and 60 somaclones are also being maintained.

Chromosome number analysis of seedlings, hybrids and inbreds of turmeric

Chromosome number analysis was completed in 14 inbreds, 20 OP seedlings and one hybrid. Most of the inbreds showed 2n=84 as the somatic chromosome number while a few had 2n=86. Among seedling progenies chromosome numbers like 2n=82, 2n=80, 2n=79, 2n=78 and 2n=74 was also observed. The hybrid between Hybrid-2 x Roma showed 2n=78.

Novel bHLH and WD 40 transcription factors from turmeric as putative regulators of curcumin biosynthesis

25 transcription factors (TFs) belonging to the classes bHLH, WD 40, NAC, WRKY and bZIP that showed differential expression with respect to curcumin were identified through comparative transcriptome analysis. Three TFs including two bHLH and one WD40, that showed maximum comparative fold change and negative correlation with curcumin content were validated through qRT-PCR analysis. The results of comparative transcriptome and qRT-PCR analyses were in congruence indicating their putative role as negative regulators (Fig. 9).

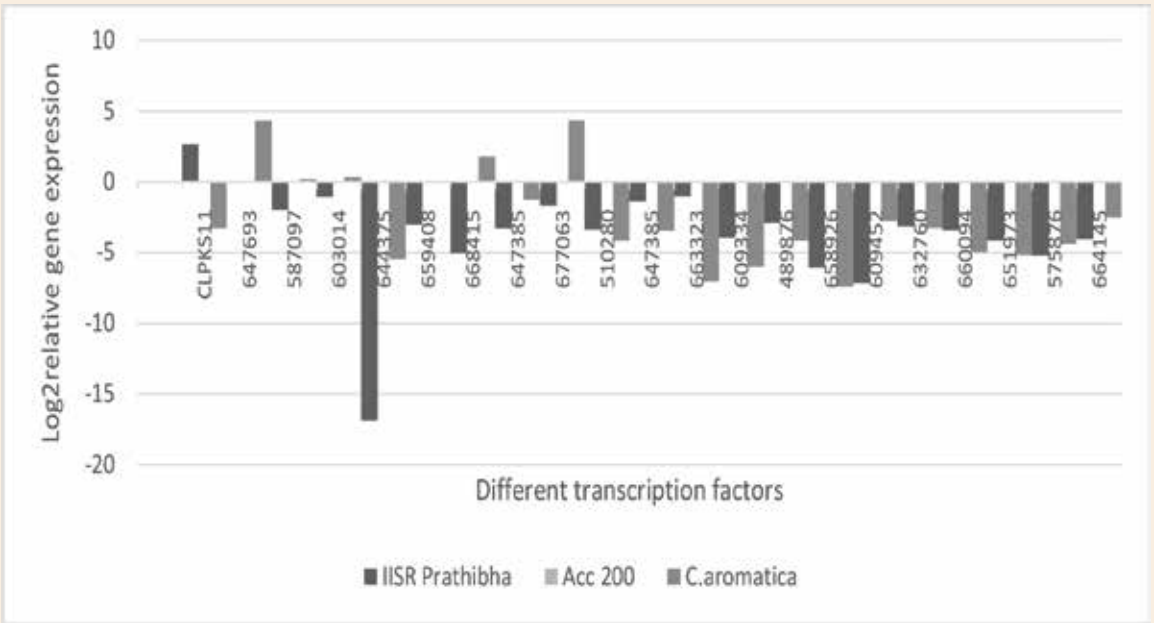


Fig. 9 Expression profiling of twenty TFs genes in germplasm accession with high, low and very low curcumin content

Evaluation of different management systems

Soil samples were collected 120 days after planting of turmeric from different management systems and analyzed for nutrients. The OC, N, P, Ca, Mg, Mn and Zn contents were significantly higher under organic management system. Among management systems, organic system (100%) recorded maximum yield (34.78 t/ha) followed by integrated system (50%+50%) (31.8 t/ha). Among the varieties, Suguna recorded highest yield (40.8 t/ha) followed by Pragati (38.6 t/ha).

Varietal Response to Organic Farming

Twelve varieties were grown under 100% organic management systems. Among these, Suguna recorded maximum yield (48 t/ha), followed by IISR Pragati (44.5 t/ha).Regarding essential oil content, IISR Pragati and IISR Prathibha were on par (5.8%). Maximum oleoresin content was recorded by IISR Prabha (14.90 %) followed by IISR Pragati (14.55 %). Maximum curcumin content was recorded by IISR Pragati (6.28 %), followed by IISR Prabha (6.08 %) (Fig. 10).

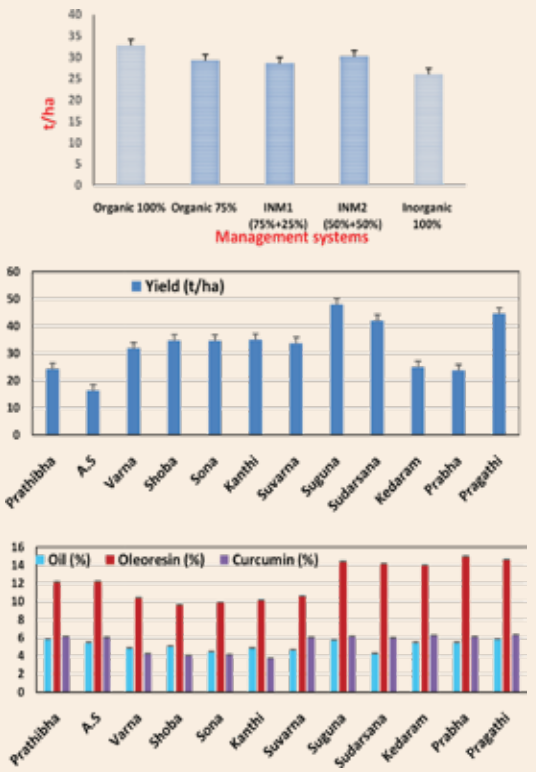


Fig. 10 Varietal response to organic farming

Effect of drying temperature, curing and slicing on the quality of turmeric

The effect of drying temperature, curing and slicing of turmeric (var.IISR Alleppey Supreme) on drying and quality of turmeric was studied. Drying of cured and uncured sliced turmeric was performed in mechanical dryer at temperatures varying from 50 to 100°C and compared to solar tunnel drying and sun drying. Samples cured for 60 min for 1 h either by steam or water boiling and then sliced in a mechanical slicer to 5 mm thickness, when dried at a temperature of 90°C produces turmeric flakes of superior quality.

Insect Pests

Spray schedule optimization of new generation insecticides against shoot borer

Three low risk insecticides (chlorantraniliprole, flubendiamide and spinosad) at two different doses (0.3 & 0.5ml/L), which were found to be effective earlier and a combination treatment of spraying chlorantraniliprole and spinosad alternatively were tested under field conditions for optimizing the spray schedule at two different spray intervals (15 and 30 days interval) against shoot borer. Results indicated that spraying insecticides at fortnightly intervals rather than spraying at monthly intervals is more effective.

Entomopathogenic fungus infecting *Conogethes punctiferalis*

An entomopathogenic fungus was isolated from *C. punctiferalis* and identified as *Metarhizium pingshaense-Q.T.* Chen & H.L. Guo (Ascomycota: Hypocreales). Bioassay studies with purified conidial suspension proved that the isolate was highly virulent to *C. punctiferalis,* causing more than 86% mortality to fifth instar larvae at 1×10^8 spores/mL, under laboratory conditions (Fig. 11). The median lethal concentration (LC_{50}) of the fungus against late instar larvae was 9.1×10^5 conidia/mL and the median survival time (MST) of late instar larvae tested at the doses of 1×10^8 and 1×10^7 conidia/mL were 4.7 and 6.4 days, respectively.

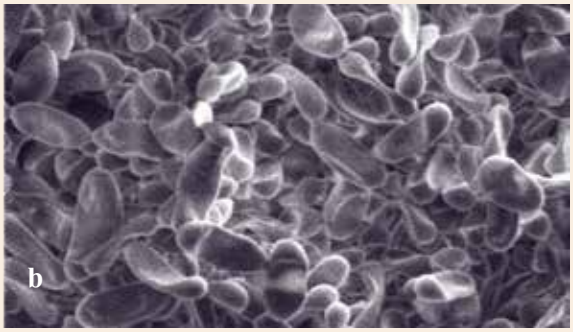


Fig. 11 (a) Sporulated cadaver of *C. punctiferalis* infected by *M. pingshaense* (b) Close up of chains of *M. pingshaense* conidia on the cuticle surface

Plant parasitic nematodes culturing of lesion nematodes

Culturing of lesion nematodes was tried on different hosts such as banana, maize, brinjal and tomato, black pepper and ginger under screen house conditions. The highest multiplication (150.5 nematodes/100g roots) of nematodes was observed in banana after four months of inoculation with 100 nematodes/plant around the root zone.

Effect of cold storage of turmeric rhizomes on lesion nematodes

The effect of storing turmeric seed rhizomes under lower temperature on survival and multiplication of *Pratylenchus* spp. was studied. Infected turmeric rhizomes stored in a cold storage (4-8˚C) for 35 days could cause 100% death of nematodes compared to storage under room temperature.

VANILLA

65 accessions of *Vanilla planifolia*, seven *Vanilla* spp. from Andaman, one each of *V. pilifera*, *V. aphylla*, *V. tahitensis* and *V. wightiana*, two species from Wayanad, one species from Assam and three species from Little Andamans were added to the conservatory (Fig. 12).

Fig.12 Vanilla germplasm conservation under protected condition

Characterization

Molecular characterization of *Vanilla* spp collected from Andamans was done for comparison with *V. planifolia.* It was found that three accessions (Acc. 4796, 4797 and 4798) collected from Andaman belong to *V.planifolia* group. Other accessions formed separate cluster and were different from *V. planifolia* .

Quality profiling

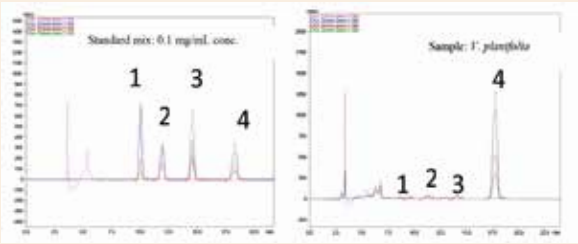


Fig.13 Vanilla quality profiling compared with standards: 1. p-hydroxybenzoic acid, 2. vanillic acid, 3. p-hydroxybenzaldehyde 4. Vanillin.

The results showed that among *V. planifolia*, vanillin was detected in the range of 0.57 to 1.99% whereas p-hydroxybenzoicacid, p- hydroxybenzaldehyde and vanillic acid are detected in the range of 0.0003 to 0.0127%, 0.017 to 0.036% and 0.055 to 0.093% respectively (Fig.13).

TREE SPICES

NUTMEG

A high yielding monoecious line with long fruits, another monoecious accession which bears fruits in clusters and a high yielding female accession of nutmeg were collected from Sirsi, Karnataka. Yield observations of nutmeg germplasm were recorded and accessions 505, 511, 530,572, 616 and 625 were found to be promising.

Best management practices (BMP) developed for nutmeg grown as intercrop in coconut gardens

- If the soil pH is < 6.0, apply 1kg dolomite lime + 1 kg gypsum along the drip line/ canopy periphery during May-June at the onset of monsoon, every year. For the soil pH ≥6.0, this may be applied during alternate years.
- Apply NPK fertilizers based on soil test values: 800 g Urea, 500 g Factamfos and 1.50 kg Muriate of Potash in two equal splits (rates based on Nutrient Index of Ernakulam District).
- Enrich 100 kg of FYM: neem cake mixture (mixed in 9:1 proportion) with *Trichoderma asperellum* @ 1-2 kg formulation per 100 kg and apply @ 20-25 kg of enriched mixture per tree during the onset of monsoon.
- Apply foliar spray of IISR nutmeg micronutrient mixture - @ 5 g/ L water at flowering and flower development stages at monthly intervals (2-3 sprays).

- Cut and remove the dried or infected branches (due to thread blight infection) and spray Bordeaux mixture (1%) on leaves at the onset of monsoon (May-June).and repeat the spray one month after first application.

Economic evaluation of this BMP showed an Incremental Benefit Cost Ratio (IBCR) of 2.1. The yield increase was up to 22% in the treated plots in the experimental condition for nut and mace yield. Yield increase of 10-25% in nut and mace from farmer's demonstration plots were observed as compared to the farmers practice.

CINNAMON

Four accessions of cinnamon and two wild species were collected from Andaman and Nicobar Islands. *Cinnamomum walaiwarense* (Fig.14) and *C. chemungianum* were collected from Agasthyamala Biosphere Reserve, Kerala.

Fig.14 *Cinnamomum walaiwarense* collected from Agasthyamala Biosphere Reserve

CLOVE

A clove accession with bold flower bud was collected from farmer's field at Kattippara, Kerala. A wild species of *Syzygium* from Agasthyamala Biosphere Reserve and five wild species from Andaman and Nicobar Islands were collected and conserved. In situ evaluation of elite clove trees were undertaken at farmer's field in Kozhikode district, Kerala. The dry flower bud yield varied from 3.38-13.63 kg per tree and the essential oil content varied from 10.5 to 13.5 %.

GARCINIA

Garcinia andamanica (Fig 15a), *G. dulcis*, *G. cowa, G. kydia, G. dhanikhariensis* and *G. speciosa* were collected from Andaman and Nicobar Islands. *Garcinia imberti*, *G. rubro-echinata* (Fig.15b), *G. travancorica, G. gamblei* and *G. morella* and a wild accession of G. gummi-gutta were collected from Agasthyamala Biosphere Reserve. Two high yielding accessions of *G. gummi-gutta* were collected from Thrissur and Nilambur. A high yielding accession of *G. indica* with red fruits and two accessions with yellow fruits were collected from Sirsi.

Fig.15a *Garcinia andamanica* collected from Andaman Islands

Fig.15b *Garcinia rubro-echinata* collected from Agasthyamala Biosphere Reserve

ALLSPICE

Two accessions of *Pimenta dioica* were collected from Thiruvananthapuram district of Kerala.

High value compounds/ pharmaceutical profiling essential oil profile of *pimenta racemosa*

The volatile constituents of samples of *Pimenta racemosa* collected from Wayanad were analyzed using GC-MS. Eugenol, myrcene, chavicol and limonene are found to be the major constituents. The eugenol content was found to be the highest in fruit stalk (57 %), followed by leaves (52.3 %) and berries (39.9 %). Other distinguishing volatiles among different parts are myrcene, limonene, trans-ocimene and chavicol.

GENERAL

DUS facility

DUS testing was completed for 19 turmeric varieties which include 14 farmers' varieties and four varieties of common knowledge and one new variety. DUS testing completed for seven ginger varieties which include four farmers' varieties and three varieties of common knowledge. Onsite preliminary observation of four black pepper and six small cardamom varieties were undertaken and corresponding reference varieties were identified. At present two ginger and four turmeric farmer varieties are under DUS testing.

DNA fingerprinting and barcoding

DNA isolation and PCR protocols were optimized in Cardamom, Ajwain and Nigella. Polymorphic ISSR markers for distinguishing candidate varieties from check in the above crops were identified.

Establishment of farming system model with spices as component crops

The farming system model plot established with different component crops viz., black pepper, turmeric, fodder grasses (Congo signal grass, CO-3, CO-4), tapioca, banana, cowpea, arrow root, coconut, elephant foot yam, other yams, maize and pineapple is maintained at ICAR-IISR,Chelavoor campus along with a dairy unit of three cows and their calves. Turmeric (560 kg), banana (150 kg), tapioca (375 kg), vegetable cowpea (20 kg) and coconut (3300 nos) were harvested from the model plot. Employment generated from this plot was 415 man days/-year with a profit of Rs 1.66 lakhs from one acre.

Production of nucleus planting materials of improved varieties

About 80000 rooted cuttings of improved varieties of black pepper were produced at Main Campus, Kozhikode and Regional Station, Appangala and distributed to farmers. Improved varieties of ginger (200 beds) and turmeric (900 beds) are planted and maintained for seed production at main campus and Experimental Farm, Peruvannamuzhi. More than 10000 cardamom suckers were produced and distributed from Regional station, Appangala. Farmers participatory seed production of ginger (var. IISR Varada) is being taken up by signing an MOU at two farmer's plots (Mr. Baiju Sebastian, Thamarasery and Mr. Cheriyan, Pulpally) (Fig.16).

Microrhizome of ginger varieties (Mahima, Varada) were subcultured and 2200 plantlets of ginger were raised in cultures and hardened in pro-trays and poly bags under nursery. Five hundred hardened micro rhizomes were raised in grow bag conditions and 300-500 g fresh rhizome yield was realized from each clump in 11 months cycle. Those rhizomes were again used as seed rhizomes for next production season.

A contiguous area subsumed in Mattilayam watershed, Vellamunda panchayat, Wayanad District, Kerala with approximately 30,000 black pepper vines has been identified and the large scale demonstration of production technologies were taken up by distribution of new varieties, bio inputs and micronutrient mixtures. A nursery was established at the watershed for meeting their continuous planting material requirement.

Fig.16a Ginger rhizome yield from microrhizome

b. Ginger plants hardened from micro rhizomes

c. Participatory seed production of ginger at Farmers field (Mr. Cheriyan, Pulpally & Mr. Baiju, Thamarasery)

Value chain incubation facility for processing of spices

The facility was inaugurated by Hon'ble Minister for Agriculture, Govt. of Kerala on 1 July 2020. At present the facility is used for commercial production of ginger and nutmeg based value-added products. Out of the trained participants one group namely Al-Dina Foods, have started using this facility to produce various value-added products.

Plant beneficial rhizosphere microorganisms (PBRMs)

Six bacterial isolates *viz., B. safensis* (IISR TB4), *B. marisflavi* (IISR GB6), *B. cereus* (IISR GB7), *Phytobacter diazotrophicus* (IISR GB3), *B. firmus* (IISR GB 7(2)) and *Pseudomonas aeruginosa* (IISR TB5) were tested for their ability to solubilize tricalcium phosphate (TCP) in liquid and in soil *per se*. The liquid medium and soil were spiked with 1000 ppm P while. P release was determined at intervals ranging between 24h to 25 days after initiation (DAI). Results were identical in both liquid medium and in soil. *B.safensis, B.marisflavi* and *B.cereus* released maximum P, especially at 10 DAI followed by a steady decrease (Fig. 17).

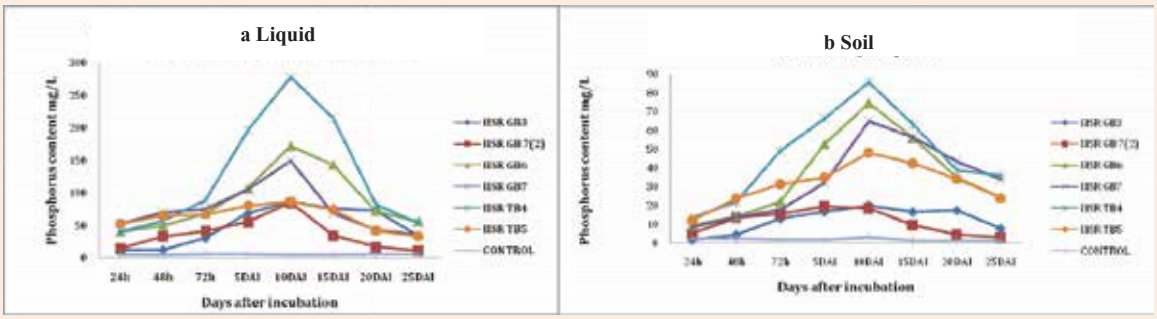


Fig.17 Phosphorus solubilization study in liquid and soil medium amended with TCP

Determination of organic acids production by bacterial isolates during phosphate/zinc solubilization

Organic acid production by six bacterial isolates viz., *Bacillus safensis* (IISR TB4), *B.marisflavi* (IISR GB6), *B.cereus* (IISR GB7), *Phytobacter diazotrophicus* (IISR GB3), *B.firmus* (IISR GB 7(2)) and *Pseudomonas aeruginosa* (IISR TB5) were estimated using insoluble substrates of P and Zn amended in liquid broth. Detection and quantification of organic acids was done using HPLC. *B. safensis, B. marisflavi* and *Pseudomonas aeruginosa* showed maximum organic production of 530, 526, 430 µg/mL and 793, 317 and 347 µg/mL when recalcitrant substrates, dicalcium phosphate and tricalcium phosphate, respectively, were used. With zinc phosphate and zinc oxide as recalcitrant sources, the bacterial strains produced 486, 386, 508 µg/mL and 404, 269 and 566 µg/mL organic acids, respectively (Fig. 18).

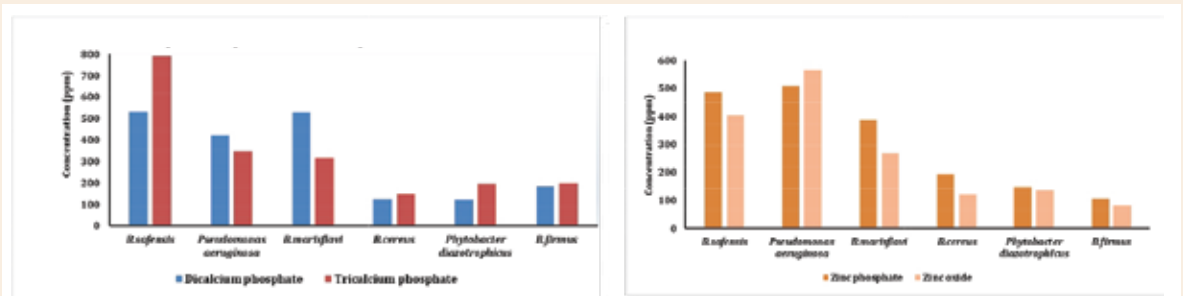


Fig.18 Organic acid production by six bacterial isolates during (a) P and (b) Zn solubilization

ECONOMICS

Budgeting Carbon Equivalence (CE) of inputs used in spices production

The secondary data (state wise)on the area under crop and quantity of fertilizers and pesticides used for different spice crops was collected and C equivalence worked out. The carbon equivalence (CE) of the used fertilizers is worked out to be 156.6, 247.6 and 297.6 Gg in 2000, 2010 and 2019, respectively.The consumption of pesticides in spices was 154.4, 156.1 and 97.4 Mg in 2001-02, 2010-11 2019-20 respectively. The corresponding carbon equivalence (CE) of the pesticides used was 926.6, 936.7 and 584.4 Mg.

Infrastructure and export issues in spice industry

One of the major requirements for the country to consolidate its position as the global leader in spices would involve critical changes in the production environment to suit the global market preference. The focus on food safety, reduction in use of pesticides, adoption of sustainable and good agricultural practices (GAP) are key components of this change. Other issues identified were:

- Specialized Farmer collectives in spices need to be promoted.
- Need for dedicated support for gathering market intelligence, demand patterns and specific consumer requirements.
- A diversified portfolio of clientele and backward linkage with primary production shall help in solving weak demand and inability to cater to the demand pattern.
- Urgent need to sensitize international organizations like Codex and WTO on the need to have uniformity in standards and procedures for spice exports.
- India should strive to emerge as a global supplier of high value extracts from spices through development of industrial varieties with specific traits.

TRIBAL SUB PLAN (TSP) AND SPECIAL COMPONENT PLAN (SCP)

An area of 1,483 ha. of turmeric involving 1,050 farmers organized under two FPO's was brought under organic cultivation adopting the technologies developed by ICAR-IISR.Training and stakeholder workshops were carried out in Golpara and Kamrup in Assam and Namsai in Arunchal Pradesh for 500 and 300 beneficiaries, respectively. The scheme "Integration of Black Pepper in Ongoing My Government Assam Clean & Green Village Campaign" was initiated for the vertical and horizontal

Analysis of output performance in spices

Across the crops, more than 150 varieties developed by public funded research has been released and in spices more than 80.0% of the total area is covered by developed varieties. Continuous genetic advancement has played a significant role in maintaining the output growth in spices, at a rate higher than that of food grains and oilseeds taken together. The continuous decadal growth rate of output of spices till 2018-19 has been consistently above that of food grains and oilseed during the last three decades implying a better rate of technology uptake and resultant output growth (Fig.19).

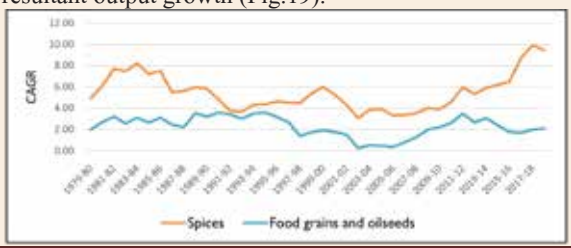


Fig.19 Output performance of Spices sector

expansion of black pepper sector in Assam. The linkage of black pepper growers of the State with technology, training and trade was established to enhance the income of small and marginal farmers by organizing them into Pepper Production Cluster (PPC). 30 black pepper nurseries were set up in 33 districts for making available quality planting material to farmers in Arunachal Pradesh, an FPO Namsai Organic Spices producer company (with 500 farmers)jointly with spices board, cultivated two varieties Rajendra Sonia and Megha turmeric covering an area of 300 acres (Fig.20).

Fig.20 Honourable former Chief Minister of Assam meets ICAR IISR Scientists

ATIC and EXTENSION SERVICES

ATIC provided advisory and technology dissemination services including sale of technology and products to various stakeholders. There was a perceptible shift from personal visits to virtual mode of contacts and use of digital platforms for availing the services offered. Visitor management system software has been developed and implemented at the ATIC for efficient and easy handling of visitor stakeholders. About 16 on-demand training programmes on production and processing technologies for the state departments and other organisations and two educational training programmes for RAWE students of College of Agriculture Kerala Agriculture University, Thrissur were organized. The institute joined hands with the Farm Information Bureau, Government of Kerala, to produce a series of radio programmes under the title "Sugandha Keralam" which were broadcasted across seven radio stations during the popular farm programme called the "Njattuvela". The institute designed short instructional videos on diverse aspects of spice farming for easy dissemination of technology through social media platforms. The institute provided technical support and expert services for video productions on its mandate spice crops for DD Kisan Channel and a total of eight programmes were broadcasted at the national level through the programme titled "Masala India".The revenue generation through the sale of planting material of spice crops, bio-inputs and micronutrients and other products from ATIC was 28.2 lakhs during 2020.

ICAR-ALL INDIA COORDINATED RESEARCH PROJECT (AICRP) ON SPICES

The XXXI Workshop of ICAR-All India Coordinated Research Project on Spices (AICRPS) was conducted during 29-30 September 2020 at ICAR- Indian Institute of Spices Research, Kozhikode through virtual platform. The workshop was inaugurated by Dr. R. Chandra Babu, Hon'ble Vice Chancellor, Kerala Agricultural University, Thrissur on 29 September 2020.Dr. A. K. Singh, Deputy Director General (Horticultural Science), Indian Council of Agricultural Research, New Delhi presided over the function. During the inaugural session the "Best AICRPS Centre Award 2019-20" was presented to AICRPS centre at IGKV, Raipur (Raigarh), Chhattisgarh. Ten booklets/pamphlets on spices production technologies in English and local languages from different AICRPS centres were released during the workshop. During the workshop, a technology for management of insect pest of large cardamom using Spinosad (45 SC @ 0.3 ml L^{-1}) or neem based oil (Azadirachtin 0.15% EC) 1500 ppm @ 3 ml L^{-1}) was recommended. Four varieties one each in ginger and fenugreek and two in turmeric, suitable for different growing regions were recommended for release. ICAR- AICRPS centres at various parts of India took the initiative to support farming community by the distribution of quality planting materials. Crop advisories to the farmers for various spice crops were prepared by AICRPS and uploaded in the website. Advisories were given through newspaper in various local languages,whatsapp group and mobile phone by different AICRPS centres. Planting materials of ginger var. Nadia and turmeric var. NDH-98, Megha Turmeric and Rajendra Sonia were distributed to farmers of Namsai and East Siang districts of Arunachal Pradesh respectively for seed production under Front Line Demonstration.

KRISHI VIGYAN KENDRA

Krishi Vigyan Kendra (KVK) imparted regular training programmes in agriculture and allied fields for the farmers, farm women, rural youth and extension functionaries. The Kendra conducted 75 on-campus and online mode trainings benefitting 12,673 participants. Online trainings were organized on "cultivation of spices, vegetables, mushroom, Ornamental fishes" and pest and disease management, which benefited more than 12,000 persons during the COVID period. Krishi Vigyan Kendra organized soil nutrient analysis camp, distribution of soil health cards and awareness creation programs for farmers on balanced fertilizer usage and soil health management.

Sponsored trainings were organized on garment making,-friends of Coconut and dairy entrepreneur (sponsored by ASCI),mechanized coconut climbing(Sponsored by Coconut Development Board, Cochin)and Nursery management (sponsored by MANAGE, Hyderabad – ASCI). One month long Rural Agricultural Work Experience (RAWE) programme was organised for B.Sc. (Agriculture) students from Dr B.R. Ambedkar University, Agra.

The Kendra organized webinar on Nutrient management in spices during Kerala Farmer's Day (17th August) with expert class on 'Soil nutrients, deficiency symptoms and fertilizer management in spices. National Farmers' Day was celebrated at KVK on 23 Dec, 2020 and a seminar on 'Bush pepper and vegetable grafting' was organized. Live - web casting of Global potato conclave on 28 January; World Environment Day seminar on Oyster mushroom cultivation on 5th June; World Yoga day on 26 June and World Soil day workshop on Soil health management on 05 December were organized as mass awareness programmes.

INSTITUTE TECHNOLOGY MANAGEMENT-BUSINESS PLANNING AND DEVELOPMENT (ITM-BPD) UNIT

ITM-BPD unit commercialized 11 technologies during the year 2020. An amount of Rs. 27.65 lakhs was earned through technology commercialization and royalty payments from licensees. The institute entered into a MoA wih Malabar Regional Co-operative Milk Producers' Union Ltd., (MRCMPU Ltd) for collaboration in research and development of novel technologies related to health and wellness and for commercial production and marketing. ITM-BPD unit produced an immunity booster formu-

lation of spices based on an age old traditional formulation viz., "Kava" through the incubatee Mrs. Maya, Arun Agro food products limited.

A patent application was filed for the invention "An antimicrobial composition for coating rhizomes and tubers and a process for its preparation" on 08 October, 2020. Approval of National Biodiversity Authority was obtained for two of the patent filed inventions 'A novel granular formulation of a beneficial fungus (*Lecanicillium psalliotae*) with multifarious plant growth promoting, immune boosting traits for cardamom and the process thereof' and 'A novel granular liquid process for mass multiplication of *Pochonia chlamydosporia'*.

Ministry of Micro, Small & Medium Enterprises (MSME) recognised ICAR-IISR as Host Institute (HI) to setup/establish Business incubator (BI). ITM-BPD unit organized a sensitization programme on a new scheme of MSME, Government of India 'Ideas for new India for supporting MSMEs through incubators' for Research scholars.

Sixteen start-ups/ entrepreneurs were enrolled as incubatees during the year 2020 under the BPD unit of ICAR-IISR for marketing of spices, development of spice based food products, marketing of agri inputs for spice cultivation and marketing planting materials of various spices and other crops.

SPIISRY, the sales outlet of BPD continues to provide market linkage and sales of products from FPOs, registered farmers, start-ups and MILMA products from MRCMPU Ltd. The Krishidhan nursery of BPD also provides support for production and distribution of quality assured planting materials produced by joint liability groups, licensees and registered farmers.

Functional product development of spices through value addition

ICAR-IISR has developed two separate technologies for turmeric milk preparation; one as ready to serve sterilized flavoured turmeric milk and the other one as turmeric milk instant mix powder. A third product using the liquid spice extract of turmeric, ginger and *Piper chaba* was used for the preparation of Ayur butter milk. The lab scale technologies developed at ICAR-IISR were further fine-tuned by carrying out industrial trial at processing plant of Malabar Regional Co-operative Milk Producers' Union Ltd. (MRCMPU), Kozhikode. The technology was then non-exclusively licensed to MILMA, and the products have been launched in the trade name "MILMA Golden Milk", "MILMA Golden Milk Mix" and "MILMA Ayur Butter Milk".

AGRICULTURAL KNOWLEDGE MANAGEMENT UNITS (AKMU)

AKMU facilitates the IT and ICT related activities of the institute, manages network security aspects, regular updating of websites of the institute, AICRP on spices, SpicE-Library, and BPD. AKMU also assists in analysis and interpretation of geographical data using ArcGIS & DIVA GIS and statistical analysis of scientific data using SAS and other statistical software.The unit developed the mobile applications ICAR-IISR Cardamom, ATIC Visitor Management System and online applications for the selection of young professionals and senior research fellows.

LIBRARY

Library subscribed twenty four Indian and nine foreign journals during the year in addition to journals accessible under Consortium of Electronic Resources in agriculture (CeRA). Full text of 200 publications was added to 'D spice' institutional repository and all newly added publications were brought into the KOHA database.

HUMAN RESOURCE DEVELOPMENT

ICAR-IISR has signed MoU with two institutions viz., University of Agricultural and Horticultural Sciences, Shivamoga, Karnataka and Dr.YSR Horticultural University, West Godavari, Andhra Pradesh for research collaboration and exchange of students. Virtual training programmes on E – office Awareness and new features of GeM Portal were organized at ICAR-IISR, Kozhikode for scientists, technical and administrative staff.


ICAR - IISR

IMPORTANT DAYS OBSERVED AT ICAR-IISR, KOZHIKODE

National Science Day	28 February 2020
International Women's Day	08 March 2020
World Water Day	22 March 2020
Earth Day	22 April 2020
World Environment Day	05 June 2020
Gareeb KalyanYojana	19 June 2020
International Yoga Day	21 June 2020
Institute Foundation Day	01 July 2020
World Coconut Day	02 September 2020
Swachatha Hi Seva	11 September to 02 October 2020
Vigilance Awareness Week	28 October to 02 November 2020
World Soil Day	05 December 2020
National Farmers Day	23 December 2020
PM Kissan Money Release Program	25 December 2020
Swachatha Pahkhwada	16-31 December 2020

ICAR-Indian Institute of Spices Research
Marikunnu. P.O., Kozhikode - 673012, Kerala, India
Ph: 0495 - 2731410, Fax: 0495 273118
web site: spices.res.in