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ICAR

Agenda Notes

Mid-term
IRC Meeting
29-30 December 2021

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ICAR-INDIAN INSTITUTE OF SPICES RESEARCH
Kozhikode- 673012, Kerala

DIVISION OF CROP IMPROVEMENT AND BIOTECHNOLOGY

Mega Project I: Characterizing genetic resources to identify core collections and their long-term conservation [Project Leader: Dr. K.V. Saji]

1. Gen. XXVIII (813): Conservation and characterization of *Piper* germplasm (2008-2025) [Dr. K.V. Saji, Dr. M.S. Shivakumar, Dr. Honnappa Asangi & Mr. R. Gobu]

Decisions:

- Compendium on *Piper* species may be prepared: A compendium on *Piper* species distributed in Western Ghats of India prepared. This consists of a key for identification of *Piper* species distributed in India, illustrations and taxonomical descriptions of each species.

Technical programme	**Achievements**
Conservation of germplasm (nursery and field gene bank) at Peruvannamuzhi.	Three thousand four hundred and 26 accessions are maintained at the black pepper germplasm nursery at the experimental farm, Peruvannamuzhi. Recently established field gene banks are conserved. Replanting carried out in the live herbarium plot adjacent to Germplasm nursery.
Conservation of field gene bank at Kozhikode.	The field gene bank of black pepper comprising 223 accessions are maintained properly.
Conservation of field gene bank at CHES, Chettalli.	735 accessions are maintained. Gap filling in germplasm block carried out on August. Started clearing of newly allotted area.
Characterization and documentation of germplasm accessions.	Germplasm plot Chettalli consist of various germplasm accessions in the present year around 124 vines yielded black pepper among the germplasm lines Acc. no. 1036 recorded highest fresh yield of 4.83 kg followed by Acc.No. 1037 (4.70kg) and Acc No. 1321 (4.45 Kg). Highest bulk density of 652.5 was recorded for Acc. No. 1197. Highest berry size of 7.9mm was recorded for Vadakkan.
Collection of germplasm from the un explored regions.	Cultivar germplasm will be collected during the 4th quarter.

2. Gen. XIX (813): Conservation, characterization, evaluation and improvement of *Zingiber* and *Curcuma* sp. (2007-2023) [Dr. D. Prasath, Dr. S. Aarthi, Dr. HJ Akshitha & Dr. N. K. Leela] (External support: Dr. C. N. Biju)

Decisions:

- The score card for disease indexing may be prepared and distributed to all the AICRPS centers for disease scoring in CVT on disease tolerance in ginger.

Technical programme	**Achievements**
Maintenance of ginger and turmeric germplasm	1404 *Curcuma* and 668 *Zingiber* accessions have been maintained in the field gene bank.
Characterization of turmeric germplasm (200 accessions).	Based on DUS guidelines, different morphological, floral traits and rhizome characters were recorded in 150 turmeric accessions. Total of 782 accessions have been characterized for morphological, rhizome characters and 305 for quality characters. Ploidy of some 102 turmeric accessions (ploidy range from 3x to 4x), from NAGS collections, showing variation in basic chromosome numbers, were determined using Flow cytometry.
Evolving extra-long and bold turmeric lines through clonal selection and OP seedling progenies.	Planted 381 open pollinated seedling progenies of 17 turmeric accessions and recorded morphological characters. Fourteen accessions of Salem Local (Erode and Salem district of Tamil Nadu) and seven accessions of Mydukkur (Andhra Pradesh) were planted for yield evaluation.
Evaluation of turmeric, ginger and mango genotypes under AICRPS CVT.	Planted four CVTs (two on turmeric, one on ginger and one on mango ginger) for yield evaluation at Experimental Farm, Peruvannamuzhi, Kerala.
Quality characterization of mango ginger genotypes.	Completed quality characterization 11 mango ginger genotypes.
Multiplication of nucleus seed of released varieties.	Planted three ginger and seven turmeric varieties (Suvarna, Sudarsana, Suguna, IISR Prabha, IISR Prathibha, IISR Kedaram and IISR Alleppey Supreme) for nucleus seed multiplication.

3. Gen. XXXIII (813): Identification of core collection, characterization and maintenance of cardamom germplasm (2012- 2025) [Dr. Honnappa Asangi, Dr.H. J. Akshitha, Dr. S. J. Ankegowda, Dr. Mohammed Faisal Peeran & Dr. M. Balaji Rajkumar]

Decisions:

- Characterization of germplasm has to be completed: 85 FGB accessions have been characterized based on morphological traits. Recorded the yield observations. Quality analysis will be carried out.

- CVT trials in this project may be shifted to project Gen. XXXVI (813): Evolving high yielding, biotic and abiotic stress resistant cardamom lines through selection and hybridization: Implemented.

Technical programme	**Achievements**
Maintenance of cardamom germplasm.	A total of 625 cardamom germplasm accessions have been maintained at National Active Germplasm Site (NAGS) which consist of 423 accessions from Appangala; 102 accessions from Pampadumpara; 41 accessions from Mudigere, 56 accessions from Sakaleshapura and 3 accessions from ICRI, Myaldumpara collections.
Characterization of germplasm has to be completed.	85 FGB accessions have been characterized based on morphological traits. Recorded the yield observations.
Multiplication of dual tolerant to rhizome rot and leaf blight accessions for AICRPS trial.	Dual tolerant to rhizome rot and leaf blight IC349358 and IC349333 accessions are under multiplication.
Biochemical characterization of cardamom germplasm.	In progress
Collection of cardamom germplasm.	Two Malabar type of cardamom were collected from Cherangala, Thanimane, Bhagamandala.

4. Gen. XXXVI (813): Genetic resources management in tree spices (2018-2023) [Mr. V. A. Muhammed Nissar, Dr. J. Rema, & Dr. Honnappa Asangi] [External support: Dr. Shivakumar M.S., & Dr. Anees K]

Decisions:

- One set of garcinia germplasm may be planted at Chelavoor campus.
- Biochemical analysis of *Cinnamon* spp. may be done at the earliest.
- Clove size and boldness may be quantified.

Technical programme	**Achievements**
Collection of genetic resources of cinnamon	Three accessions of cinnamon were collected from Elappara, Idukki. Cinnamon variety YCD-1 was obtained from AICRPS centre, Yercaud. Nine accessions of cinnamon were newly planted in tubs.
Collection of genetic resources of clove and all spice	Seeds of *P. dioica* were collected from Bonacaud.
Collection of genetic resources of *Garcinia*	Two exotic species, *G. puat* and *G. warrenii* were collected from farmer's field.
Characterisation of germplasm in *Garcinia*	The yield and morphological data of 9 accessions of *G. gummi-gutta* at Peruvannamuzhi were recorded.
In situ evaluation of clove accessions in farmers field	Ten elite trees of clove are under evaluation in farmer's field at Thottilpalam. The yield and morphological observations will be recorded in

	harvesting season.
Maintenance of genetic resources in tree spices.	The existing collections of tree spices in nursery and field are being maintained.
Quality evaluation of the selected accessions of tree. spices	Biochemical analysis of 16 accessions of *G. gummi-gutta* and 4 wild species were completed
Planting of Garcinia accessions in the field.	The fencing work for planting *Garcinia* in field at Peruvannamuzhi is in progress. Planting will be done with the onset of monsoon. 28 accessions of Garcinia comprising 20 species were planted in tubs at Peruvannamuzhi.
Planting of unique clove accessions in tubs.	13 unique variants of clove were planted in tubs inside Poly house at experimental farm, Peruvannamuzhi

5. Gen. XXXVII (813): Conservation of *Vanilla* spp. and their utilization in crop improvement (2018-2023) (Dr. S. Aarthi, Mr. V. A. Muhammed Nissar & Ms. R. Sivaranjani)

Decisions: Nil

Technical programme	**Achievements**
Maintenance of Vanilla germplasm at ICAR IISR, Chelavoor.	65 *Vanilla planifolia* and 12 *Vanilla* spp. total 77 accessions were established in Polyhouse.
Vanilla planting material production.	500 (1 m) vanilla rooted cuttings are available.
Collection of vanilla germplasm.	No new collections.
Molecular characterization of new collection along with *Vanilla planifolia* selected accessions to identify the polymorphism.	The selected 11 accession (Acc. 4701, Acc. 4714, Acc. 4716, Acc. 4723, Acc. 4738, Acc. 4741, Acc. 4742, Acc. 4760, Acc. 4761, Acc. 4762, Acc. 4772) from previous project having >15 cm bean length was short listed and multiplied for field evaluation. Planting work initiated at Peruvannamuzhi.
Multiplication and field planting of selected vanilla accession.	Molecular characterization of 22 genotypes comprising of Vanilla accessions (11), Andaman collection (2), Wayanad collection (2) and other *Vanilla* spp (7) were done using 20 ISSR primers. A total of 143 scorable alleles were generated by 18 ISSR primers. Among the 18 primers used for ISSR analysis, primers UBC 818 had the highest number of ISSR loci (11) followed by primers UBC 822 with 10 loci.
Processing and Quality profiling of vanilla germplasm.	2020-21-year vanilla beans harvested are under processing.

Mega Project II: Genomics assisted breeding for trait specific varieties in spices [Project Leader: Dr. D. Prasath]

1. **Gen. XXXI (813): Breeding black pepper for high yield, quality and resistance to stresses (2012-2022) [Dr. M.S. Shiva Kumar, Dr. K. V. Saji, Mr. R. Gobu & Dr. K.S. Krishnamurthy [External support: Dr. A. Jeevalatha]**

   Decision:

   - Hybridization in black pepper may be initiated by Mr. R. Gobu at Peruvannamuzhi.

Technical programme	**Achievements**
Multiplication of selected genotypes for taking up trial in misty areas.	Selected lines are being multiplied at Regional station, Appangala.
Field planting of all core set black pepper accessions.	One set of core set (80 No.) was planted in B1 plot Peruvannamuzhi farm.
Hybridization and identification of superior hybrid for economically important traits.	New cross combination of Thevam × Panniyur-1; is done in large number other comination like Girimunda × Malabar Excel; Thevam × PLD-2, Thevam × ACC 7398 were also done.
Participatory plant breeding – surveying and identification of promising lines.	Identified genotypes samples are collected and quality analysis is under progress and cuttings are planted in Appangala.
Screening promising lines for drought tolerance.	Morphological and physiological parameters on 37 drought tolerant accessions revealed significant difference among the genotypes.
Screening promising lines for *Phytophthora* resistance	Unique and promising lines collected from farmers field are being multiplied for *Phytophthora* screening.

2. **Gen. XXVI (813): Evolving high yielding and high-quality nutmeg clones by selection (2007-2022) [Dr. J. Rema, Dr. K.V. Saji & Mr. V.A. Muhammed Nissar] (External support: Dr. N. K. Leela & Dr. S. Aarthi)**

   Decisions: Nil

Technical programme	**Achievements**
Collection and conservation of elite nutmeg.	10 farmers varieties were added to the germplasm this year. Collections made last year were maintained in the nursery. All the collected germplasm which attained sufficient growth were established and in field.

	A crossing block for nutmeg established at Peruvannamuzhi is being maintained for future breeding work.
Evaluation of nutmeg germplasm accessions for morphological, yield and quality parameters.	50 germplasm of nutmeg has been characterized. Recorded the yield observations of nutmeg germplasm. Quality analysis is being carried out.
Conservation and evaluation of seedling/clonal progenies of monoecious nutmeg trees.	Harvested and yield observations recorded.
Evaluation of grafts of elite lines having high myristicin and elemicin in nutmeg and mace oils.	Harvested and yield observations recorded.
Evaluation of grafts of elite lines having low myristicin, elemicin and safrole and high sabinene in nutmeg and mace oils.	Harvested and yield observations recorded.
Evaluation of seedling progenies of yellow maced nutmeg.	Harvested and yield observations recorded.

3. Gen. XXXVI (813): Evolving high yielding, biotic and abiotic stress resistant cardamom lines through selection and hybridization (2018 - 2023) [Dr. H. J. Akshitha, Dr. S. J. Ankegowda, Dr. M. Balaji Rajkumar & Dr. M. S. Shivakumar] (External support: Dr. Honappa Asangi)

Decisions:

- CVT trial on cardamom thrips and leaf blight may be presented under this project: The progress in both the CVT trials will be presented under this project

Technical programme	**Achievements**
Screening of OP progenies of IC 584058 and IC 349537 for moisture stress tolerance and selection of moisture stress tolerant genotypes.	Open pollinated progenies seedlings of IC 584058 and IC 349537 were evaluated for moisture stress tolerance by using PEG. 2-3 leaf stage seedlings were raised in the Hoagland solution. After stabilizing the growth in Hoagland solution for one month, seedlings were subjected to moisture stress using PEG (15 %). After 30 days treatment in 15 % PEG the seedlings which survived were subjected to 20 % PEG. Seedlings survived after subjecting to 20 % PEG stress were transplanted to polythene bags filled with nursery mixture. IC 584058 (10 seedlings) and IC 349537 (7 seedlings) which put forth 4-5 leaves after transplanting to polythene bags were transplanted to field remaining moisture stress

	escape seedlings are being maintained in nursery.
Hybridization and raising of hybrid progenies.	Hybridization was carried out between 4 female parents (Appangala – 1, IISR Avinash, *Njallani* green gold and Clone 893) and 5 male parents (IC 349606, IC 349370, IC 547167, IC 349364 and IC 349358). Capsules from the successful crosses are being harvested and sown.
Field planting of OP progenies.	OP progenies of Appangala 1, IC 349537 and IC 584058 are planted in field for further evaluation.
Identification of phenological stages in small cardamom based on BBCH scale.	In progress.
CVT on farmers varieties of cardamom.	Observations on morphological and yield parameters were recorded from CVT on farmers varieties of cardamom trial consisting of nine farmer's varieties of small cardamom *viz*., *Arjun, Wonder Cardamom, Panikulangara, Thiruthali, Elarajan, Pachakai, Paupali, Njallani, PNS Gopinath* supplied by National Innovation Foundation (NIF) and a local check variety Appangala-1.
CVT on hybrids of small cardamom – 2018 Series VII.	In the CVT trial consisting of nine hybrids *viz.,* Bold × IC 547219, (GG × Bold) ×Appangala 1 and (GG × NKE 19) × Bold from IISR RS, Appangala; MHC-1 & MHC-2 from ICRI, Myladumpara; SHC-1 & SHC-2 from ICRI RS, Sakaleshapura and PH-13 & PH-14 from Pampadumpara with national check variety *Njallani* green gold, highest dry yield of capsules per plant was recorded in hybrid PH-13 841.67 (g/plant) followed by hybrid Bold × IC 547219 (361.33 g/plant).
Multilocation trial of leaf blight resistant cardamom accessions.	The trial with five leaf blight tolerant genotypes *viz.,* IC – 349650 IC – 547222, IC – 547156, IC – 349649, IC – 349648 along resistant checks: Appangala 1, *Njallani* Green Gold and IISR Vijetha has been planted and established under field. The planting materials have been supplied to all the centers. Biometric observations *viz.,* plant height and number of tillers is recorded.
Multilocation evaluation of thrips tolerant cardamom lines.	The experiment on multilocation evaluation of 4 thrips tolerant cardamom lines with *Njallani* green gold and Appangala 1 is in progress. Crop is in its first year of growth. The genotype IC 349362 (V_3) was recorded with maximum plant height (189.4 cm), highest average number of panicles (5.44), length of panicle (22.89 cm) and number of capsules (30.81).

4. Biotech. XIV (813): DNA fingerprinting and barcoding in spices (2018 - 2023) (Dr. T.E. Sheeja & Dr. P. S. Divya) (External support: Mr. R. Gobu)

Decisions:

- Dr. M.S. Shivakumar may be dissociated from the project and Dr. Divya P.S. may be associated in the project.

Technical programme	Achievements
Identification of polymorphic markers for distinguishing spice varieties.	Unique markers identified in *Pimenta dioica* were confirmed by blind sampling. Unique markers identified in nutmeg varieties IISR Vishwashree, IISR Keralashree and Sindhushree were confirmed by blind sampling.
DNA isolation from black pepper samples for testing country of origin.	About 70 numbers of DNA samples were isolated and stored in the DNA bank.
Fingerprinting of spices from various centers of AICRPS for varietal registration.	Established unique status of new varieties of turmeric, fennel, coriander using ISSR markers and report submitted.
Optimizing a greater number of primers for fingerprinting in seed spices and black pepper.	250 ISSR primers screened in black pepper and shortlisted 6 highly polymorphic primers. 150 primers screened and shortlisted to identify the unique marker/profiles for establishing status of new varieties of seed spices.

6. Biotech. XV (813): Identification & characterization of gene editing targets for *Ralstonia* resistance in ginger (2021-2024) (Dr. P. S. Divya, & Dr. C.N. Biju)

Decision:

- The project which was kept in abeyance is revived with Dr. Divya P.S. as the project leader.
- Project is extended for 3 years.
- Title of the project modified as "Identification & characterization of gene editing targets for disease resistance in ginger" is approved.
- Dr. A. Jeevalatha will be dissociated from the project.
- Dr. C. N. Biju will be associated in the project.
- The modified objectives and technical programme is approved.

Technical programme	Achievements
Analysis of the expression profile and sequences of *Ralstonia* infected ginger.	Performed transcriptome sequence assembly from raw transcriptome data of *Ralstonia* infected and uninfected ginger.
Comparative analysis of potential candidate genes to identify the targets.	-
Initiation of molecular docking studies.	-
Initiation of cloning of selected targets and sequencing.	-

7. DBT- CIB VIII: Survey, identification and characterization of unique ginger and turmeric land races endemic to North Eastern Region of India (2018-2021) [Dr. D. Prasath & Mr. V.A. Muhammed Nissar]

Decision: Nil

Technical programme (2021-22)	**Achievements**
Development a molecular profile for ginger and turmeric genotypes collected from NER	Twelve flanking polymorphic EST-SSR primers were validated using 48 ginger genotypes representing North-Eastern India and different eco-geographical adaptations by PCR amplification and allele sizing through capillary electrophoresis. The 12 markers divided the 48 genotypes into three main groups using the UPGMA cluster analysis. The dendrogram revealed that the North Eastern collections are highly diverse and falls in a different cluster along with other cultivated ginger varieties. Out of the 57 microsatellite markers tested in 18 released varieties of turmeric, 56 of them were polymorphic. The average number of alleles per genotype per marker ranged from 1 to 3.44, with most markers showing two alleles in accordance with the reported triploid status of turmeric. The marker with the highest average number of alleles per genotype was CuMiSat 08 and UBC 889 with 3.44 allele.
Evaluation of unique NER collections	Characterization of 40 red ginger genotypes for different quality characters resulted in identification of a superior red ginger genotype with high essential oil (4.3%) along with high pungent principles, gingerol (1.92%) and shogal (0.55%). The identified genotypes were planted for multiplication.
Conservation of the unique ginger and turmeric genetic wealth at NAGS	The collected ginger and turmeric genotypes were planted and maintained in National Active Germplasm Site (NAGS) of ginger and turmeric at Peruvannamuzhi Farm of ICAR-IISR. The new conservatory 'Garden of Gingers' is maintained with unique ginger and turmeric genotypes.

8. DBT-CIB IX: Quality enhancement of turmeric through comparative evaluation of genotypes for nutritional and quality profiles for sustainable turmeric production (2019-2023) [Dr. D. Prasath, Dr. N. K. Leela & Dr. S. Aarthi]

Decision: Nil

Technical programme (2021-2022)	**Achievements**
Development of nutritional and chemical fingerprints of released varieties and popular turmeric cultivars	The germplasm accessions and seedling progenies were screened against leaf spot and leaf blotch diseases. 192 turmeric genotypes were screened under natural epiphytotic conditions during August to November 2021 to identify resistant sources against leaf blotch caused by *Taphrina maculans* using 0-6 scale. The per cent disease index (PDI) was computed and the genotypes were categorized into different groups based on reaction towards the disease among which, 119 genotypes were grouped under resistant category and 4 as well as 6 genotypes under moderately susceptible and susceptible categories, respectively. 63 genotypes were grouped under highly susceptible category and no genotypes were found to be moderately resistant towards the disease. Two evaluation trials to identify the turmeric genotype suitable for organic production system have been undertaken.
Comparative evaluation of shortlisted turmeric genotypes under organic and integrated systems	A total of 17 genotypes were characterized for different quality parameters. Among the genotypes, seven varieties considered as high curcuminoid varieties (curcumin > 4%). Lowest curcumin and oleoresin were observed in Santra (0.24% and 5.52 %). All the varieties recorded essential oil greater than 4 %, in which Rajendra Sonia and Varna have significantly high essential oil (6.40 %).
Curcumin and other novel compounds profiling in potential *Curcuma* Sp.	The yield and compositions of the essential oil of fresh and dry rhizomes of four selected *curcuma* species were analyzed and compared with *curcuma longa*. Curcuminoid profile of 95 turmeric accessions revealed three groups, genotypes with equal quantity of BDMC and DMC, BDMC greater than DMC and DMC greater than BDMC.

9. ICAR-CIB-III: Genomics-assisted identification of trait-specific markers for major biotic and abiotic stresses and development of core collections of black pepper (2020-2023) (Dr. Santhosh J. Eapen, Dr. A.I. Bhat, Dr. K.S. Krishnamurthy, Dr. T. E. Sheeja, Dr. A. Jeevalatha, Dr. M.S. Shivakumar, Dr. U.B.Angadi & Dr. Sunil Kumar) (External support: Ms Sona Charles & Mr R. Gobu

Decisions: Nil

Technical programme	**Achievements**
Identification of suitable genotypes for re-sequencing and recording morphological characters in black pepper.	Whole genome resequencing of 39 genotypes of pepper completed. Ten varieties (P1-P10) collected from Panniyur Research Station, Panniyur were established at IISR Experimental Farm, Peruvannamuzhi for multiplication and field planting. Completed field planting of Coreset genotypes at Experimental Farm, Peruvannamuzhi.
Validation of gene specific primers for expression studies related to candidate genes of piperine biosynthesis.	Gene specific primers and qRT-PCR parameters optimised for amplification of all isoforms of the key pathway gene *viz*., BAHD acyltransferase. Identified the candidate isoform by gene expression studies involving four berry stages (2MAP, 4MAP, 6 MAP and 8MAP), leaf and stem.
Bioinformatics analysis of transcriptome data of black pepper.	The raw transcriptomics sequences of drought induced and control transcriptomes of Acc No: 4226 were subjected to quality check by FASTQC using standard parameters. Standard FASTQ file formats were generated using FASTQ groomer.
Comparative genome analysis of Phytophthora isolates and identification of effectors.	The genomes of *Phytophthora capsici* isolate 05-06 and *P. tropicalis* isolate 98-93 were assembled through hybrid genome assembly of short (Illumina) and Long read (PacBio) sequences. The total assembled genome size of *P. capsici* was 61.9 Mb and *P. tropicalis* was 62.2 Mb. About 460 and 318 cytoplasmic effectors and 14 & 13 apoplastic effector genes were predicted in *P. capsici* and *P. tropicalis,* respectively using offline tool Effector P3.0 beta.

10. DUS project (2010-2023) (Dr. K. V. Saji, Dr. J. Rema, Dr. D. Prasath & Dr. S. Aarthi (External support: Dr. M. S. Shivakumar)

Decision: Nil

Technical programme (2021-2022)	**Achievements**
Maintenance of example varieties of black pepper at Peruvannamuzhi and Chettalli.	Maintaining 21 example varieties of black pepper at CHES, Chettalli. Example varieties are being multiplied and maintained at Peruvannamuzhi.
Maintenance of example varieties of cardamom at Regional Station, Appangala.	15 cardamom varieties are being maintained at Regional Station, Appangala.
Maintenance of example varieties of Ginger and turmeric.	29 example varieties of ginger and 35 turmeric are maintained and multiplied at Peruvannamuzhi and Kozhikode
Ongoing DUS testing/ onsite.	Ginger – 2, Turmeric-4, Black pepper-4 and small cardamom-6.
Registration of new varieties.	Three black pepper varieties. The authority issued registration certificate for two farmers varieties of black pepper viz. Sigandini and Adi pepper (*Piper relictum*) to Mr. Remakanth Ramachandra Hegde, Siddapur, Taluk and Mr. Poonacha, Madapura, respectively. Facilitated a progressive farmer Mr. K. V. George for applying genome savior award and he received genome savior award from PPVFRA, New Delhi. So far, the Authority has issued certificates for: o 9 black pepper varieties (5 Farmer & 4 VCK) o 9 small cardamom varieties (6 Farmer, 2 VCK & 1 Extant)

DIVISION OF CROP PRODUCTION AND POST HARVEST TECHNOLOGY

Mega Project III: Enhancing input-use efficiency and productivity in spices through smart farming [Project leader: Dr. V. Srinivasan]

1. Phy. X (813): Evaluation of black pepper and cardamom elite lines for yield and quality under moisture stress (2010–2023) [Dr. S.J. Ankegowda, Dr. K.S. Krishnamurthy, Dr. M. Alagupalamuthirsolai) (External support: Dr. H. J. Akshitha and Dr. M.S. Shivakumar]

Decision:

- Data/observation on disease incidence should be made and presented.

Technical programme (2021-2022)	Achievements
Recording of growth characters in different genotypes during establishment in cardamom.	Six genotypes of cardamom (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 under AICRP (Spices). Mositure stress was imposed in summer from February to April 2020 in stress block by withholding irrigation. The control block was irrigated by sprinkler (25mm) once in 12-15 days interval. Soil moisture, gas exchange parameters, growth and yield data were recorded.
Field testing of black pepper germplasm accessions for drought tolerance.	Among the twelve field planted accessions, accession no. 1277 produced maximum yield (2.5 kg fresh berries per vine) followed by accession no. 1622 (1.8 kg) under irrigated condition. Accession 1277 also produced maximum yield under water stress (1.0 kg per vine) followed by accession 1495 (0.8 kg per vine). Accession 1495 was superior w.r.t. physiological traits.
Screening of black pepper germplasm accessions (100 nos) for drought tolerance.	Fifty germplasm accessions have been multiplied. Screening will be taken up in the coming quarter.
Assessment of impact of climate change on pepper and cardamom in distinct environments.	Rainfall during the year was well distributed and total rainfall was also good. Light availability in the plantations was good (700-1200 µ moles) even during June and July due to rainless days. Spike intensity, spike length, number of filled berries and fruit set per cent were recorded in 25 locations in Kodagu, Hassan and Chikkamagaluru districts in black pepper and three locations in cardamom.

2. SSC VI (813): Nutrient cycling and soil C sequestering potential of spice crops under different management systems (2011-2022) [Dr. V. Srinivasan, Dr. R. Dinesh, Dr. S.J. Ankegowda, Dr. A. Ishwara Bhat, Dr. C.N. Biju, Dr. K.S. Krishnamurthy & Dr. M. Alagupalamuthirsolai]

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Developing a DSS for fertilizer recommendation.	A DSS is being designed and validated.
Working out the C budgeting of different inputs in spice-based systems for working out the C foot print.	The sustainability index of the soil was measured with nutrient index, microbial index and crop index of soil comparing the over the year's values with the initial status. The nutrient index was highest in conventional management system (1.22) whereas the microbial and crop indices were high under fully organic (1.23) and Integrated systems (1.19), respectively. The overall Sustainability Index was highest under INM system followed by conventional and organic systems in Cardamom. In turmeric, the overall sustainability Index was highest under Organic (100%) management (1.99) followed by INM (1.30) with the lowest in conventional management (0.68).

3. ICAR-NASF-1: Risk assessment of nanoparticle accumulation in soils: Effects of metal oxide nanoparticles on soil bacterial communities, soil microbial processes and evaluation of phytotoxicity using genomic approaches (2020-2023) [Dr. R. Dinesh, Dr. V. Srinivasan, Dr. T. E. Sheeja TE & Dr. C. Sarathambal] (CCPI: Dr. V. Sajith, NIT-K)

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Effects of ZnO NP on abundance, diversity and bacterial community shifts in soils.	Dominant bacterial communities in a neutral pH soil spiked with varying levels of nZnO and bZnO have been determined. Alpha diversity indices (ACE, Chao I and Shannon, Simpson) and beta-diversity indices in these soils have been estimated.
Effects of ZnO NP on functional metabolic patterns in bacterial communities in soils.	Functional metabolic shifts among bacterial communities in these soils due to both nZnO and bZnO have been studied in a neutral pH soil.

4. ICAR Mega Seed Project (Agr. XXXVII (813): Production of nucleus planting materials of improved varieties of spice crops (2006-2022) [Dr. V. Srinivasan, Dr. K. Kandiannan, Dr. S.J. Ankegowda, Dr. K.V. Saji, Dr. P. Rajeev, Dr. Sharon Aravind, Dr. M. Alagupalamuthirsolai, Dr. Ljio Thomas, Dr. & Honnappa Asangi] (External support: Dr. J. Rema, Dr. D. Prasath, Dr. R. Praveena & Mr. V. A. Muhammad Nissar)

Decisions:

- One person from CPPHT division may be identified to look after the planting material production at Peruvannamuzhi farm.

- Alternative to plastic poly bags for planting material production may be explored.

Technical programme (2021-2022)	**Achievements**
Production of rooted black pepper cuttings.	Improved varieties of black pepper are being multiplied from Main Campus (MC), Kozhikode and Regional Station (RS), Appangala and distributed. Totally 0.75 Lakh cuttings were produced.
Production of ginger and turmeric seed rhizomes.	Improved varieties of ginger 200 beds and 750 beds of turmeric are planted and maintained for seed production at Chelavoor & Peruvannamuzhi. 500 bags of grow bag ginger are planted in Chelavoor farm for seed production. Four farmers were also identified for production of seed ginger multiplication.
Production of cinnamon seedlings & nutmeg grafts.	3000 seedlings of IISR Navasree/ Nithyasree cinnamon are produced. KVK is producing 2500 nutmeg grafts.
On farm water management & setting up Micro irrigation.	Micro sprinklers are established for ginger and turmeric in our seed production plots (Chelavoor) and 2 farmers were also supported with micro sprinklers for ginger
FLD on organic black pepper on large scale area.	The farmers of Mattilayam, Vellamunda are being adopted for large scale demonstration of black pepper. The inputs are being distributed.
MIDH Farmers Training/Seminar.	Two training programmes to be conducted.

5. AGR. XXXI (813). Development of fertigation schedule for better productivity in black pepper (2015-2023) [Dr. C.K. Thankamani and Dr. M. Alagupalamuthirsolai]

Decision: Nil

Technical programme (2021-2022)	**Achievements**
Maintenance of black pepper plants and imposing fertigation schedule.	Fertigation treatments 50 RDF, 75 RDF including daily hose irrigation (control) were imposed to black pepper plants, IISR Thevam, Girimunda, and Sakthi.
Analysis of soil and leaf samples of black pepper in response to fertigation.	Soil and leaf samples were collected, analysed for major nutrients, secondary nutrients, and micro nutrients.
Recording Physiological parameters and yield influenced by fertigation.	Photosynthetic gas exchange parameters of black pepper were recorded. Maximum yield was recorded by the fertigation treatment 50 NPK in 24 splits (2.1 kg/pl) followed by the treatment 100 RDF in 3 splits.

6. Phy. XII (813): Physiological interventions for yield improvement in small cardamom (*Elettaria cardamomum* Maton) under weather extremities (2016-2022) [Dr. M. Alagupalamuthirsolai, Dr. S.J. Ankegowda, Dr. Sharon Aravind and Dr. M. Murugan)

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Test nano chitosan and potassium silicate for irrigation postponement under pot and field.	Established cardamom seedlings and provided drought stress followed by chemical spray. Observations are under process.
Analyse the essential oil composition of cardamom varieties collected from Pampadumpara.	In progress.

7. Biochem. X (813): Study on spike abscission: Developing chemically induced method for harvesting black pepper (*Piper nigrum* L.) (2018-2022) [Dr. Anees, K., Dr. K.S. Krishnamurthy & Dr. C. N. Biju]

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Dose optimization of antioxidant with Ethrel for selective abscission of spike (spraying method).	-
Microscopic staining for ROS in abscission zone.	Microscopic study of abscission zone under revised concentration of ethrel and ascorbic acid have been completed. Microscopic staining for ROS in abscission zone needs to be completed.

8. Development of drought mitigating physiological strategies in black pepper (2020-2025) (Dr. M. Alagupalamuthirsolai, Dr. C. K. Thankamani (External support: Dr. K. S. Krishnamurthy & Dr. C. Sarathambal C)

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Testing of drought alleviating chemicals in black pepper under greenhouse conditions.	Established rooted cuttings and provided chemical spray under drought stress. The chemicals Nano chitosan, potassium silicate and calcium chloride showed better drought alleviating effect in pepper rooted cuttings.
Testing of AMF for drought tolerance in black pepper under greenhouse conditions.	In progress.

9. Hort. VII (813): Evaluation of nutmeg for its suitability for high density planting (2011-2022) [Dr. J. Rema, Dr. Sharon Aravind & Dr. C.K. Thankamani]

Decision:

- The project is extended for one more year.

Technical programme (2021-2022)	**Achievements**
Evaluation of nutmeg grafts for its suitability for high density planting.	Harvested nutmeg and recorded yield observations.
Nutrient management studies in nutmeg grafts.	Harvested nutmeg and recorded yield observations

10. ICAR-CPPHT-1: Network project on organic farming (2014-2025) [Dr. C.K. Thankamani, Dr. V. Srinivasan, Dr. R. Praveena, Dr. C. Sarathambal, Dr. S. Shanmughavel & Dr. B. Pradeep]

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
To study the impact of organic, conventional and integrated management practices on productivity and quality of turmeric varieties.	Effect of different management systems on soil nutrient availability of turmeric at 120DAP indicated that the organic carbon, nitrogen, phosphorous, calcium, magnesium, manganese, and zinc content were significantly higher under the organic management system. Effect of management systems on yield of Turmeric varieties indicated that inorganic system recorded (33.1 t/ha) maximum yield. Among the varieties, Pragati recorded the highest yield (41.4 t/ha).

	Response of Turmeric varieties to organic farming revealed that Suguna and Sudarshana had maximum yield (37 t/ha).
Budgeting the farming system model with fisheries component.	Integrated organic farming system model with crops Coconut, Fodder grass, (Co3, Co4), Turmeric, Tapioca, Banana, Vegetable cowpea with dairy component (2 HF cows + calves) recorded a net income of (Rs.2 lakhs/acre). IOFS model with fisheries component recorded a net income of (Rs.2963) from a water harvesting pond (65 m^3) within 6 months.
Weed management in turmeric.	Application of dried coconut leaf at the time of planting, Hand weeding at 45&90 DAP recorded maximum yield/ ha, Net returns (2 lakhs /ha), and less cost of cultivation (2.23 lakh/ha).

11. ICAR-CPPHT-2: Network on Organic Farming in Horticulture Crops (2014-22) (Dr. V. Srinivasan, Dr. K. Kandiannan, Dr. R. Dinesh, Dr. J. Rema, & Dr. Honnappa Asangi) (External support: Dr. S.J. Ankegowda, Dr. C.N. Biju &Dr. C.M. Senthil Kumar)

Decision: Nil

Technical programme (2021-2022)	**Achievements**
Evaluating different management system for yield sustainability in cardamom and monitoring the soil health and pest and disease incidence under different management systems.	Treatments on fully organic, integrated and chemical management on cardamom were also imposed for comparing the yield sustainability under different management systems. Yield and quality parameters are being recorded.

Mega Project IV: Value addition in spices through post-harvest interventions and product diversification [Project leader: Dr. N.K. Leela]

1. CPPHT X (813) Investigation on bioactive phytochemicals from spices (2021-24) [Dr. N. K. Leela, Ms. R. Sivaranjani, Ms. Sona Charles] (Dr. K Anees – External support)

Decision:

- This network project (ICAR-CPPHT-3) is closed.

Technical programme (2021-2022)	**Achievements**
Isolation, purification and characterization of secondary metabolites of methanol extract of *C. caesia*.	Extraction and fractionation of methanol extract is in being carried out.
Characterization of secondary metabolites of *C. caesia*.	-

Isolation, purification and characterization of non-starch polysaccharides from *Curcuma caesia*.	Non-starch polysaccharides were extracted from *Curcuma caesia*.

2. Biochem. IX (813): Evaluation of chemo-diversity and microencapsulation of selected spices (2018-2023) [Ms. R. Sivaranjani] (External support: Dr. N.K. Leela & Dr. Anees K.]

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Effect of chemical elicitors on improved quality of turmeric.	-
Quality analysis and volatile profiling of black pepper germplasm.	Around 100 black pepper germplasm was analyzed for quality parameters namely essential oil, oleoresin, piperine and total phenolics. The volatile profiling of around 40 essential oil of black pepper germplasm using GC-MS was completed. The analysis identified 62 volatile compounds which showed significant variation among the genotypes.
Standardization of encapsulation of essential oil of spices.	Chitosan loaded encapsulation of essential oil of *Pimenta racemosa* was done and its activity against two major pathogens of ginger namely *Fusarium* and *Ralstonia* was studied.

3. CPPHT IX (813): Functional product development of spices through value addition and by-product utilization (2020-2025) [Dr. E. Jayashree, Dr. Anees, K., & Dr. B. Dayakar Rao (ICAR-IIMR, Hyderabad)]

Decision: Nil

Technical programme (2021-2022)	**Achievements**
Development of value-added dairy/ nondairy products with spices and evaluation of its quality.	Oats milk prepared with 2% concentration of oats powder, enriched with turmeric oleoresin (10% concentration of curcumin) at the rate of 50 mg/100 ml milk, ginger oleoresin (14% concentration of gingerol) at the rate of 10 mg/100 ml of milk and cinnamon powder at the rate 50 mg/100 ml milk, produced the most preferred oats milk with an overall acceptability value of 8.3 (for unsterilised milk) and 8.37 (for sterilised milk).
Value added products of spices with millets will be optimized.	Finger millet enriched spice-based cookies were developed. Eight different spices were tried for its flavour enhancement in the preparation of cookies. The cookies prepared with the addition of finger millet flour of 40% concentration as

	replacement to refined wheat flour with 4% cardamom seed powder ranked first in sweet flavor followed by black pepper (12.5%) and spice blend 8% (of chicken masala flavour).

Project V: Ensuring food safety in spices through value chain management
[Project leader: Dr. Anees K]

1. CPPHT VIII (813): Pesticide residue monitoring of major spices (2020-2024) [Dr. Anees K., Dr. N. K. Leela, Dr. C. M. Senthil Kumar & Dr. M. Balaji Rajkumar]

Decisions:

- Ginger pesticide analysis should be repeated with samples from latest pesticide trials: 100 samples of ginger have been tested for 29 pesticide standards available with us. Repeated analysis of ginger samples from 2019-20 trials.

- Standardization of multiresidue analysis method for crops already available should be avoided and concentrate on crops where the method is not available: Complied

Technical programme (2021-2022)	**Achievements**
Multi-residue analysis for Ginger market samples.	-
Multi-residue analysis for black pepper and cardamom market samples.	-
Degradation kinetics of pesticides in ginger.	A study on degradation kinetics of Imidachloprid has been initiated with an objective of studying the degradation product and to find out the method(s) for removing pesticide residue from ginger after harvest

2. DST-CPPHT-1: Aflatoxin management in spices: Development of novel preventive methods (2021-2023) [Dr. Anees K., Dr. E Jayashree, Dr. C. Sarathambal, Dr. Muhammed Fahim Ansari]

Decisions: Nil

Technical programme (2021-2022)	**Achievements**
Fractionation of mature turmeric leaf oil to identify the specific compound responsible for *A.flavus* growth inhibition.	The Essential oil extracted from mature leaves have components with chemopreventive effects on aflatoxin producing strains of *Aspergillus flavus.* The GC-MS profile of mature leaf EO samples identified 21 different constituents respectively. The compounds specific to mature turmeric leaf oil were α-Santalene (4.49%), Caryophyllene (2.72%), α-Bergamotene (1.26%), (Z)-β-Farnesene (2.49%) , Ar- Curcumene (1.11%), α-Zingiberene (16.01%), β-Bisabolene (3.42%), β-Sesquiphellandrene (8.16%),

	Germacrene-B (2.08%) and Germacron (3.65%).
Screening for new phytochemicals from wild species of nutmeg for its effectiveness against *A. flavus*.	-
Standardization of protocol for water soluble formulation using lac resin for nutmeg seed coating.	Water soluble lac resin-based formulation was tried for managing aspergillus flavus infection in nutmeg and mace. The experiment is under progress.

DIVISION OF CROP PROTECTION

Mega Project VI: Bio-intensive management of pests and diseases in spices [Project Leader: Dr. Santhosh J Eapen]

1. ICAR-CP 1. ICAR-Consortium research project on borers in network mode (2014-2023) [Dr. C.M. Senthil Kumar & Dr. M. Balaji Rajkumar]

Decisions:

- Compatibility of promising insecticides and fungicides and their efficacy under field conditions may be studied: The studies will be taken up during the next crop season with the support of plant pathologists

- Efficacy of promising molecules may be tested in Karnataka conditions too: Promising chemicals are being tested in Karnataka through AICRPS

- Correlation between shoot borer incidence and weather variables may be elucidated: All weather data during the study period is being recorded and the correlation between these parameters and pest occurrence will be worked out.

Technical programme (2021-2022)	**Achievements**
Spray schedule optimization of low risk insecticides against shoot borer of ginger.	Low risk insecticides such as chlorantraniliprole, flubendiamide and spinosad, which were found to be effective earlier and a combination treatment of spraying chlorantraniliprole and spinosad alternatively are being screened under field conditions at farmer's field at Venappara for spray schedule optimization at two different spray schedules (*i.e.* 15- and 21-days' interval) against shoot borer infesting ginger.
Influence of plant phenology and crop duration on the occurrence of shoot borer infesting turmeric.	The influence of crop duration and phenology with respect to the seasonal incidence of *C. punctiferalis* infesting turmeric is being studied for the second consecutive year at chelavoor by recording the incidence of the pest at fortnightly intervals.
Dose optimization of low risk insecticides against shoot and capsule borer infesting cardamom.	Three low risk insecticides (spinosad, flubendiamide, chlorantraniliprole) and a combination treatment of spraying chlorantraniliprole and spinosad alternatively along with a standard check (quinalphos) is being screened under field conditions at IISR-RC, Appangala for dose optimization against shoot and capsule borer for the second consecutive year.
Screening of low risk insecticides against pollu beetle infesting black pepper.	Low risk insecticides such as chlorantraniliprole, flubendiamide and spinetoram) at two doses along with quinalphos as control are being screened for their efficacy against pollu beetle (*Lanka ramakrishnai*) at Peruvannamuzhi farm.

2. Integrated management of mealy bug (Pseudococcidae: Hemiptera) infesting black pepper (2019 – 2022) [Dr. M. Balaji Rajkumar & Dr. C. M. Senthil Kumar]

Decision:

- Molecular characterization of mealy bugs shall be expedited.

Technical programme (2021-2022)	**Achievements**
Survey for mealybug in black pepper growing areas.	Six low risk insecticides (two green and four blue labeled) screened against mealy bug (*Ferrisia* sp) under laboratory (Spirotetramat 15.31 OD, Chlothianidin 50 WDG, Chlorfenapyr 10 SC, Triflumezopyrim10 SC, Spiromesifen 22.9 SC, & Abamectin 1.9 EC).
Collection and culturing of mealybug in laboratory.	In progress.

3. KSCSTE-CP-1: Development of a *Metarhizium* sp.-based bio-pesticide formulation for the control of shoot borer, *Conogethes punctiferalis* infesting cardamom, ginger and turmeric (2021-2024) [Dr. C. M. Senthil Kumar, Dr. M. Balaji Rajkumar & Dr. R. Praveena]

Decision:

- The project is approved and RPP I may be submitted.

Technical programme (2021-2022)	**Achievements**
Infectivity and host range studies of *M. pingshaense*.	Laboratory studies have been initiated to know the infectivity potential and host range of *M. pingshaense* against different insect pests.
Studies on intracellular and extracellular bioactive metabolites of the fungus.	Studies to elucidate the potential of the fungus to release intracellular and extracellular bioactive metabolites are in progress. Zn solubilization efficiency and extracellular enzyme activity like amylase activity has been completed.
Mass production and bio-formulation of the fungus.	Studies on mass production of the fungus on different substrates such as parboiled rice, major millets, coconut frond, coir pith are in progress.
Field evaluation of *M. pingshaense* against shoot borer (*C. punctiferalis*) infesting ginger and turmeric and cardamom.	Field studies are in progress to evaluate the efficacy of the entomopathogenic fungus, *M. pingshaense* against shoot borer infesting ginger and turmeric. The fungus is being tested at three different doses along with an insecticide control, chlorantraniliprole at Chelavoor, Kozhikode at a spray interval of 21 days.

4. Nema. VII (813): Prevalence of lesion nematodes in turmeric growing tracts of India and their economic significance (2018-2022) [Dr. C. Sellaperumal, Dr. Santhosh J Eapen & Dr. R. Praveena]

Decisions:

- New methods for analyzing population dynamics of *Pratylenchus* sp. under field conditions may be developed:
- Culturing of *Pratylenchus* sp. may be expedited.

Technical programme (2021-2022)	**Achievements**
Study on population dynamics and survey of lesion nematode infecting region of turmeric.	Population dynamics and survey is in progress.
Management of lesion nematode infecting turmeric under field condition.	Lesion Nematode population has reduced treated with *fluopyram* when compared to other treatments under field condition.
Study on interaction and pathogenicity of *Pratylenchus* spp and other soil borne pathogens associated with turmeric.	Interaction and pathogenicity is in progress.
Screening of bio-control isolates against PP nematodes.	Screening of bio-control agent is in progress.
Maintenance of nematode cultures.	Continuing maintenance of nematode stock (*Prtaylenchus* spp, *Radopholus similis* and *Meloidogyne* spp) under *in-vitro* and *in-vivo*. Nematode stock of *Pratylenchus* spp, *Radopholus similis* on banana and *Meloidogyne* spp on brinjal has been maintaining as ex situ under screen house condition and *Radopholus similis* on carrot culture in *in vitro*.

5. Path. XXVII (813): Development of microbial biostimulants for growth promotion and disease resistance in major spices (2018-2023) [Dr. C. Sarathambal, Dr. A. Jeevalatha& Ms. R. Sivaranjani] (External support: Dr. Mohammed Faisal Peeran]

Decisions:

- Activity profile and duration of defense related enzyme expression in the host shall be studied.
- Histopathology in black pepper-AM fungi interaction shall be undertaken.
- Alternative strategies for multiplication on AM fungi shall be developed.

Technical programme (2021-2022)	**Achievements**
Field evaluation of AM fungi inoculation effect on growth and nutrition uptake of ginger	Plant growth, disease incidence and mycorrhizae spore count were analyzed up to 180 days. Nutrient uptake pattern and yield parameter analysis is under progress.

Effect of mycorrhizal colonization on biochemical and molecular defense responses to *Phytophthora capsici* in black pepper.	Peroxidase enzyme activity and CAPX gene expression analysis were performed to see the AM colonization effect to *Phytophthora capsici* in black pepper.
Effect of AM inoculation on growth, mineral nutrient uptake of cardamom seedlings.	Plant growth and dry weight were recorded. Nutrient uptake and AM spore count analysis are under progress.

6. Path. XXVIII (813): Novel strategies for managing bacterial wilt and soft rot diseases of ginger (2018-2022) [Dr. C. N. Biju & Dr. Mohammed Faizal Peeran]

Decision:

- Efficacy of new molecules against bacterial wilt may be studied under field conditions.

Technical programme (2021-2022)	**Achievements**
Evaluation of capsule formulation of *Bacillus licheniformis* under field conditions	Among the various treatments evaluated to manage soft rot/wilt diseases of ginger under non-solarized field condition, the highest plant survival and lowest disease incidence (rot/wilt) were recorded with calcium chloride (21.5%) followed by Bacillich (powder formulation) (23.7%) and *Methylobacterium komagate* (24%).
Analyzing the effect of $CaCl_2$, *Methylobacterium komagate* and *B. licheniformis* on other major pathogens in ginger	In order to detect the genes responsible for quorum sensing in ginger bacterial wilt pathogen, *Ralstonia pseudosolanacearum* (Sakleshpur isolate), primers were designed targeting the genes *viz*., *SolI* and *phcB* responsible for acyl homoserine lactones (acyl-HSL) and 3-hydroxypalmitic acid methyl ester (3-OH PAME) synthesis, respectively. The expected amplicons of 555 bp and 913 bp were generated with the primers *viz*., ACYL-HSL2 and PHCB 2r, respectively indicating the presence of both *SolI* and *phc* genes responsible for synthesizing the quorum sensing molecules. Evaluation of fungicides and antibiotics (singly and combination) at three different concentrations against *Ralstonia pseudosolanacearum* under *in vitro* condition (inhibition zone assay) indicated that, growth inhibition was maximum with the combination, copper oxychloride + tetracycline hydrochloride at all the concentrations tested.
Evaluation of ginger varieties for Phyllosticta leaf spot resistance	The leaf spot incidence was recorded during June to October 2021. In general, the disease incidence was low during 2021. Among the varieties, maximum incidence was recoded in IISR Rejatha with 33.33% (PDI) during September. The pooled disease incidence during the period 2019-2021 indicated that, IISR Mahima is comparatively tolerant to Phyllosticta leaf spot.

7. Path, XXIX (813): Strategic approaches for management of black pepper diseases (2019 – 2024) [Dr. C. N. Biju, Dr. A. Ishwara Bhat, Dr. A. Jeevalatha, Dr. Mohammed Faisal Peeran, Dr. C. Sellaperumal, Dr. R. Praveena, Dr. Santhosh J. Eapen] (External support: Dr. V. Srinivasan)

Decisions:

- Efficacy of new nematicides may be assessed under field conditions.
- Bioefficacy of endophytic microflora inhabiting wild *Piper* species against *Phytophthora* may be investigated.

Technical programme (2021-2022)	**Achievements**
Establishment of demonstration plot of black pepper at Experimental Farm, Peruvannamuzhi	Black pepper varieties/genotypes *viz*., P-24-O4, IISR Shakthi, IISR Thevam, IISR Pournami, C1114, C1090, Hp 780, 1324, 1386 and 1389 were planted for establishing demonstration plot at ICAR-IISR, Experimental Farm, Peruvannamuzhi.
Analyzing virulence pattern of *Phytophthora* isolates and developing host differentials	In order to develop host differentials, a preliminary study was undertaken on black pepper varieties (IISR Shakthi and Sreekara), landrace (Narayakodi) and allied species of black pepper (*Piper attenuatum*, *P. chaba*, *P. colubrinum* and *P. arboreum*) with two *Phytophthora* species (*P. capsici* and *P. tropicalis*). *P. capsici* caused leaf fall in *P. chaba* (120 hours post inoculation), Sreekara and IISR Shakthi (144 hours post inoculation) and Narayakodi (168 hours post inoculation). Host differential studies with *P. tropicalis* revealed that, *P. chaba* was highly susceptible wherein defoliation occurred 96 hours after inoculation. The characteristic lesion with yellow halo was manifested in Sreekara (32.97 mm^2) and the lesion development was restricted in *P. arboreum* with 2.35 mm^2 lesion area 168 hours after inoculation.
Analyzing sensitivity of *Phytophthora* isolates towards fungicides	The inhibitory effect of four fungicides *viz*., metalaxyl-mancozeb, propineb, metalaxyl and fluopicolide-propamocarb hydrochloride at five different concentrations on mycelial growth and sporangial production in *Phytophthora capsici* (05-06) and *P. tropicalis* (98-93) was studied under *in vitro* condition. In *P. capsici* (05-06), propineb, metalaxyl-mancozeb and fluopicolide-propamocarb hydrochloride completely inhibited mycelial growth at recommended concentrations. The sporangial production was found to be the minimum with metalaxyl-mancozeb (19.6) and maximum in metalaxyl (86.6). In *P. tropicalis* (98-93), fluopicolide-propamocarb hydrochloride completely inhibited mycelial growth. The sporangial production was found to be the minimum with propineb (51.8) and

	maximum in metalaxyl-mancozeb (99.8). Among the fungicides, propineb and metalaxyl also induced aberrations in hyphal architecture both in *P. capsici* and *P. tropicalis*.
Screening pathogenic fungal isolates for the presence of mycoviruses	Out of 38 isolates of *Fusarium* screened for the presence of mycoviruses, one isolate from black pepper (*Fusarium concentricum*) showed the association of mycoviruses. Similarly, out of 18 *Colletotrichum* isolates screened, one isolate (*C. gloeosporioides*) from cardamom showed the presence of mycoviruses.
Flow cytometry and confocal microscopy analyses of *Phytophthora* nuclei	The nuclei of *Phytophthora* isolates 05-06 and ATCC 52239 (*P. palmivora;* as internal standard) were visualized and documented employing confocal microscopy. The DNA contents were also analyzed using flow cytometry and found to be 82.9 Mb and 135 Mb in 05-06 and ATCC 52239, respectively.
Evaluation of nematicides against burrowing nematode in black pepper under nursery and field conditions	The efficacy of two nematicides *viz*., Fluopyram and Fluensulfane along with Carbosulfan against *Radopholus similis* in black pepper was assessed under nursery and field conditions. In nursery, Fluopyram at all the concentrations reduced nematode population in soil as well as root to a considerable extent. The highest plant mortality was recorded with Fluensulfane (65% to 75%), followed by Fluopyram (25%) and Carbosulfan (20%). Among the nematicides, Fluopyram proved to be promising compared to Fluensulfane and Carbosulfan. Under field condition, Fluopyram (0.75ml/L) reduced the nematode population during both pre- as well as post-monsoon periods.

8. Path. XXX (813): Development and formulation of Plant Beneficial Rhizosphere Microorganisms (PBRMs) for disease antagonism, soil nutrient solubilization and plant growth promotion (2020-2024) [Dr. R. Praveena, Dr. R. Dinesh & Dr. C. Sarathambal] (External support: Dr. V. Srinivasan)

Decisions:

- The observational trials under AICRPS and investigations pertaining to *Pochonia chlamydosporia* shall be included as technical programmes.

Technical programme (2021-2022)	**Achievements**
Evaluation of selected PBRMs for nutrient (Zn & P) solubilization potential under greenhouse conditions.	Selected PBRMs, IISR GB7 (3) (B*acillus* spp.) & IISR TB4 (*Bacillus safensis*) are being evaluated under greenhouse conditions for Zn & P solubilization. Observations on plant growth parameters, Zn and P release are being recorded.
Evaluation of selected PBRMs for P & Zn solubilization potential and disease antagonism under field conditions.	*B. safensis* is being evaluated for P & Zn solubilization potential and disease antagonism in ginger and turmeric under field conditions. Monthly observations on growth parameters, disease incidence and soil P & Zn release are being

	recorded.
Development and *in vitro* evaluation of formulations.	Evaluation of different formulations developed is in progress.
Evaluation of novel PBRMs for N fixation & K mobilization traits.	Shortlisted PBRMs isolated different rhizosphere niches are being evaluated for plant growth promotion, N fixation and K mobilization traits under *in vitro* conditions.
Observational trials under AICRPS.	Trial is in progress and observations are being recorded.

9. Path. XXX1 (813) Development of off- and on-site detection techniques for major pathogens of spice crops. (2020-2025) [Dr. A Jeevalatha, Dr. A. Ishwara Bhat, Dr. C. N. Biju & Dr. Mohammed Faisal Peeran]

Decisions:

- Simple reliable tools for on-site testing of field samples may be developed for major pathogens and nematodes: RPA-LFA kit has been developed for PYMoV
- Diagnostic tools based on pathogen-induced markers in the host may be developed.

Technical programme (2021-2022)	**Achievements**
Development of RPA protocol for detection of *Pythium* spp and *Ralstonia pseudosolanacearum* in ginger	Singleplex and duplex recombinase polymerase amplification (RPA) assays were optimized for specific and sensitive detection of *Pythium* spp. and *Ralstonia pseudosolanacearum* from ginger rhizomes. In a validation test, these pathogens could be successfully detected using crude DNA extracted from ginger rhizome samples collected from field, storage and market.
Development of LAMP protocol for the detection of *Pythium* spp. in *turmeric*/*Fusarium* in Vanilla	LAMP primers were designed for *Fusarium oxysporum* fsp *vanillae* infecting vanilla using PrimerExplorer V5 software and the standardization of LAMP assay is in progress.
Production of polyclonal antiserum against PYMoV infecting black pepper to develop LFIA.	Coat protein gene of piper yellow mottle virus was cloned into two expression vectors, pCOLD & pRSET A. The resulting recombinant plasmids (pCOLD 645-644, pRSETA 645-801) were transformed into BL21 DE3 for in vitro expression. The presence of insert within the recombinant plasmids was verified by sequencing.
Development of RPA-LFA for PYMoV detection in black pepper	Basic RPA method for the detection of PYMoV in black pepper was standardized using TwistAmp DNA amplification kit. Different reaction conditions of the assay such as concentration of magnesium acetate, reaction incubation time and temperature were optimized. The RPA-LFA method was standardized for the on-site detection of PYMoV using TwistAmp nfo kit. Sensitivity of the assay was compared with RPA and PCR. Validation of the assay was performed along with PCR using different varieties of black pepper.

10. Path XXXII (813) (2021-2024): *Bacillus spp.-based* formulation for the management of rhizome rot disease in small cardamom (2021-2024) [Dr. Mohammed Faisal Peeran, Dr. C. Sarathambal] (External support: Dr. R. Praveena)

Decisions:

- The project is approved.
- The findings related to CAR/CP/6.11 - Evaluation of fungicides against rhizome rot in small cardamom and CAR/CP/6.12 Evaluation of fungicides against leaf blight in small cardamom may be reported in this project.

Technical programme (2021-2022)	**Achievements**
Survey, collection and isolation of *Bacillus* spp.	Survey has been conducted in major small cardamom grown regions of Karnataka (Kodagu and Hasan). The disease incidence ranged from 20-40% during the season. Soil samples from 8 locations has been collected and totally 44 bacterial samples has been isolated. Based on the colony morphology and biochemical test twenty isolates belonging to *Bacillus* sp. has been short listed.
Collection of *Bacillus* spp. from bioagents repository, *B. amyloliquefaciens* and *B. safensis*.	Two species of *Bacillus* has been collected from repository.
CAR/CP/6.11 - Evaluation on of fungicides against rhizome rot in small cardamom.	Application of Tebuconazole @ 1ml/L or Metalxyl - Mancozeb @ 1.25g/L significantly reduces the disease severity of rhizome rot.
CAR/CP/6.12 Evaluation of fungicides against leaf blight in small cardamom.	Application of Hexaconazole @ 2ml/L significantly reduces the disease incidence of leaf blight.

SOCIAL SCIENCES SECTION

Mega Project VII: Empowering spice stakeholders through skilling, entrepreneurship management and policy inputs [Project Leader: Dr. P. Rajeev]

1. **Ext. VI (813). Capacity building and front-line intervention programmes for (spice sector development in NE states and tribal empowerment (2014-23) (Dr. P. Rajeev & Dr. Lijo Thomas)**

   Decision: Nil

Technical programme (2021-2022)	Achievements
Capacity building demonstrations and community asset building in selected tribal belts and NE region.	Proposal for asset creation; nursery sheds in NE in progress. Capacity building programmes and training organized in Pooppara Tribal colony, Parambikulam Tiger reserve region, Kerala and through Attapady farming Cooperative Society Palakkad, Kerala.
Follow up workshop and evaluation studies in selected tribal locations and NE region.	Yield and income evaluation of the turmeric cultivation by FPO in Namsai, Arunachal Pradesh in progress.
Aspirational Districts projects in Assam for Tribal empowerment and spices production.	Follow up of establishment of black pepper nurseries in 15 districts in progress.

2. **Eco. IV (813): Developing models for enhancing technology and policy impact in spices sector (2020-2025) (Dr. Lijo Thomas, Dr. P. Rajeev & Mr. K Jayarajan**)

   Decision: Nil

Technical programme (2021-2022)	Achievements
Global value chain analysis of spice export trade in selected spice crops for identifying critical policy elements.	Shifts in spice trade due to the pandemic has been analyzed. Spice export trade in turmeric, ginger and black pepper analyzed to identify key structural changes.
Analysis of technology inputs and its impact on spice crop ecosystem.	Commercial viability Small scale industrial production of biocapsules developed. Analysis of key technologies for economic viability and monetary benefits completed.
Development of application for cost of commercial cultivation of ginger and turmeric.	Work in progress.
Policy briefs on selected aspects of spice economy.	One policy brief on pesticide use in spices prepared and published. Work on policy brief on GI in spices in progress.
Develop regional strategy for clove and nutmeg in major producing states.	Data analysis on cost economy of clove completed. Data analysis for nutmeg economy in progress.

Trade analysis and price analysis of spice commodities at the national and global level.	Global price trends in selected spices undertaken.

3. DBT - Kisan Biotech Hub Project (2020-2022) (CPI- Director, ICAR-IISR; Dr.V. Srinivasan, Dr. Lijo Thomas & Dr. P. Rajeev)

Decision: Project approved. RPP 1 may be submitted.

Technical programme (2021-2022)	**Achievements**
Create awareness on the soil health, IPM, agronomic practices for pepper and coffee and fruits farmers.	Soil health card issued to 100 beneficiaries. Five training programmes organized on various topics including Summer care of spice crops, Use of bio inputs like biocapsules, soil health management, improved crop management practices. 1000 kg seed material of improved varieties of ginger and turmeric distributed. 4210 black pepper cuttings of improved varieties distributed to 90 beneficiaries.
Training of Scientists in farmer's field on best traditional practices suitable for particular climatic conditions.	Three scientist- farmer interaction programmes were held. Three exposure visits were organized for beneficiaries.