भाकृअनुप
ICAR

वार्षिक प्रतिवेदन
ANNUAL REPORT
2022

ICAR-Indian Institute of Spices Research
Kozhikode- 673012, Kerala, India
भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान
कोषिक्कोड-६७३०१२, केरल, भारत

G20 भारत 2023 INDIA

INTERNATIONAL YEAR OF MILLETS 2023

वार्षिक प्रतिवेदन
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CORRECT CITATION
Praveena R , Lijo Thomas, Senthilkumar C M , Akshitha H J, Alfiya P (Eds.) (2022) Annual Report 2022, ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, India, P-86

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

HINDI TRANSLATION
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COVER DESIGN
The doodle in the central circle is a metaphorical representation of the emergence of spices as one of the key identities of India across the globe. Spices are depicted as blending seamlessly with important symbols and institutions unique to India.
Doodle Artist: Abhinav

ISBN: 978-81-86872-64-2
January 2023

PRINTERS
Compix Printers, Kozhikode, Kerala

PREFACE

I am privileged to present the Annual Report-2022 of the ICAR-Indian Institute of Spices Research, Kozhikode, Kerala. The strong export demand for spice commodities and the global reach of spice commodities and value-added products from India is increasingly in the limelight. This situation places a tremendous sense of urgency and responsibility on the institute to cater to the research needs of this unique agricultural sector. During the year, the institute was awarded the **"Sardar Patel Outstanding ICAR Institution Award"** for the third time. The award, built on the painstaking efforts of each and every personnel of the institute, reflects our committed approach to science and our ability to make meaningful change in the lives of key stakeholders.

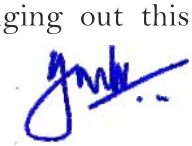
During the year, we have established a dedicated facility named *"Gingerarium"* for conserving ginger accessions and related species. The drought tolerant cardamom genotype IC 349537 was recommended for release as a new variety, *IISR Manushree*. The research on developing recommendations for organic production systems and fertigation requirements for spices has led to customized schedules for crop management. The crop specific micronutrient technologies developed by the institute has found wide acceptance across the spice growing tracts of the country. Considerable research focus of the institute has led to developing practical and cost-effective solutions for managing pest and disease incidence in its mandate crops. I am sure that the molecular and genome level information on several important pathogens available with the institute can be combined with emerging technologies for finetuning our strategies for mitigating biotic stresses.

This year, the institute received a patent for its micronutrient composition for cardamom (Patent No: 413017). The development of Decision Support System for Site Specific Nutrient Recommendation (IISR-e-SOFT) is expected to enhance the adoption of soil test based nutrient application in spice crops. The inking of agreement with Lysterra LLC, a Russian company for commercialization of the novel microbial encapsulation technology was a watershed moment in the institute's history. A significant development has been the establishment of an Incubation Facility for Microbial Encapsulation (iFAME) to fulfil the long-awaited demand from aspiring start-ups and firms who are willing to license this encapsulation technology. This facility will provide a host of services to new enterprises interested in manufacture and marketing of biofertilizers.

During the year, 33 customised training programmes were conducted for the state departments and other organizations. Apart from this, 26 outreach initiatives targeting the SC/ST beneficiaries were also organized. Entrepreneurship incubation services and handholding commercial business ventures has helped in generating employment and creating confidence in agripreneurship.

As a research institute, we remain committed to the generation of new knowledge and technologies. The strong foundations built on diligent basic research work and the existing repository of scientific knowledge need to be shepherded to deliver translational research. This will significantly impact our support to primary production, processing, value addition and in generation of technologies for secondary agriculture.

I am indebted to Dr. Himanshu Pathak, Director General, ICAR and Secretary, DARE for the trust and confidence bestowed on the institute. I am thankful for the guidance received from Dr. T Mohapatra, Former Director General, ICAR in all the endeavours and also immensely thank Dr. A K Singh, DDG (Horticultural Sciences), Dr. Sudhakar Pandey, ADG (Hort I) and Dr. Vikramaditya Pandey, Former ADG (Hort I) for their persistent support and motivation. Special thanks to the editors for bringing out this report.



31 January 2023
Kozhikode, Kerala

R Dinesh
Director

OUR VISION

Enhancing the productivity of spices to meet the growing demand and to make India the global leader in spices export

CONTENTS

कार्यकारी सारांश

काली मिर्च

- असम के डिब्रूगढ़, तिनसुकिया और उत्तर लखिमपुर जिलों के नये अक्सेशनों को जोड़ कर आईसीएआर-आईआईएसआर काली मिर्च जर्मप्लासम नर्सरी में तीन हज़ार चार सौ छियासठ अक्सेशनों का रखरखाव किया जा रहा है। सी.एच.ई.एस, चेत्ताली, कर्नाटक के एक्स-सिटु जीन बैंक में बयालीस काली मिर्च जर्मप्लासम अक्सेशनों का रखरखाव किया जा रहा है।
- काली मिर्च जीनोटाइप के उपज योगदान लक्षणों के लिए भारित पैरामीटर्स को विकसित किए गए थे, जिसमें उपज को सबसे अधिक महत्व दिया गया, इसके बाद थोक घनत्व, स्पाइक की लंबाई और बेरी की संख्या का नंबर आता है।
- प्रत्याशी जीन के मूल्यांकन तथा संयुक्त सह अभिव्यक्ति विश्लेषण के लिए पाइपर नाइग्रम के पत्ते, तने और बरी के चार चरणों (२ एमएपी, ४ एमएपी, ६ एमएपी और ८ एमएपी) की सीडीएनए लाइब्रेरी का निर्माण किया गया था। क्रोमसोम छह से बीएएचडी -एटी जीन ने पाइपरिन की मात्रा से संबंधित एक सापेक्ष अभिव्यक्ति दिखायी।
- पाइपरोयलको-ए के साथ छह बीएएचडी आईसोफोर्म का आणविक संबंध आणविक डॉकिंग अध्ययन द्वारा निकाला गया था। छह प्रोटीनों में से केवल सीएचआर ६ बीएएचडी आईसोफोर्म ने नकारात्मक बाध्यकारी ऊर्जा (-०.७७कि काल/मोल) दिखाई और अन्य सभी आईसोफॉर्मों ने सकारात्मक बाध्यकारी ऊर्जा दिखाई।
- आईआईएसआर शक्ति और गिरिमुंडा किस्मों में सबसे अधिकतम उपज जब ५०% आरडीएफ और ८ लिटर पानी प्रति दिन को फर्टिगेशन के रूप से २४ भागों में देने पर और उसके बाद १००% आरडीएफ और ८ लिटर पानी प्रति दिन को पारंपरिक सिंचाई की दर पर ३ समान विभाजनों में बेसल आवेदन से देने पर पाया गया था।
- काली मिर्च को संक्रमित करने वाले फाइटोफ्थोरा स्पी. का पता लगाने के लिए एक पुन: संयोजक पोलीमरेज़ प्रवर्धन (आरपीए) प्रोटोकॉल को विकसित किया गया है। जांच में काली मिर्च की पत्ती और जड़ के अर्क में १ एनजी तक रोगजनक डीएनए का पता लगाने की संवेदनशीलता है।
- आरईपी पीसीआर और आरएएमएस विश्लेषण के द्वारा फाइटोफ्थोरा वियुक्तियों के विविधता विश्लेषण ने संकेत दिया कि पी. कैप्सीसी और पी. ट्रोपिकालिस वियुक्तियों को स्पष्ट रूप से दो प्रमुख समूहों में विभाजित किया गया था और आगे चार उप-समूहों (I और II - पी. कैप्सीसी वियुक्तियां और III और IV पी. ट्रोपिकालिस वियुक्तियां) में विभाजित किया गया था।
- रीकॉबिनेस पोलीमरेस एम्प्लिफिकेशन (आरपीए) पर आधारित दो द्रुत परख (ए) ६-कार्बोक्सिफ्लूरोसिन (एफएएम) लेबल वाले एनएफओ प्रोब और बायोटिन लेबल वाले रिवेर्स प्राइमर और (बी) एफएएम लेबल वाले फॉरवेड और बायोटिन लेबल वाले रिवेर्स प्राइमर का उपयोग करके पार्श्व प्रवाह परख (एलएफए) के साथ युग्मित-लेबल रिवर्स प्राइमर को ट्विस्टएम्प डीएनए प्रवर्धन अभिकर्मकों का उपयोग करके पीवाईएमओवी का पता लगाने के लिए विकसित किया गया था।

- स्पाइरोमेसिफेन २२.९ एससी, ट्राइफ्लुमेसोप्राइरिम १० एससी (१मि.लि/लि.), स्पाइरोटेट्रामेट (१.५मि. लि./लि.) और क्लोतयानिडिन ५० डब्ल्युडीजी (१ ग्रा/लि.) को इन विट्रो परिस्थितियों में काली मिर्च के मीली बग, फेरीसिया विरगेटा के प्रति बहुत प्रभावी पाया गया।
- बरोयिंग निमाटोड (राडोफोलस सिमिलिस)कि आबादी को कम करने के लिए, साल में दो बार (मनसून से पहले और बाद में) को खेत में फ्लूपाइराम का प्रयोग करना प्रभावी पाया गया।

इलायची

- भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान क्षेत्रीय स्टेशन, अप्पंगला में राष्ट्रीय सक्रिय जर्मप्लासम साइट में (एनएजीएस) छह सौ पच्चीस इलायची अक्सेशनों का रखरखाव किया जा रहा है। विभिन्न रूपात्मक और उपज लक्षणों के आधार पर पचासी खेत जीन बैंक अक्सेशनों का चरित्रांकन किया गया।
- छोटी इलायची संकरों पर किये गये सीवीटी परीक्षणों में प्रति पौधा उच्चतम ताज़ी और सूखी उपज संकर पीएच १३ (क्रमश: ६.३० कि.ग्रा./पौधा और १.१८ कि. ग्रा. /पौधा) में दर्ज की गई।
- आठ जीनोटाइप्स अर्थात, आईसी ३४९५३७, आईसी ५८४०५८, जीजीXएनकेई-१२, आईसी ५८४०७८, सीएल ६६८,एचएस-१, एपीजी-१ और आईसी ५८४०९०का मूल्यांकन सिंचाई और नमी तनाव स्थितियों में किया गया था। उनमें से, जीनोटाइप आईसी ३४९५३७, जो अन्य अक्सेशनों से बेहत्तर प्रदर्शन किया, उसे 'आईआईएसआर मनुश्री' के रूप में ज़ारी करने के लिए सिफारिश की गई।
- इलायची को संक्रमित करने वाले फाइटोफ्थोरा स्पी., पिथियम वेक्सान्स और राइज़ोक्टोणिया सोलानी रोगजनकों का एक साथ पता लगाने के लिए मल्टीप्लक्स पीसीआर परख विकसित की गई थी।
- इलायची मोसाइक विषाणु (सीडीएमवी) का पता लगाने के लिए रिवेर्स ट्रान्स्क्रिप्शन पोलीमरेस एम्प्लिफिकेशन (आरटी-आरपीए) पर आधारित एक द्रुत परख विकसित की गई थी।

अदरक

- फील्ड जीन बैंक में अदरक की छह सौ अड़सठ प्रविष्टियां रखी गई है। असम के डिब्रूगढ़, तिनसुकिया और उत्तर लखिमपुर जिलों से नये अक्सेशनों को संग्रह में जोड़ा गया।
- देश के विभिन्न भागों से संचित अदरक अक्सेशनों और संबंधित प्रजातियों के संरक्षण के लिए समर्पित एक सुविधा, "जिंजरेरियम" को आईआईएसआर प्रायोगिक फार्म में स्थापित की गई थी।
- लाल अदरक में टेट्राप्लोयिड (२एन=४४) का सफलतापूर्वक प्रवेश किया गया था जो इन विवो कोलिचीसीन उपचार के माध्यम से प्राप्त किया गया था।
- अदरक में उत्पादन प्रणालियों के मूल्यांकन के तहत एकीकृत प्रबंधन (७५% जैविक + २५% अजैविक) अधिकतम उपज (१४.९ टन/हेक्टर) अंकित किया था, जिसका उपज जैविक

(२५%) + अजैविक (२५%) + बीजामृत (बीए), गणजीवामृत (जीजेए) और जीवामृत (जेए) के साथ बीज उपचार (१३.३ टन/हेक्टर) के बराबर था।

आम अदरक

- आम अदरक के नौ अक्सेशनों का उपज मूल्यांकन चैक अम्बा किस्म के दौरान वर्ष २०१९-२०२०, २०२०-२०२१ और २०२१-२०२२ में किया गया। इन अक्सेशनों में से, अक्से. ३४७ ने उच्चतम उपज अंकित की तत्पश्चात् एनवीएमएस २.

हल्दी

- खेत जीन बैंक में एक हज़ार चार सौ चार कुरकुमा अक्सेशनों का रखरखाव किया जा रहा है।
- अध्ययनों से संकेत मिलता है कि हल्दी की किस्में एनडीएच१, राजेंद्र सोणिया और कांति उनके समीपस्थ (नमी, राख, प्रोटीन, वसा और कार्बोहाइड्रेट) और खनिज (Cu, Mn, Fe, Zn, K, Ca, Mg, P) रचना के आधार पर पूरक पोषण का एक वैकल्पिक स्रोत हो सकते हैं।
- विशिष्ट बाज़ारों के लिए हल्के पीले रंग की हल्दी पर सीवीटी ने संकेत दिया कि अक्से. ८४९ ने अधिकतम ताज़ा उपज अंकित की तत्पश्चात् अक्से. १५४५.
- आईपीसीसी की पांचवीं मूल्यांकन रिपोर्ट के परिदृश्य के आधार पर भारत में हल्दी के लिए भूमि उपयुक्तता का मूल्यांकन पर विश्लेषण किया गया था। जलवायु पैरामीटर जैसे तापमान और वर्षा और भूमि की विशेषताएं जैसे मिट्टी की जल निकासी, बनावट, पीएच, गहराई और ढ़लान का विचार किया गया।
- मृदा पी विलेयकरण और विकास संवर्धन के लिए फॉस्फेट घुलनशील बैक्टीरिया (पीएसबी) के ग्रीनहाउस मूल्यांकन ने संकेत दिया कि पीएसबी के अनुप्रयोग ने हल्दी के विकास को महत्वपूर्ण रूप से बढ़ावा दिया, जो टिल्लर की बढ़ी हुई संख्या, शूट की लंबाई, पत्तियों की संख्या, सूखे प्ररोह की वज़न और रूट आदि से स्पष्ट होता है।
- हल्दी में पादप वृद्धि को बढ़ाने तथा ज़िंक घुलनशीलता के लिए मल्टी -ट्रेट पीजीपीआर, बैसिलस सर्फेसिस के मूल्यांकन से पता चलता है कि जिंक और बी. सर्फेसिस का संयुक्त अनुप्रयोग मिट्टी में ऑर्गानिक कार्बन, नाइट्रोजन की उपलब्धता और डीहाइड्रोजनेस एनज़ाइम गतिविधि जैसे भौतिक-रासायनिक मापदंडों को बढ़ाते हुए दिखाई पड़ा।
- १X१०^{७} कोनीडिया/मिलीलिटर पर एम. पिंगशाएंस का छिड़काव अदरक और हल्दी पर हमला करने वाले प्ररोह बेधक के प्रबंधन में प्रभावी पाया गया।
- फ्लुपाइरम (०.५ मिलीलिटर) के प्रयोग से घाव सूत्रकृमि (प्राटिलेंकस स्पी.) की आबादी प्रभावी रूप से कम हो गई, टिलर की संख्या और हल्दी की उपज में वृद्धि हुई।

वृक्ष मसाले

- जायफल के उच्च उपजवाले एक अक्सेशन; आईसी ०६४५७५६ को आईसीएआर-एनबीपीजीआर (आईएनजीआर २२०९२) में इसके एकलिंगी चरित्र के लिए पंजीकृत किया गया है।
- मइक्रोवेव की सहायता से संवहन सुखाने की प्रणाली के तहत जायफल जावित्री सुखाने के काइनटिक्स, मॉडलिंग और गुणवत्ता मूल्यांकन ने संकेत दिया कि १ मिनट के लिए ३२० डब्ल्यु की इष्टतम शक्ति पर माइक्रोवेव में आवश्यक तेल, ओलिओरसिन और सूखे जावित्री के रंग का बेहत्तर प्रतिधारण पाया

गया।

- दालचीनी के वन्य प्रजातियों के पांच अक्सेशनों (जिसमें दो स्पीसीस शामिल है) को असम के दिब्रुगढ़, तिनसुकिया और उत्तर लखिमपुर जिलों तथा कर्नाटक के बाबा बुदान पहाडियों से एकत्र किया गया। गार्सीनिया के छब्बीस अक्सेशनों को असम के दिब्रुगढ़, तिनसुकिया और उत्तर लखिमपुर जिलों से एकत्र किया गया।
- पिमेंटा रेसिमोसा से पिमेंटा डयोयकिया को अलग करने के लिए विशिष्ट आईएसएसआर मार्केर्स की पहचान की गई है।

वैनीला

- प्रमुख फ्लेवर यौगिकों जैसे वैनिलिन, पी-हाइड्रोक्सिबेंसोयिक एसिड, पी-हाइड्रोक्सिबेंसाइलडिहाइड और वैनिलिक एसिड की मात्रा निर्धारण करने के लिए प्रोटोकॉल को मानकीकृत किया गया।

सामान्य

- प्रमुख मसाला फसलों जैसे काली मिर्च, अदरक, हल्दी और इलायची के लिए स्थान विशिष्ट पोषक तत्वों की सिफारिश के लिए एक निर्णय समर्थन प्रणाली (ई-सोफ्ट) विकसित की गई थी।
- जीवाणु सामुदायिक संरचना और संबंधित कार्यात्मक मार्गों पर nZnO के प्रभाव को पूर्वानुमानित मेटाजीनोमिक प्रोफाइलिंग और क्वांटिटेटीव रियलटाइम पीसीआर के माध्यम से निर्धारित किया गया था।
- हल्दी, सुगंधित हल्दी, काली हल्दी, मेथी, कलौंजी और अजवाइन की कुछ किस्मों की पहचान करने के लिए विशिष्ट डीएनए मार्केर्स विकसित किए गए है।
- संस्थान ने अनुसूचित जाति और अनुसूचित जनजाति के लाभार्थियों के लिए तैंतीस अनुकूलित प्रशिक्षण कार्यक्रम और छब्बीस केंद्रित कार्यक्रम आयोजित किए।
- संस्थान ने मसाला खेती के विभिन्न पहलुओं पर आठ रेडियो भाषण तैयार करने के लिए आकाशवाणी, मडिकेरी, कर्नाटक के साथ भागीदारी की।
- संस्थान ने बागवानी विभाग, त्रिपुरा सरकार के सहयोग से अगरतला में २७-२८ सितंबर २०२२ को "मसालों का उत्पादन और प्रसंस्करण प्रौद्योगिकियों की प्रगतियां" पर दो दिवसीय कार्यशाला का आयोजन किया।
- भारत में कीटनाशक विनियमन नीति पर एक नीतिगत विश्लेषण से संकेत मिलता है कि भारत में पंजीकृत कीटनाशकों की संख्या बढ़ाने और मसालों में इस्तेमाल होने वाले कीटनाशकों के लिए राष्ट्रीय और कोडेक्स एमआरएल दोनों निर्धारित करने की तत्काल आवश्यकता है।
- संस्थान को वर्ष २०२१ के लिए सरदार पटेल उत्कृष्ट आईसीएआर संस्थान पुरस्कार से सम्मानित किया गया।
- iFAME (माइक्रोबियल एनकैप्सुलेशन के लिए इनक्युबेशन सुविधा) नामक बायोकंट्रोल फॉर्मुलेशन के उत्पादन के लिए एक समर्पित सुविधा स्थापित की गई थी।
- संस्थान को इलायची के सूक्ष्म पोषक सूत्रीकरण के लिए पेटेंट प्राप्त हुआ।

EXECUTIVE SUMMARY

Black Pepper

- Three thousand four hundred and sixty six accessions are being maintained at the black pepper germplasm repository at ICAR-IISR with new additions included from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam. In the *ex-situ* gene bank at CHES, Chettalli, Karnataka forty two black pepper germplasm accessions are being maintained.
- Weighted parameters for yield contributing traits of black pepper genotypes were developed with maximum weightage given to yield followed by bulk density, spike length and number of berries.
- cDNA library of *Piper nigrum* leaf, stem and four stages of berry were constructed for the evaluation of candidate genes and for combined co expression analysis. The *BAHD-AT* gene from Chromosome six showed a relative expression correlating with piperine content.
- Molecular interaction of six BAHD isoforms with Piperoylco-A was deduced by molecular docking studies. Out of the six proteins, only CHR6 BAHD isoform showed negative binding energy (-0.77 kcal/mol) and all other isoforms showed positive binding energy.
- In drip irrigation trial, the varieties IISR Sakthi and Girimunda recorded maximum yield with drip irrigation @ 8 L with 50 % of RDF applied as fertigation in 24 splits, followed by conventional irrigation @ 8 L of water per day with 100% RDF applied in 3 equal splits as basal dose.
- A recombinase polymerase amplification (RPA) protocol to detect *Phytophthora* spp infecting black pepper has been developed. The assay has a sensitivity of detecting upto 1 ng of pathogen DNA in leaf and root extract.
- Diversity analysis of *Phytophthora* isolates using REP PCR and RAMS analysis indicated that *P. capsici* and *P. tropicalis* isolates were clearly separated into two major clusters and were further separated into four sub-clusters (I & II- *P. capsici* isolates and III & IV- *P. tropicalis* isolates)
- Two rapid assays based on the recombinase polymerase amplification (RPA) coupled with lateral flow assay (LFA) using (i) 6-carboxyfluorescein (FAM) labelled nfo probe and biotin-labeled reverse primer and (ii) FAM labelled forward and the biotin-labelled reverse primer was developed for the detection of PYMoV using TwistAmp DNA amplification reagents.
- Spiromesifen 22.9 SC, Triflumezopryrim 10 SC (1ml/L), and Spirotetramat (1.5ml/L) and Clothianidin 50 WDG (1g/L) were found to be effective against the black pepper mealy bug *Ferrisia virgata* under *in vitro* conditions.
- The application of fluopyram twice a year (pre- and post-monsoon) was found to be most effective against burrowing nematode (*Radopholus similis*) under field conditions in reducing the nematode population.

Cardamom

- Six hundred twenty five cardamom accessions are being maintained in National Active Germplasm Site (NAGS) at ICAR-IISR, Regional Station, Appangala. Characterization of 85 field gene bank accessions was carried out based on different morphological and yield traits.
- CVT trials conducted on hybrids of small cardamom recorded highest fresh and dry yield per plant in the hybrid PH 13 (6.30kg/plant and 1.18kg/plant

respectively).

- Eight genotypes, *viz*., IC 349537, IC 584058, GG×NKE-12, IC 584078, CL 668, HS-1, APG-1 and IC 584090 were evaluated under both irrigation and moisture stress conditions. Among them, the genotype IC349537, out performed the other accessions which was recommended for release as IISR Manushree.
- Multiplex PCR assay was developed to simultaneously detect *Phytophthora spp*., *Pythium vexans*, and *Rhizoctonia solani* pathogens infecting cardamom.
- A rapid assay based on the reverse transcription recombinase polymerase amplification (RT-RPA) was developed for the detection of cardamom mosaic virus (CdMV).

Ginger

- Six hundred and sixty-eight ginger accessions are being maintained in the field gene bank. New additions to the collection were made from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam.
- "Gingerarium" a dedicated facility for conserving ginger accessions and related species collected from different parts of the country was established at IISR Experimental farm.
- Successful induction of tetraploid (2n=44) was achieved in red ginger, through *in vivo* colchicine treatment.
- Under the evaluation of production systems on ginger, integrated management (75% organic + 25% inorganic) recorded maximum yield of 14.9 t/ha which was on par with organic (25%) + inorganic (25%) + seed treatment with Beejamrit (BA), Ganajeevamrit (GJA) and Jeevamrit (JA) (13.3t/ha).

Mango ginger

- Nine accessions of mango ginger were evaluated for yield performance under field conditions during 2019-2020, 2020-2021 and 2021-2022. Among the accessions, Acc. 347 recorded the highest yield followed by NVMS 2 .

Turmeric

- One thousand four hundred and four *Curcuma* accessions are being maintained in the field gene bank.
- Studies indicate that turmeric varieties, NDH 1, Rajendra Sonia, and Kanti could be an alternative source of nutritional supplement based on their proximate (moisture, ash, protein, fat, and carbohydrates) and mineral (Cu, Mn, Fe, Zn, K, Ca, Mg, P) composition.
- CVT on light yellow colour turmeric for speciality markets indicated that Acc 849 recorded maximum fresh yield followed by Acc. 1545.
- Land suitability assessment for turmeric in India was analysed based on the 5^{th} Assessment Report Scenarios of IPCC. Climatic parameters such as temperature, rainfall and land characteristics such as soil drainage, texture, pH and depth and slope were considered
- Greenhouse evaluation of promising phosphate solubilizing bacteria (PSB) for soil P solubilization and growth promotion indicated that application of PSB significantly promoted turmeric growth as evidenced from the enhanced number of tillers, shoot length, number of leaves, dry weight of shoot and root.
- Evaluation of multi-trait PGPR, *Bacillus safensis* for plant growth promotion and zinc solubilization in turmeric showed that combined application of Zn and *B. safensis* was found to increase physico-chemical parameters like organic carbon, available nitrogen and dehydrogenase enzyme activity in soil.
- Spray application of *M. pingshaense* at 1×10^7 conidia/ml was found to be effective in managing shoot borer

infesting ginger and turmeric
- Application of fluopyram (0.5 ml/L) effectively reduced the lesion nematode (*Pratylenchus spp.*) population, enhanced the number of tillers and the yield in turmeric.

Tree spices
- A high yielding nutmeg accession; IC0645756 has been registered with ICAR-NBPGR (INGR22092) for its monoecious character.
- Drying kinetics, modelling and quality evaluation of nutmeg mace under microwave assisted convective drying system indicated that microwave at optimal power of 320 W for 1 minute was found to have better retention of essential oil, oleoresin and colour of dried mace.
- Five accessions of wild cinnamon comprising of two species each were collected from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam and Baba Budan hills of Karnataka. Twenty-six accessions of *Garcinia* species were collected from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam.
- Unique ISSR markers, for distinguishing *Pimenta dioica* from *P.racemosa* have been identified.

Vanilla
- Protocols for quantification of major flavour compounds *viz*., vanillin, p-hydroxybenzoic acid,p-hydroxy benzaldehyde and vanillic acid were standardized.

General
- A Decision Support System (e-SOFT) for site specific nutrient recommendation for major spice crops *viz*., black pepper, ginger, turmeric and cardamom was developed.
- The effect of nZnO on bacterial community structure and associated functional pathways were determined through predictive metagenomic profiling and Quantitative Realtime PCR.
- Unique DNA markers have been developed for distinguishing certain varieties of aromatic turmeric, black turmeric, turmeric, fenugreek, nigella and ajwain.
- The institute conducted 33 customised training programmes and 26 focused programmes for beneficiaries belonging to Scheduled Caste and Scheduled Tribes.
- The institute partnered with AIR Madikeri, Karnataka to develop eight radio talk modules on various aspects of spice farming.
- The institute organized a two-day workshop on "Advances in Production and Processing Technologies of Spices" in collaboration with Department of Horticulture, Government of Tripura during 27-28 September, 2022 at Agartala.
- A policy analysis on the pesticide regulation policy in India indicate that there is an urgent need to enhance the number of registered pesticides, and to set both national and codex MRLs for pesticides used in spices.
- The Institute was conferred with Sardar Patel Outstanding ICAR Institution Award -2021 for the third time.
- A dedicated facility for production of biocontrol formulations named an Incubation Facility for Microbial Encapsulation (iFAME) was established.
- The institute received patent for micronutrient formulation for Cardamom.

INTRODUCTION

History

Intensive research on spices in the country was initiated with the establishment of a Regional Station of Central Plantation Crops Research Institute (CPCRI) at Kozhikode, Kerala, during 1975, by the Indian Council of Agricultural Research (ICAR). This Regional Station was upgraded as National Research Centre for Spices (NRCS) in 1986 by merging with it the Cardamom Research Centre of CPCRI at Appangala, Madikeri, Karnataka. The NRCS was further elevated to the present Indian Institute of Spices Research (IISR) during 1995.

Location

The laboratories and administrative offices of the institute are located at Chelavoor (50 m above MSL), 11 km from Kozhikode (Calicut), Kozhikode District, Kerala, on the Kozhikode - Kollegal road (NH 212), in an area of 14.3 ha. The research farm is located 51 km North East of Kozhikode at Peruvannamuzhi (60 m above MSL), on the Peruvannamuzhi-Poozhithode road in Kozhikode District, in an area of 94.08 ha. The Regional Station (920 m above MSL) is located at Appangala, Kodagu District, Karnataka, on the Madikeri-Bhagamandala road, 8 km from Madikeri, in an area of 17.4 ha.

Mandate

The mandate of the institute was revised with effect from 16 May 2016 during the 87th Annual General Meeting of the ICAR Society held on 04 February 2016 (DARE vide Letter F.No. 13(102)/2015-Cdn.Tech. dated 20 May 2016)

- Basic, applied and strategic research on genetic resource management, crop improvement, crop production and protection technologies for enhanced production of safe spices.
- Transfer of technology, capacity building and impact assessment of technologies.
- Coordinate research and validation of technologies under AICRP on Spices.

The spice crops on which research is being conducted at the institute include black pepper (*Piper nigrum* Linn.), cardamom (*Elettaria cardamomum* Maton), ginger (*Zingiber officinale* Rosc.), turmeric (*Curcuma longa* Linn.), cinnamon (*Cinnamomum verum* J. Presl.), cassia (*C. cassia* Nees ex Blume), clove (*Syzygium aromaticum* (L.) Merrill & Perry), nutmeg (*Myristica fragrans* Houtt.), allspice (*Pimenta dioica* (L.) Merrill & Perry), Garcinia (*Garciniagummi-gutta* (L.) N. Robson and *G. indica* Choisy) and vanilla (*Vanilla planifolia* Jacks. ex Andrews).

Organization

The Director is the administrative head of the institute. The Institute Management Committee, Research Advisory Committee and Institute Research Council assist the Director in matters relating to management and research activities of the institute. Research on various aspects of the mandate crops is conducted in three divisions, namely, Division of Crop Improvement and Biotechnology, Division of Crop Production and Post Harvest Technology and Division of Crop Protection and a Social Sciences Section. The other facilities available at the institute include Agricultural Technology Information Centre, Agricultural Knowledge Management Unit, Bioinformatics Centre and Krishi Vigyan Kendra. The institute also functions as the headquarters for the All India Coordinated Research Project on Spices (AICRPS). The institute has also linkages with several universities, research institutes, and developmental agencies for collaborative research and developmental activities in spices.

Budget

The total budget of the institute was Rs.2168.34 lakhs during the year. The institute earned total revenue of 53.57 lakhs through sale of planting materials, biocontrol agents, trainings, publications and consultancy services etc.

Staff

The institute has a sanctioned strength of 48 scientific, 35 technical, 24 administrative and 31 supporting staff, of which 37, 25, 11 and 4 of scientific, administrative, technical and supporting staff, respectively are in position. The KVK has a sanctioned strength of 1 scientific, 11 technical,2 administrative and 2 supporting staff.

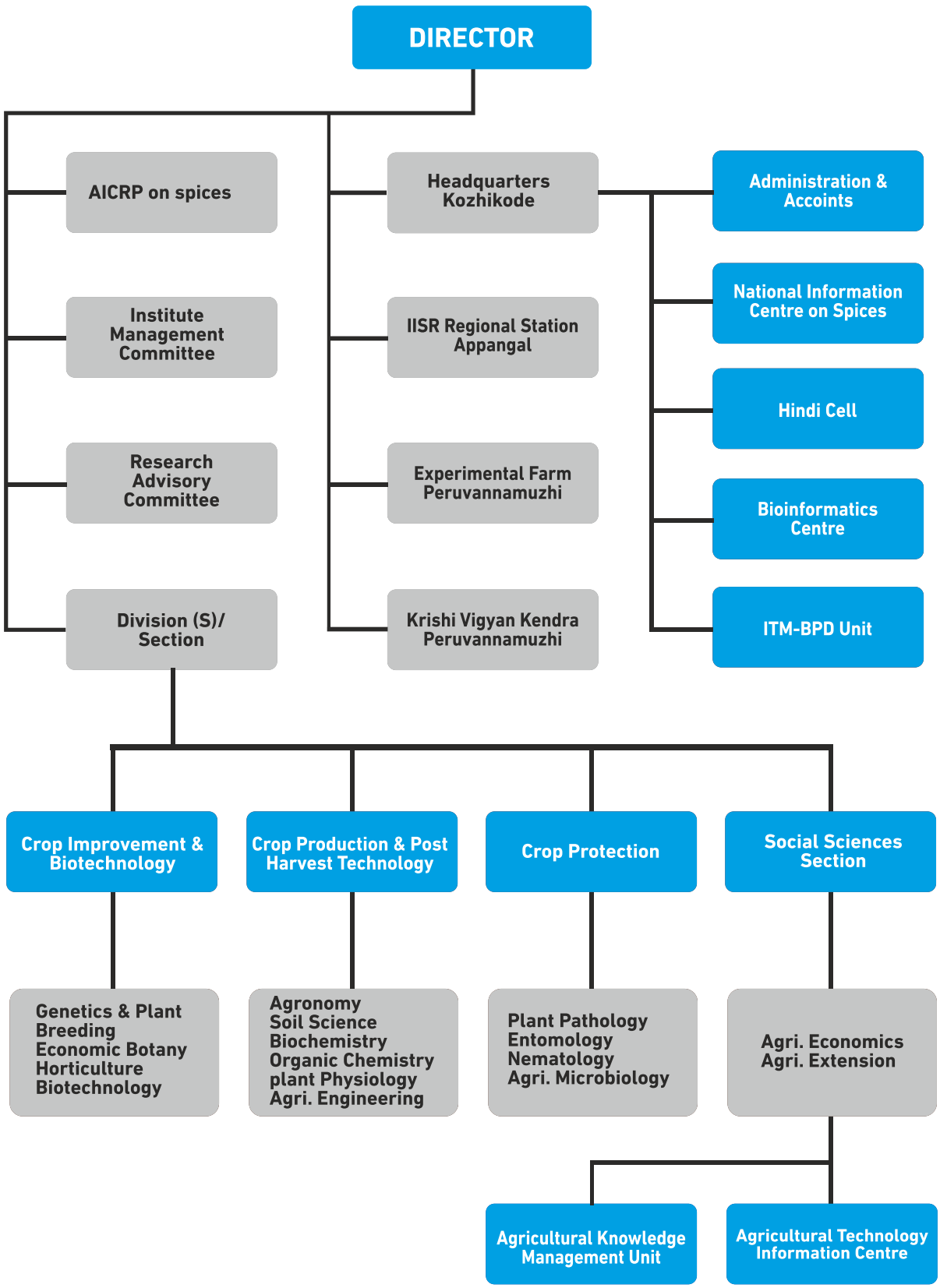
Staff Position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientist	47+1	28	03	06	37	10+1
Technical	35	14	08	03	25	10
Administration	24	09	01	01	11	3
Supporting	31	01	01	02	04	27
Total	37+1	52	13	12	77	60+1

Staff position of KVK, Peruvannamuzhi

Category	Sanctioned	Position	Total	Vacant
Scientific	01	01	01	
Technical	11	08	08	03
Administration	02	01	01	01
Supporting	02	01	01	01
Total	16	10	10	06

ORGANIZATIONAL CHART



PAST ACHIEVEMENTS

Black pepper

About 3466 germplasm accessions are presently being maintained at ICAR-IISR, Chelavoor; Experimental Farm, Peruvannamuzhi as well as in alternate sites (Appangala and Chettalli of Karnataka). So far, the Institute has released nine improved varieties such as Sreekara, Subhakara, Panchami, Pournami, PLD-2, IISR Thevam, IISR Girimunda, IISR Malabar Excel and IISR Shakthi. Three unique accessions, INGR 8099-*Piper thomsonii* (IC 398863) -for its character for sex change and INGR 8100 - *P. nigrum* (IC 563950) - a novel spike variant with proliferating spikes, and IC-0619910, known for its spike length were registered with NBPGR, New Delhi.

Microsatellites developed in the past for *Piper* species were successfully used to detect poly morphism in black pepper cultivars. Additionally, six polymorphic ISSR primers for finger printing varieties of black pepper were also identified. Assembly and functional annotation of sequences derived from the transcriptome of *P. colubrinum* and *P. nigrum* helped in the identification of many genes involved in defense and secondary metabolism.

Seedlings of *P. colubrinum* on screening for *Phytophthora capsici* showed segregation of the resistance character. Putative transgenic black pepper plants with osmotin gene conferring resistance to drought and *P. capsici* have been developed. *In vitro* and *in vivo* propagation methods were standardized. Eighteen black pepper genotypes consisting of varieties/ hybridsand land races/farmers selection characterized based on traits like spike length, number of mature berries/spikes, dry seed weight, fresh seed weight and berry weight showed high positive correlation with spike weight. Grouping of genotypes based on Scott-Knott test revealed Panniyur-1 and Nedumchola as contrasting genotypes for maximum number of traits.

The adoption of site-specific soil fertility management helped in increasing the productivity of black pepper besides enhancing soil quality. Soils from all Panchayats of Kerala state have been analyzed for their physico-chemical properties and nutrient advisory cards have been generated and distributed to farmers. Mathematical models for optimum climatic factors for high production of black pepper have been developed. Antitranspirants such as Kaolin 2.0%, Kaolin 2.0% + 0.5 % MOP, lime 1.5% and lime 1.5% + 0.5% MOP were tested for imparting drought tolerance in black pepper. Spraying lime 1.5% showed higher photosynthetic rate with lower leaf temperature.

Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized. Irrigating pepper vines once in a fortnight from March to May months at the rate of 50 L/vine enhanced yield substantially. Drip fertigation schedules for three black pepper varieties, IISR Thevam, Girimunda and Shakthi have been standardized. Quality analysis of black pepper genotypes indicated that the total alkaloid content (mg/g) ranged from 16.7(Panniyur 4) to 35.7 (Subhakara). Oleoresin was negatively correlated with bulk density but positively correlated with essential oil content and piperine content. Organic production technology and GAP for black pepper have been developed and standardized. Cost effective method for production of disease-free rooted cuttings was developed. Novel soil pH based micronutrient mixture for enhancing growth, yield and quality of black pepper has been developed and licensed. Package for enhancing sustainability of black pepper in coconut based cropping system through site specific nutrient management was also standardized.
Major pests, pathogens, viruses and their insect vectors and nematodes affecting pepper were characterized and documented. Morphological

and molecular characterization of black pepper isolates of *Phytophthora* further revealed that isolates shared the characters of both *P.capsici* and *P. tropicalis*. RNA virus, *Cucumber mosaic virus* (CMV) and a DNA virus, *Piper yellow mottle virus* (PYMoV) were found to be associated with stunted disease of black pepper. A method for simultaneous isolation of RNA and DNA from infected black pepper plants and multiplex PCR for simultaneous detection of CMV, PDV-1, PDV-2 and PYMoV in a single reaction was standardized. SYBR green based real-time PCR was developed for detection of PYMoV and CMV in black pepper. Integrated strategies involving cultural methods, biocontrol agents, plant products and resistant varieties were developed for the management of pests and diseases including nematodes.

Species-specific primers were developed for detection of *R. similis* in soil and plant samples. Black pepper accessions, HP-39 and Acc. 1090 were found to be resistant to nematodes besides being rich in caryophyllene. Basal application of *Trichoderma harzianum* and aerial spray with 1% Bordeaux mixture were found effective in controlling anthracnose disease. Finger printing data was generated for biocontrol agents, *Trichoderma asperellum* (NAIMCC-SF-0049) and *Pochonia chlamydosporia* (NAIMCC-SF-0048) and the seorganisms were deposited in NAIMCC, NBAIM, Mau under safe deposit. Large scale multiplication of biocontrol agents such as *T. asperellum*, *P. chlamydosporia* and PGPR was also undertaken for distribution to farmers. A PGPR consortium (*Micrococcus luteus* +*Enterobacter aerogenes* + *Micrococcus* sp) for enhanced growth promotion and disease management in black pepper has been developed and licensed for large scale production. A novel method for targeted delivery of beneficial microorganisms by encapsulation(biocapsules) was developed and licensed to five companies for mass production.

An integrated pest management schedule for management of root mealy bug has been developed. Metalaxyl-MZ sensitivity of 81 *Phytophthora* isolates was tested and the EC50and EC90 values ranged from 0.0002 to 14.4 ppm and 1.1 to 68.5 ppm, respectively. PCR based techniques were developed for identification of traded black pepper and to detect adulterants in commercial black pepper powder. Post-harvest technologies for drying, processing, storage and production of value-added products like white pepper were standardized.

Genetic diversity of *Phytophthora* isolates from black pepper was studied by SSR profiling and ITS sequencing with the universal primers ITS 6 and ITS 4. A native isolate of *P. capsici* (98-93) infecting black pepper was sequenced using next generation sequencing platform. A multiplex PCR assay has been developed for simultaneous detection of *Phytophthora*, *Pythium* and *Fusarium*.

Climate analogues sites were identified for cultivation of pepper in newer areas to reduce climate change effects on production. The Carbon Equivalence (CE) from the shade trees commonly used as black pepper standards, *Ailanthus* spp. showed the highest C sequestration potential with 2.98 kg C per year (equivalent to 10.94 kg CO_2 sequestration per year) followed by *Glyricidia* spp. with a potential of 1.9 kg C per year (6.99 kg CO_2 sequestration per year).The level of adoption studies of recommended technologies indicated that the adoption level for aerial spraying of Bordeaux mixture for the control of fungal diseases was 57.14% and for application of biocontrol agents was 64.2%. The adoption level for application of soil fungicides, fertilisers and pesticides were very low at 21.14%, 7.7% and 7.6 % respectively. A video on "Augmenting Black Pepper Production – A Success Story" (Malayalam, English, and Hindi) was produced. A facility for DNA fingerprinting and barcoding was established for undertaking finger printing services to facilitate varietal release from AICRPS centres. 25 varieties of spices have been fingerprinted and their uniqueness was established for the new varieties in comparison with its closely related/resembling varieties.

Cardamom

Germplasm collections are being maintained at the National Active Germplasm Site at IISR Regional Station, Appangala, Karnataka and IC numbers have been obtained for all the available 622 accessions. Four germplasm accessions with unique characters have been registered with NBPGR, New Delhi. Improved varieties such as Appangala-1, IISR Vijetha, IISR Avinash and Appangala-2 (hybrid) have been developed, which has immensely contributed in increasing the productivity of cardamom.

Molecular profiles were developed for 100 accessions of small cardamom germplasm using 25 ISSR markers for studying the genetic diversity. Molecular profiling of Indian cardamom revealed the existence of two genetically distinct clusters such as "Kerala cluster" and "Karnataka cluster" among the germplasm collections. Characterization of export grade cardamoms from India, Sri Lanka and Guatemala based on physical, biochemical parameters and molecular techniques revealed the superiority of Indian produce. GC-MS study confirmed superiority of Indian cardamom over Guatemalan and Sri Lankan cardamom. High production technology has been standardized. Drip irrigation and sprinkler irrigation once in 12 days significantly improved yield attributing characters. Soil and water conservation measures have been standardized in cardamom based cropping system. Organic packages and GAP have been developed and standardized. Cardamom accessions APG 257, APG 414 and APG 434 were found to be promising for drought tolerance. Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations.

A small cardamom-mosaic virus interactive transcriptome database (SCMVTDb) was developed in collaboration with ICAR-IASRI. A protocol for SYBR green based real-time RT-PCR for detection of *Cardamom mosaic virus* (CdMV) and *Banana bract mosaic virus* (BBrMV) in cardamom was developed. Surveys conducted in Karnataka and Kerala, revealed the prevalence of *Banana bract mosaic virus* (BBrMV) infection. A reliable RT-PCR based method was also developed for detection of the virus in plants. Based on molecular studies, the *cardamom vein clearing virus* (CdVCV) was found to be a new virus species in the genus, *Nucleorhabdovirus*. Two isothermal molecular assays *viz.*, reverse transcriptase loop mediated isothermal amplification (RT-LAMP) and reverse transcriptase recombinase amplification (RT-RPA) were developed to detect the CdVCV.

The survival of *C. gloeosporioides* infecting cardamom in infected plant part (leaves) was studied under laboratory, greenhouse and field conditions. *Colletotrichum gloeosporioides* isolate from cardamom showed the presence of dsRNA indicating association of a mycovirus. This is the first report of a mycovirus infecting *C. gloeosporioides* from India. A new bacterial wilt disease on small cardamom was noticed in Wayanad, Kerala. The causative organism was identified as *Ralstonia solanacearum* biovar 3 phylotype 1, which is 100% similar to the ginger strain of *R. solanacearum*. An entomopathogenic fungus, *Lecanicillium psalliotae* (IISR-EPF-02) was found to reduce damage by thrips, *Sciothrips cardamomi* significantly and also promotes plant growth. Field screening of 180 cardamom germplasm accessions for three years at Appangala resulted in identification of eight accessions resistant to cardamom thrips. Different morphological traits such as panicle type, persistence of bract and nature of adherence of leaf sheath were found to impart resistance against thrips. A novel soil pH based micronutrient mixture for enhancing growth, yield and quality of cardamom has been developed and non-exclusively licensed. The sustainability index of the soil was measured and the overall index was the highest under INM system followed by conventional and organic systems.

Ginger

Six hundred and sixty eight accessions are being maintained in field germplasm conservatory. Four varieties namely, IISR Varada, IISR Rejatha, IISR Mahima and IISR Vajra were released for their high yield and quality. A superior red ginger genotype with high essential oil (4.3%) along with high pungent principles, gingerol (1.92%) and shogaol (0.55%) has been identified. Acc. 195, a tetraploid having 2n=44, showed mean pollen fertility of 67.73%by glycero-carmine staining and 60.31% by *in vitro* germination and is suitable for futurestudies on induction of seed set. Three potential mutants have been identified through gamma ray irradiation which showed resistant reaction against bacterial wilt caused by *Ralstonia solanacearum*. A conservatory (Garden of Gingers) for Zingibers has been established at ICAR-IISR. Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations. The relationship between leaf P/Zn ratio and soil P/Zn ratio to rhizome yield has been established. The economic optimum in terms of profitable response for money invested was found to be Rs. 3.75 /bed for N, Rs. 1.30/ bed for P and Rs. 0.60 /bed of $3m^2$ for K. Novel soil pH-based micronutrient mixtures for enhancing growth, yield and quality of ginger has been developed and licensed.

Post-harvest technologies for processing and technologies for preparation of value-added products were standardized. Comparison of essential oil constituents of fresh and dry rhizomes indicated that fresh rhizomes contained higher level of monoterpenes namely, citral and *E*-citral whereas the dry rhizomes were predominated by the sesquiter penehydro carbons *viz.*, zingiberene, farnesene and sesquiphellandrene. Indian mango ginger, *Curcuma amada* was found to be free from bacterial wilt even under inoculated conditions.

The species of *Pythium* causing rhizome rot of ginger in Kerala, Karnataka, Uttar Pradesh and Sikkim was identified as *P. myriotylum*. Nine actinomycetes isolates from ginger soil were found to be antagonistic to *R.solanacearum*. Technique for ginger seed rhizomes treatment (for elimination of bacterial wilt pathogen) and integrated disease management strategy for soft rot and bacterial wilt diseases and shoot borer was developed. *Bacillus amyloliquefaciens* (GRB 35) and *B.safensis* (IISR TB4) were effective for disease control and plant growth promotion in ginger. PGPR formulation to enhance nutrient mobilization and growth, yield and biocontrol was developed and commercialized. New technology for integrated management of wilt integrating physical (soil solarization), chemical (soil amelioration with calcium chloride -3%) and biological (ginger apoplastic bacterium – *B. licheniformis*) methods was developed. The formulation of the bioagent was launched as 'Bacillich'. A protocol for priming rhizomes with *Trichoderma* spp. was developed to regulate the germination process, prevent the growth of dry rot pathogens during storage, to improve the vigour of buds and to provide uniform tillering of seed rhizomes.

Seed treatment and three rounds of foliar spraying with tebuconazole (0.1%) at 15 days interval was found to be effective in managing foliar diseases of ginger. Alternatively, first spray with tebuconazole (0.1%) followed by carbendazim + mancozeb (0.2%) at 15 days interval was also found to be equally effective. Two viruses associated with chlorotic fleck disease of ginger were identified as ginger chlorotic fleck associated tombusviridae virus(GCFaTV) and ginger chlorotic fleck associated ampelovirus (GCFaAV) and the complete genomes of GCFaTV and partial genome of GCFaAV were cloned, sequenced and analyzed.Two isothermal assays, RT-LAMP and RT-RPA assays were developed and validated for the quick detection of GCFaV-1 and GCFaV-2.

The life cycle of shoot borer (*Conogethes*

punctiferalis) on six resistant and six susceptible accessions was studied. The infectivity of EPNs strains IISR-EPN 01 to 08 was tested against shoot borer larvae under *in vitro* conditions. One species of EPN belonged to *Oscheius gingeri* and was identified as new species on the basis of morphological and molecular characterization. Field studies indicated that spinosad, flubendiamide and chlorantraniliprole were effective in the management of ginger shoot borer (*Conogethes punctiferalis*) even at the lowest dose (0.3ml/litre of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect. The improved varieties and technologies developed on cropping system, nutrient and water requirement, pest and disease management and post harvest processing techniques were disseminated to farmers and other agencies through publications, training programmes and demonstrations. Large scale multiplication and distribution of elite planting material were also undertaken.

Turmeric

The germplasm with over 1404 accessions is being conserved in the field gene bank. These have been characterized for yield, quality, and resistance to pests, diseases and drought. Seven high curcumin and high yielding varieties, Suvarna, Sudarsana, Suguna, IISR Prabha, IISR Prathibha, IISR Alleppey Supreme and IISR Kedaram were released for commercial cultivation.

Molecular genetic fingerprints of 16 *Curcuma* species using RAPD and ISSR markers revealed high degree of polymorphism. A total of 140 microsatellites containing genomic DNA fragments were isolated adopting the selective hybridization method with di and trinucleotide biotinylated probes. Two synonymous *Curcuma* species *viz.*, *C. zedoria* and *C.malabarica* showed identical SSR profiles for 40 microsatellite loci. Efficient protocol for plant regeneration through organogenesis and somatic embryogenesis was standardized.

Variations in rhizome morphology were observed among calli-regenerated somaclones indicating somaclonal variation. Accessions with high curcumin and root knot nematoderesistance were identified. About 40 seedling progenies with higher curcumin (> 3%) and dry recovery (> 20%) were identified. Three different curcuminoids (curcumin, demetho xycurcumin and bisdemeth oxycurcumin) could be separated from oleoresin byemploying chromatographic techniques. Turmeric essential oil components have been char acterized by GC-MS. A PCR based method was developed to detect adulteration of turmeric powder with wild *Curcuma* species. Through transcriptome analysis the genetic basis and regulation of curcumin biosynthesis in *Curcuma* sp. were unravelled and microRNAs that showed differential expression with respect to curcumin in turmeric accessions with contrasting curcumin content have been identified.

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 per bed of size 3 × 1 m was found to be Rs. 0.65, 0.40, 0.85 for N, P and K respectively. Increase in curcumin content was recorded when sprayed with micronutrients like zinc and boron. The optimum spacing, nutrient and water requirement were standardized for different soils and an organic farming system was developed for turmeric.

Among the management systems, organic system (75.0%) recorded maximum yield(13.9 t/ha) which was on par (13.8 t/ ha) with integrated system (75.0% + 25.0%). Maximum oil content (5.3%) was recorded by organic 100.0% and organic 75.0% management system. Among the 12 turmeric varieties evaluated under 100.0% organic management, significantly higher yield was recorded in IISR Pragati (22.1 t /ha) followed by Kanthi (19.2/ t ha).Higher oil content was noticed in varieties

IISR Prathibha (6.0%) and IISR Alleppey Supreme (5.9%) and least oil content was noticed in Suvarna. Novel soil pH based micronutrient mixtures for enhancing growth, yield and quality of turmeric has been developed and licensed.

A novel spice mix formulation with turmeric, ginger and cinnamon was developed for turmeric milk preparation; one as ready to serve flavoured turmeric milk and the other one as turmeric milk instant mix powder. The technologies were commercialized to Kerala Cooperative Milk Marketing Federation Ltd (MILMA), Kozhikode.

Basic data on distribution, bioecology, population dynamics of shoot borer (*Conogethes punctiferalis*) and its natural enemies and crop loss due to shoot borer was generated. Lamdacyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer. New generation insecticides such as, chlorantraniliprole, fluben diamide and spinosad were also found effective in the management of shoot borer even at the lowest dose(0.3 mL litre^{-1} of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect. The improved varieties and technologies were disseminated to farmers and other agencies through publications and demonstrations. The adoption of released varieties like IISR Prathibha in Andhra Pradesh, Karnataka and Tamil Nadu were studied. A novel soil pH based micro nutrient mixtures for enhancing growth, yield and quality of turmeric, ginger, black pepper and cardamom were developed. Video film on success story of a 'IISR Prathibha' grower was produced.

Tree spices

The germplasm of important tree spices like nutmeg, clove, cinnamon including cassia, garcinia and allspice are being conserved. IC numbers for cinnamon, clove, nutmeg and allspice accessions were obtained from NBPGR, New Delhi. Cassia C1 (IC 370415) has been registered as INGR 05029 with NBPGR, New Delhi for its high oleoresin content (10.5%) besides a dwarf clove accession. The cassia elite line A1 (IC 370400) has been registered with NBPGR for high cinnamal dehyde content in bark oil (81.5%) and leaf oil (80.5%). Two high quality cinnamon varieties, IISR Navashree and IISR Nithyashree and a nutmeg variety, IISR Viswashree were released. Nutmeg accession, A11/25 was found to be promising for high yield. Nutmeg accession A9-71(IC-537220), as a source of high sabinene (45.0% sabinene in nutmeg oil and 41.9% sabinene in mace oil) was registered with NBPGR. Tissue culture protocols have been developed for nutmeg. Protocols for DNA isolation from nutmeg have been standardized. Performance of nutmeg on *M. malabarica* continued to be better than other rootstocks for productivity. Green chip budding with orthotropic buds was standardized in nutmeg on *Myristica fragrans* rootstock with 90-100% success. GC-MS study revealed the presence of two chemotypes in *Cinnamomum verum*. GC-M Sanalysis showed that eugenol, myrcene, chavicol and limonene were the volatile constituents in leaves, berries and fruit stalk of *Pimenta racemosa*. Drying and processing methods for cinnamon, nutmeg and mace have been developed. A package was developed for enhancing sustainability of nutmeg in coconut based cropping system through site specific nutrient management. Antioxidant properties and food color value are being studied in tree spices.GC-MS analysis of the chemical constituents of essential oils in leaves of *Cinnamomum sulphuratum*, *C. glaucescens*, *C. glanduliferum*, *C. macrocarpum* and *C. perrottetti* revealed that the major chemical constituents in these oils were phellandrene, camphor, t-*caryophyllene* and *germacrene*-D respectively. Vegetative propagation techniques were standardized for nutmeg, cassia and cinnamon. Major pests and diseases on tree spices were documented. The improved varieties and technologies developed on propagation and post-harvest processing were

disseminated to the farming community.

Vanilla

Vanilla germplasm is being maintained in the repository with 65 accessions, of *Vanilla planifolia*, 7 *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. Interspecific hybridization was made between *Vanilla planifolia* and *V. aphylla*. Reciprocal crosses were conducted between *V. planifolia* and *V. tahitensis* (species reported as resistant to root rot disease) and high percent of fruit set was observed in both the crosses. Fifty interspecific hybrids each of *V. planifolia* x *V.tahitensis*, *V. tahitensis* x *V. planifolia* and selfed progenies of *V. tahitensis* were established *ex vitro*. Chromosome number analysis of two interspecific hybrids between *V. planifolia* and *V. tahitensis* showed 2n=30 in one (PT-5) and 2n=32 in the other (PT-17).

Protocols for micro propagation through direct shoot multiplication as well as callus regeneration were standardized. Root rot and wilting were found to be the major problems inmost of the plantations. Root rot incidence ranged from 5 to 100%. Mosaic and necrosis were also observed in all the plantations and the incidence ranged from 2 to 80%. *Cucumber mosaic virus* (CMV) of vanilla was characterized on the basis of biological and coat protein(CP) nucleotide sequence properties, which showed that CMV infecting vanilla belongs to subgroup IB. A virus causing mild chlorotic mottle and streaks on leaves of vanilla was identified as a strain of *Cymbidium mosaic virus* (CymMV) based on coat protein gene sequence comparison and phylogenetic studies. Another virus associated with necrosis and mosaic on vanilla was identified as a strain of *Bean common mosaic virus* (BCMV) based on coat protein gene sequence comparison and phylogenetic studies.

Paprika

The germplasm collected from various places of cultivation were characterized for variousmor phological, yield and quality characters such as oleoresin, pungency and colour value. Considerable variability was observed in total extractable colour and capsaicin content (pungency) of selected paprika accessions. The lines ICBD-10, Kt-pl-19 and EC-18 were found promising with high colour value and low pungency. PCR based technique was developed to detect adulterants in commercial chilli powder.

Awards

Besides numerous prestigious fellowships and awards to scientists, the Institute was bestowed twice with the Sardar Patel Outstanding ICAR Institution Award (1999 & 2009). The All India Coordinated Research Project on Spices (AICRPS) won the prestigious Chaudhary Devi Lal Outstanding Award for the best AICRPS in the year 2017-18. Other notable awards obtained by the Institute in the past include, Rajbhasha Shield Award 2013, 2014 & 2015, Best official Language Magazine Award 2015 for Masalon Ki Mehak, ICAR Swachhta Pakhwada Award Second Prize 2018, Fakhrudin Ali Ahammed Award for outstanding research in tribal farming systems 2019 etc. The Institute has been awarded sevan patents for the designer micro-nutrient formulations developed for black pepper, ginger and turmeric, seed coating, white pepper production and microbial encapsulation technology.

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RESEARCH ACHIEVEMENTS

BLACK PEPPER

Genetic resources

Three thousand four hundred and sixty-six accessions are being maintained at the black pepper germplasm nursery at the experimental farm, Peruvannamuzhi. A new set of about 180 germplasm accessions, starting from Accession number 7452 to 7757 were planted for establishing a field gene bank at Peruvanna - muzhi. A plot with 200 wild *Piper* accessions were also planted during July, 2022 to establish a wild ex-situ field gene bank. Seedling progenies were established from *Piper barberi* collected from Anakulam forests (Fig. 1).Piper *ornatum* – an exotic ornamental species was collected and added to the *Piper* germplasm. In a collaborative germplasm exploration with ICAR-NBPGR, New Delhi, 25 accessions of Piper were collected from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam and added to the germplasm repository of ICAR-IISR(Fig. 2). Four accessions of *Piper* spp. were collected from the forest areas in Raigad, Ratnagiri, Sindhudurg (Konkan region) and Kolhapur, Sangli, Satara (Western Maharashtra) and these are being maintained for further studies.

Characterization

Forty-two black pepper germplasm accessions maintained in ex-situ gene bank at CHES, Chettalli were characterized for 10 economically important quantitative traits. Highest coefficient of variation was recorded for fresh yield per vine and lowest for berry size (Fig. 3). Correlation analysis indicated high positive correlation between fresh berry weight and dry berry weight, whereas setting percentage and number of immature berries showed negative correlation. Clustering using UPGMA clustered 42 accessions to three main clusters with 22, 6 and 14 genotypes

Fig. 1: *Piper barberi* **with ripened fruits**

Fig. 2:*Piper lonchites* **male plant from Assam**

Weighted parameter index for identifying promising genotypes

Weighted parameters for yield contributing traits to identify promising genotypes in black pepper were developed with maximum weightage given to yield followed by bulk density, spike length and number of berries. Other traits included in the index are spikes per lateral branch, spike setting, berry size, pericarp thickness, dry recovery early maturity type, *Phytophthora* resistance, nematode resistance, drought tolerance, anthracnose resistance, high piperine and high oleoresin (Table 1a & 1b).

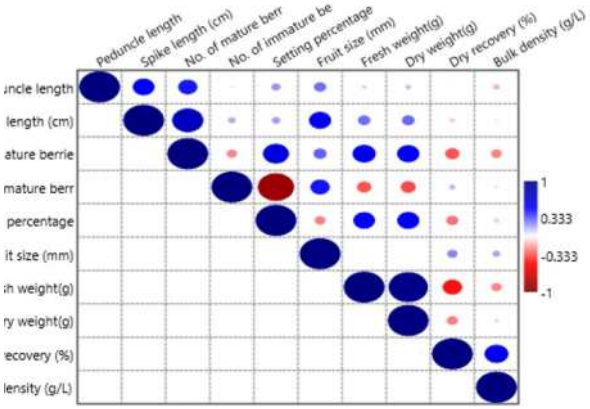


Fig. 3 Phenotypic correlation coefficients for different characters in black pepper accessions

Table 1a: Weighted parameters for yield contributing trait			
Sl. No.	**Traits**	**% weightage**	**Remarks**
1	*Phytophthora* resistance	30	
2	Nematode resistance	20	
3	Drought tolerance	15	
4	Anthracnose resistance	10	
5	High piperine	15	
6	High oleoresin	10	> 5.49%
	Total	100	> 14 %

Table 1b: Additional weighted parameters			
Sl. No.	**Traits**	**weightage**	**Remarks**
1	Yield	25	Dry yield > 3kg will be given 25 %
2	Bulk density/litre weight	15	> 600g will be given 15%
3	Dry recovery	15	> 35 % will be given 15 %
4	Spike length	10	> 15 cm will be given 10 %
5	Spike setting	10	Compact setting >85 % will be given 10 %
6	Spikes per lateral branch	08	> 7 will be given 08 %
7	Berry size	08	Bold > 4.26 will be given 08 %
8	Early maturity type	05	Early maturing < 7 months will be given 5 %
9	Pericarp thickness	04	Thinner pericarp <1.30 will be given 4 %
	Total	**100**	

Yield Relative to Environment/year Maximum (YREM) as a criterion for selecting best genotype

Pooled analysis was performed for yield data of three years, significant mean squares due to genotypes, years and genotypes × year interaction (GYI) indicates substantial differences for yield and their differential response to year-to-year variation. Average Yield Relative to Environment/Year Maximum was calculated for 10 genotypes and it ranged from 0.24 to 0.95. Highest YREM was recorded by HP 2173 followed by OPKM.

Participatory plant breeding

Two promising genotypes with long spike, bold berries and morphological marker on berries were identified from Sirsi (Fig.4). Quality analysis of few farmer's collections revealed highest essential oil (4.3 %) and oleoresin (8.6 %) in Huchmensu and high piperine (5.5 %) in Kuthiravally.

Fig.4: a. Promising line with long spike (Master Kere); b. Bold berries (KK king); c. morphological marker on berries (Kudurebala).

Validation of gene specific primers for expression studies related to candidate genes of piperine biosynthesis

BAHD acyltransferase (piperine synthase) is the most important downstream enzyme that catalyzes the terminal formation of piperine from piperidine and piperoyl-CoA. The unigene of BAHD acyltransferase was retrieved from NCBI and Uniprot database. Local BLAST with *Piper nigrum* chromosome-scale reference genome was done. Most matching sequences with the E-value above e-10 were selected. 63 longest ORF sequences were retrieved and 6 ORF sequences were shortlisted based on the signature motif of BAHD acyltransferase (HXXXD, DFGWG) (Fig. 5). Unique real-time PCR primers were designed, verified and the candidate BAHD isoforms were shortlisted.

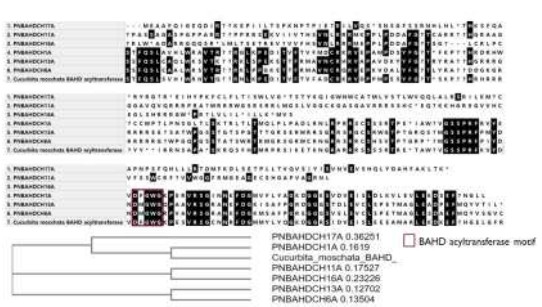


Fig. 5: Multiple sequence alignment & Phylogenetic tree of BAHD isoforms

cDNA library of *Piper nigrum* leaf, stem and 4 stages of berry were constructed for the evaluation of candidate genes and for combined co expression analysis involving whole genome and transcriptome data. The result shows that BAHD-AT gene from Chromosome six showed a relative expression (Fig.6) correlating with piperine content

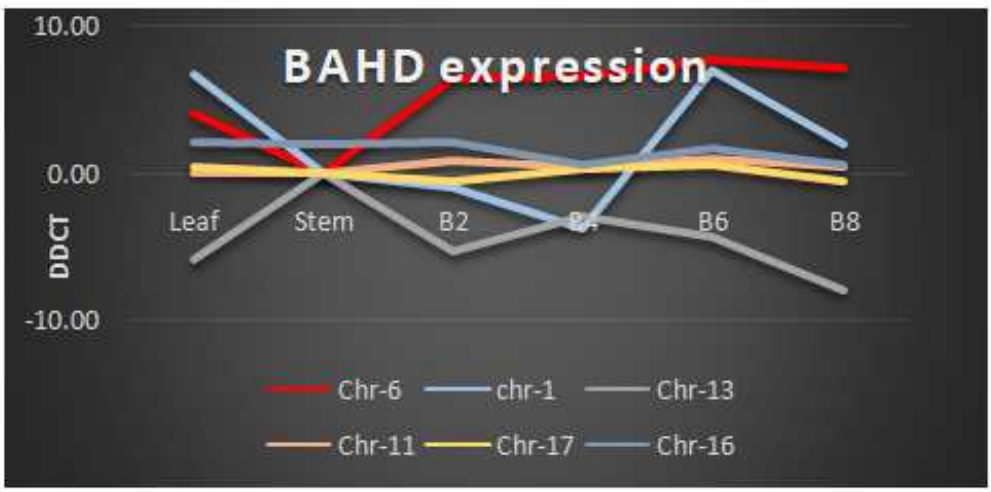


Fig.6 :Differential expression profiles of the 6 BAHD isoforms

In silico analysis of BAHD-AT genes

The six BAHD-AT genes were modelled using SWISS MODEL workspace. The template used to build the model of BAHDch1, BAHDch13 and BAHDch6 were retrieved from Protein data bank with ID: 6ZBS, which has the sequence similarity of 34.96%, 34.83% and 35.10% respectively. The selected templates of BAHDch11 has a similarity of 41.44% to 7CYS, BAHDch17 has a similarity of 64.63% to 4GOB, and BAHDch16 has a similarity of 34.82% to 4G22. The structures were validated using Ramachandran plot using the MolProbity program. Molecular interaction of six BAHD isoforms with Piperoylco-A has been understood by molecular docking carried out by Autodock 4.2. Out of the six proteins, only CHR6 BAHD isoform showed negative binding energy (-0.77 kcal/mol) and all other isoforms showed positive binding energy. Figure 7 shows the binding of the ligand molecule piperoyl CoA in the binding site of BAHDCh6 protein.

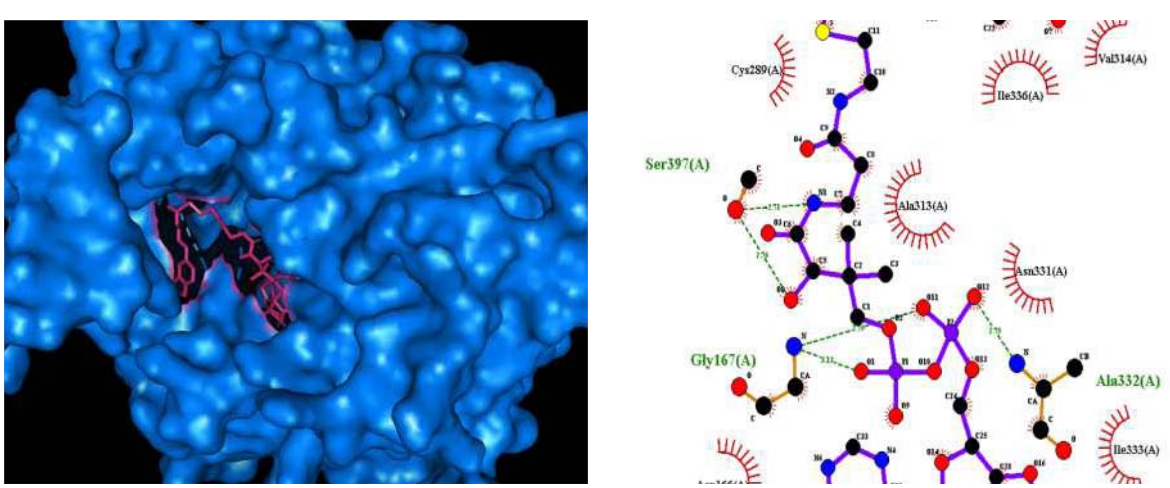


Fig.7:Molecular docking analysis: A) pose view of Ligand molecule Piperoyl CoA (Pink) in the active site of CHR6 BAHD isoform (Blue). B) 2D view of ligand and active site residues, hydrogen bonds are in green dotted lines.

Transcriptome analysis

Rooted cuttings of black pepper genotype (IC 317179) were grown under normal as well as water stressed (15 days stress by withholding water) conditions. RNA was isolated from the leaves and Illumina HiSeq 2000 platform was used for the paired-end sequencing. Raw reads were pre-processed using fastqc. De-novo and reference based assembly of drought stressed transcriptome was performed using Trinity and STAR respectively. Transcript expression values were estimated using Salmon while the genes were mapped using HTSeq. Differentially expressed genes and transcripts were identified using edgeR (Fig.8). The significantly differentially expressed genes and transcripts (log fold change >1 and p-value) were shortlisted for validation.

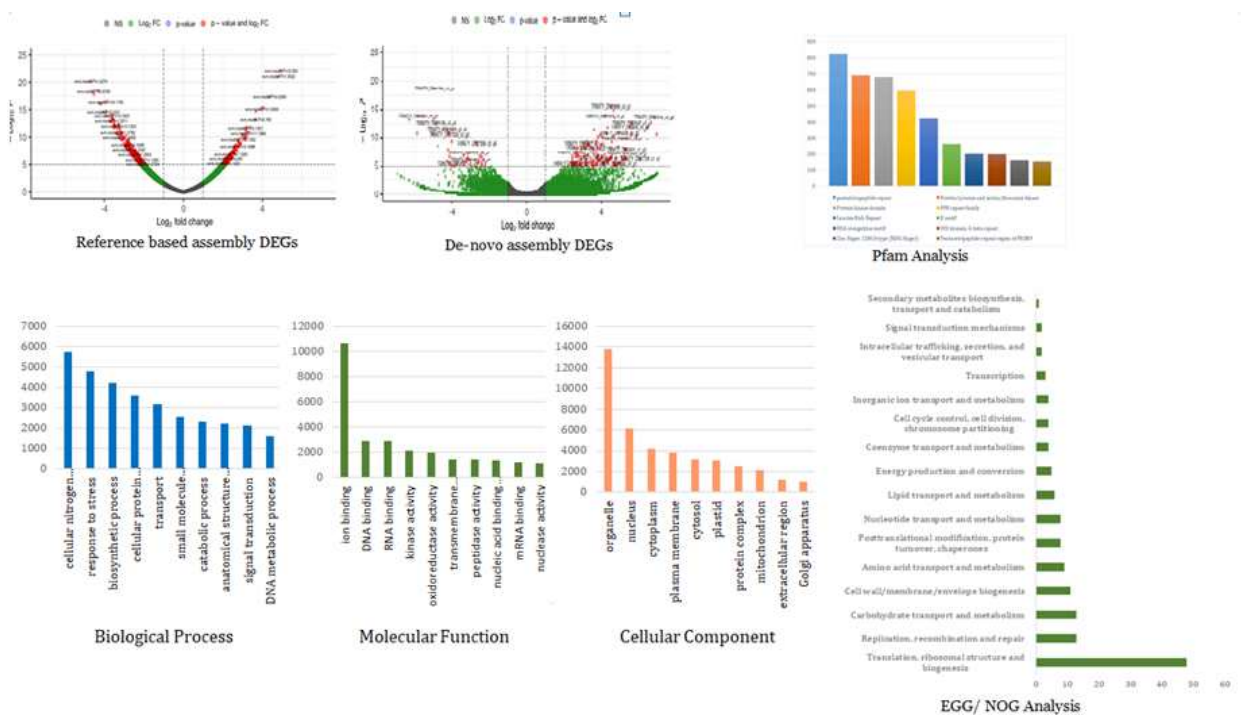


Fig.8 : Results of reference based and de-novo analysis of Black pepper transcriptome

Development of fertigation schedule

The varieties IISR Sakthi and Girimunda recorded maximum yield with drip irrigation @ 8 L with 50 % of RDF applied as fertigation in 24 splits, followed by conventional irrigation @ 8 L of water per day with 100% RDF applied in 3 equal splits as basal dose. Whereas, in variety IISR Thevam, maximum yield was observed in recommended dose of fertilizer with conventional irrigation.

Effect of blanching on drying kinetics, physical and biochemical quality

The drying characteristics of black pepper were analyzed before and after blanching. Blanching was done by dipping the whole pepper in boiling water for 1 min. Blanching had a significant effect on drying rates as the highest drying rates were observed for blanched and sun-dried pepper.

Impact of rainfall on yield parameters

Spiking intensity and berry setting was recorded in 40 plantations in different estates (Madikeri, Virajpet, Somvarpet, Saklespur, Mudigere, Chickkmangalore). Spike intensity ranged from 19.6 to 72.5 per 0.5 square meter canopy area with mean of 32.41%. Spike length (cm) ranged from 7.11 to 15.15 with a mean of 12.25. Berry set percentage ranged from 48.81 to 92.29 percent with a mean of 69.50 per cent.

Recombinase polymerase amplification (RPA) protocol for the detection of *Phytophthora* spp.

A recombinase polymerase amplification (RPA) protocol to detect *Phytophthora* spp infecting black pepper has been developed. The assay has a sensitivity of detecting upto 1 ng of pathogen DNA in black pepper leaf and root extract. The assay was validated with isolates of *P. capsici* and *P. tropicalis* collected from various locations and also infected leaf samples.

Diversity analysis of *Phytophthora* isolates using REP PCR and RAMS analysis

Forty-eight isolates (24 isolates each of *P. capsici* and *P. tropicalis*) of *Phytophthora* spp. infecting black pepper were analyzed using RAMS, REP, ERIC, and BOX PCR primers. The *P. capsici* and *P. tropicalis* isolates were clearly separated into two major clusters and were further separated into four sub-clusters (I & II- *P. capsici* isolates and III & IV- *P. tropicalis* isolates).

Genome analysis of *Phytophthora* isolates

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, Nanopore) sequences. The total assembled genome size of *P. capsici* was 68.2 Mb and *P. tropicalis* was 63.3 Mb. The details of genome assembly are given in the Table 2.

Table 2. Details of genome assembly of *Phytophthora capsici* and *P. tropicalis*

Description	*P. capsici* (05-06)	*P. tropicalis* (98-93)
Scaffold	2117	1393
Min	2020	3235
Max	235340	468356
N50	47533	96026
Total size	**68,239,007**	**63,314,208**
GC Content	50.65	50.03

Identification and analysis of effector genes

The RxLR 29 gene was cloned from *P.tropicalis* isolate 98-93 and sequenced. The gene was 827 bp long, coding for 275 amino acid protein. Blast analysis of the RxLR effector protein (RxLR29) showed 31.96% similarity with RxLR effector protein PSR2 of *P. sojae*. A three-dimensional (3D) protein structure was constructed using SWISS-MODEL workspace (Fig. 9a). The modeled structure was validated using the Ramachandran plot from the MolProbity program. All amino acid residues of the modeled protein fit within the Ramachandran plot allowed regions (Fig. 9b).

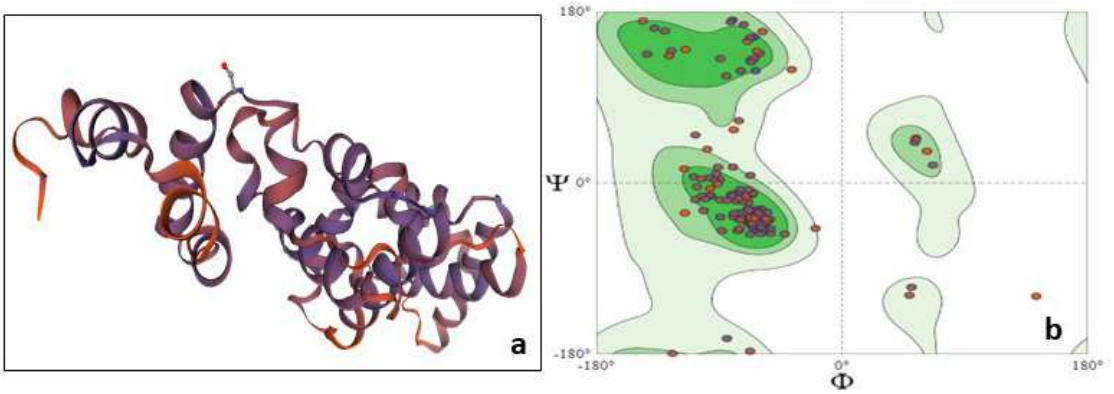


Fig. 9:Predicted structure of the RxLR 29 protein (a) and Ramachandran plot of modelled RxLR29 protein (b)

In vitro evaluation of fungicides against *Phytophthora capsici* and *P. tropicalis*

Fifteen fungicides representing different chemical groups and toxicity classes were evaluated *in vitro* at five different concentrations against *P. capsici* and *P. tropicalis* isolates, 05-06 and 98-93 by poisoned food technique. The effect of fungicides on mycelial growth, sporangial production, and ability to induce hyphal aberrations were investigated. Among the 15 fungicides tested, Bordeaux mixture, copper oxychloride, fluopicolide-propamocarb, cymoxanil-mancozeb, iprovalicarb-propamocarb, and metalaxyl-mancozeb showed complete mycelial growth inhibition and reduced the sporangial production under *in vitro* conditions.

Root colonization studies with temperature-tolerant *Trichoderma* isolates

Endophytic colonization of temperature tolerant isolates of *Trichoderma viz. T. asperellum* (NAIMCC 0049), *T. erinaceum* (APT1), *T. atroviridae* (APT 2), *T. harzianum* (KL3), *T. lixii* (KA15) and *T. asperellum* (TN3) were studied under *in vitro* conditions. Intercellular colonization by the mycelium was observed in the cortical zone, later advancing to the vascular system followed by intracellular colonization. Colonization capacities of the test isolates varied with isolates and the isolate, *T. atroviridae* colonized the most and the least was observed in *T. asperellum* (Fig 2).

Evaluation of the antagonistic potential of temperature-tolerant *Trichoderma* isolates

Six *Trichoderma* isolates were tested for antagonism against *Phytophthora capsici* and *Pythium deliense* on PDA. The isolates inhibited the radial mycelial growth of *P. capsici* and *P. deliense* with the percentage inhibition ranging from 75.3 to 82.2 % for *P. capsici* and 73.8 to 96 % for *P.deliense*, respectively. The isolates which showed maximum inhibition under *in vitro* conditions (IISR NAIMCC 0049 and IISR APT2) were evaluated *in vivo* under greenhouse conditions. Plants treated with only *P. capsici* got infected (80-85%) on the third day after inoculation and died within seven days. In the case of plants treated with both *Trichoderma* and *P. capsici*, the disease incidence ranged from 10-15 and 5-10 % for the strains IISR NAIMCC-0049 and IISR APT2, respectively. Whereas, the disease incidence ranged from 5-8 and 3-6 %, respectively, in black pepper plants inoculated with *P. deliense* and *Trichoderma* strains, IISR NAIMCC 0049 and IISR APT2.

Arbuscular mycorrhizal colonization to induce defense responses against *Phytophthora capsici* infection

The effect of arbuscular mycorrhizae colonization of black pepper plants to induce defense responses against *P. capsici* infection was studied under greenhouse conditions. The leaf and root samples were collected from 0 to 3 days after inoculation (DAI) *P. capsici* at 24 h intervals and were subjected to qPCR analyses. The findings indicate that the AM pre-inoculation up regulated pathogenesis-related genes viz., cAPX, osmotin,and β-1,3-glucanase, phenylalanine ammonia-lyase and NPR 1 in black pepper leaves and roots upon *P. capsici* inoculation (Fig.10). Sole inoculation of *P. capsici* also positively influenced the copies of most genes studied.

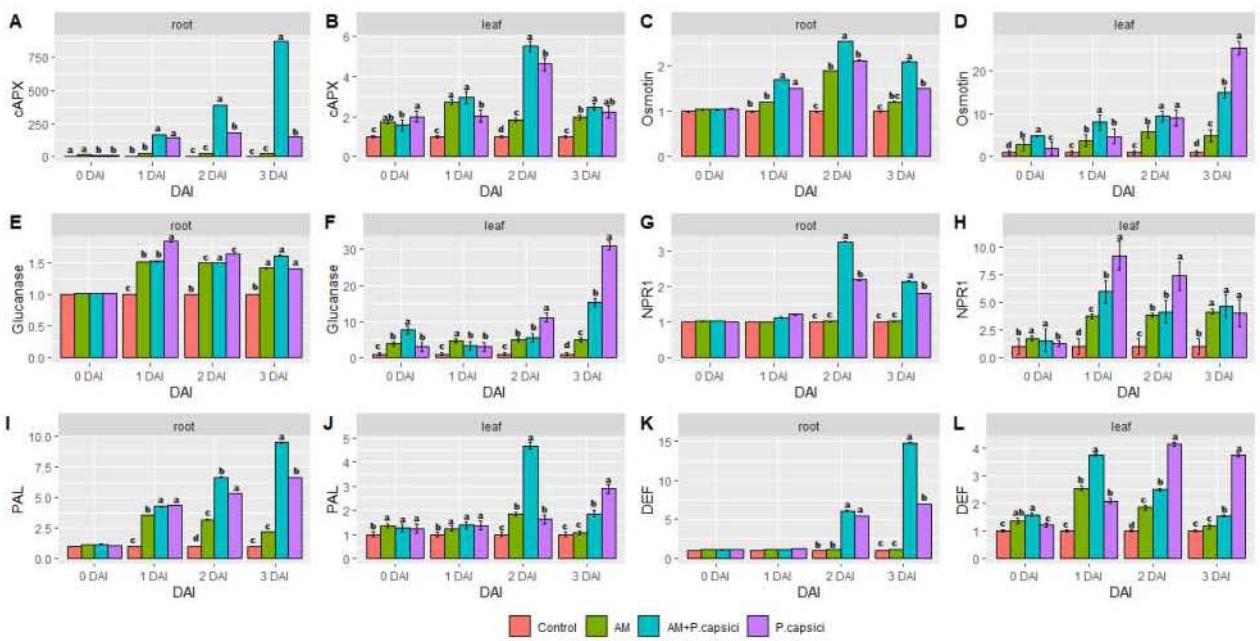


Fig.10:. Differential expression of cytosolic ascorbate peroxidase (cAPX), osmotin gene, glucanase gene, NPR1gene, PAL gene, DEF gene in roots and leaves.

Recombinase polymerase amplification-lateral flow assay (RPA-LFA) for the detection of piper yellow mottle virus (PYMoV)

Two rapid assays based on the recombinase polymerase amplification (RPA) coupled with lateral flow assay (LFA) using (i) 6-carboxyfluorescein (FAM) labeled nfo probe and biotin-labeled reverse primer and (ii) FAM labeled forward and the biotin-labeled reverse primer was developed for the detection of PYMoV using TwistAmp DNA amplification reagents. Crude extract from the infected plant was used as a template. The formation of a coloured line at the test line of a lateral flow device was considered positive for PYMoV (Fig. 11). The entire process from sample preparation to visualization of results could be completed in about 30 min and this assay is ten times more sensitive than PCR. The assays were validated using field samples of black pepper and mealybug vectors. The assay will be useful to identify virus-free black pepper mother plants for the production of virus-free plants.

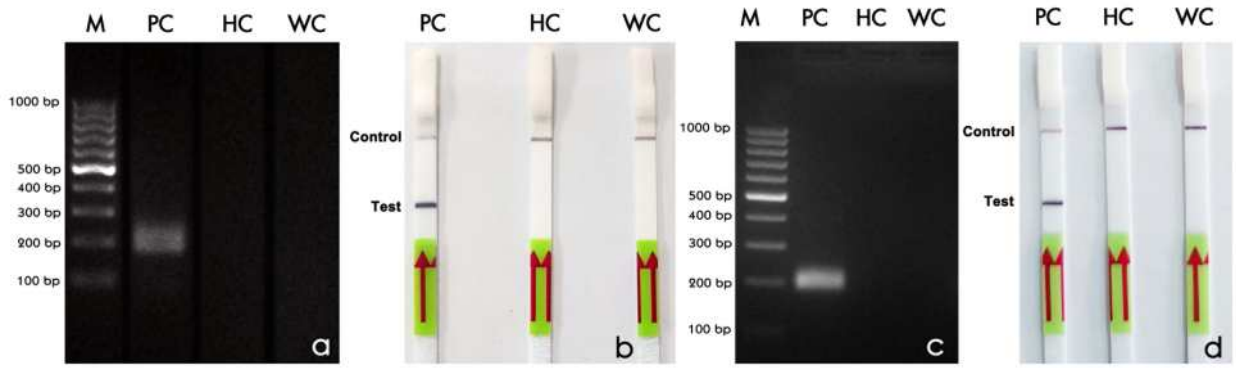


Fig. 11: Detection of piper yellow mottle virus infecting black pepper through recombinase polymerase amplification (RPA) (a, c) and RPA-coupled with lateral flow assay (RPA-LFA) (b, d).

Cloning, *in vitro* expression, and production of recombinant antiserum against coat protein gene of cucumber mosaic virus (CMV)

The coat protein gene of cucumber mosaic virus (CMV) infecting black pepper was amplified by reverse transcription-polymerase chain reaction (RT-PCR) using specific primers and cloned into the prokaryotic expression vector pRSET A. The resulting recombinant plasmids were transformed into *Escherichia coli* BL21 DE3 and BL21 DE3 pLysS strains and induced with IPTG to express the coat protein at the expected size of 23 kDa. The recombinant protein was purified under denaturing conditions using urea buffer on a Ni NTA spin kit (Qiagen, Germany). The purified protein was renatured via successive dialysis against decreasing concentrations of urea buffer (6 M, 4 M, 2 M and 1 M) and the presence of the recombinant protein was confirmed through SDS-PAGE analysis (Fig. 12). The dialyzed protein in 1 M urea buffer was used for antiserum production in rabbits. The antiserum collected five, seven, and nine weeks after the first immunization showed a specific reaction against the antigen both in ELISA (OD values ranged from 0.63 to 1.13) and western blotting.

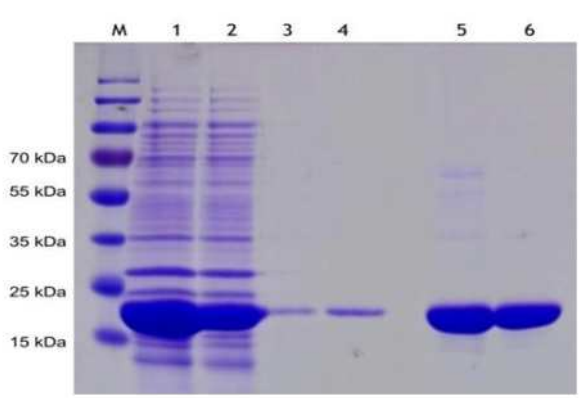


Fig. 12: Purification of the cucumber mosaic virus recombinant coat protein using Ni-NTA column. Lane 1 & 2: cell lysates in buffer B; Lane 3 & 4: flow-throughs in buffer C; Lane 5 & 6: recombinant protein eluate 1 & 2.

Curing of mycoviruses associated with *Fusarium concentricum*

The mycoviruses associated with *Fusarium concentricum* could be cured using ribavirin (concentration >75 µM/ml) amended PDA. Further, *F. concentricum* harbouring viruses showed reduced mycelial growth and conidial production compared to the isolate without mycoviruses.

Screening of low-risk insecticides against *Ferrisia virgata*

Seven low-risk insecticides viz., Abamectin, Clothianidin, Spiromesifen, Spirotetramet

Triflumezopyrim, and chlorfenapyr at three different doses were screened for their efficacy against the black pepper mealy bug *Ferrisia virgata* under *in vitro* conditions. Spiromesifen 22.9 SC, Triflumezopryrim 10 SC (1ml/L), and Spirotetramat (1.5 ml/L) and Clothianidin 50 WDG (1 g/L) were found to be very effective against mealy bugs.

Screening of new generation low-risk insecticides against pollu beetle *(Lanka ramakrishnai)*

Low-risk insecticides such as chlorantraniliprole, flubendiamide and spinetoram) at two doses (0.3 & 0.5 ml/L) along with quinalphos (2 ml/L) as control were evaluated for their efficacy against pollu beetle under field conditions at Peruvanna- muzhi. All the tested low-risk insecticides were found to be more effective than quinalphos in controlling the pest.

Efficacy of new nematicides against burrowing nematode

Nematicides such as fluopyram (0.5 ml/L) and fluensulfone (20 g/plant) along with carbosulfan (2 ml/L) as control were evaluated for their efficacy against burrowing nematode (*Radopholus similis*) under field conditions at Peruvannamuzhi. The application of fluopyram twice a year (pre- and post-monsoon) was found to be most effective in reducing the nematode population.

CARDAMOM

Genetic resources

Six hundred twenty-five cardamom accessions consisting of 423 accessions from Appangala, 102 from Pampadumpara, 41 from Mudigere Station, 56 from Sakaleshapura and 3 from ICRI, Myladumpara are being maintained in National Active Germplasm Site (NAGS) at ICAR-IISR, Regional Station, Appangala. Three unique accessions, SKP388, SKP389 and SKP390 were submitted from ICRI, RS, Sakaleshapura. Characterization of 85 field gene bank accessions was carried out based on different morphological and yield traits. Essential oil content of fifty-three germplasm accessions ranged from 5.50 % (IC 349581) to 9.57 % (IC 547214) and oleoresin content ranged from 2.36 (IC349529) to 4.29% (IC547149). Natural incidence of leaf blight and rhizome rot diseases were recorded in 80 accessions and PDI for leaf blight and rhizome rot ranged between 15-30 % and 18- 43 %, respectively.

CVT on farmers varieties

Morphology and yield parameters were recorded from the varieties under trial viz., Arjun, Wonder Cardamom, Panikulangara, Thiruthali, Elarajan, Pachaikkai, Pappalu, Njallani green gold, PNS Gopinath and Appangala 1 (LC). Plant height ranged from 207.77 cm (Wonder cardamom) to 297.77 cm (Panikulangara green bold no. 1). Highest panicle length of 79.38 cm was recorded in Panikulangara green bold no. 1 which was on par with variety Thiruthali (70.33 cm). Among the varieties, highest dry yield per plant was recorded in variety, Thiruthali (0.318kg /plant) followed by variety, Panikulangara green bold no.1 (0.247 kg/plant). Rhizome rot incidence ranged from 18.89 to 30.00 % and its maximum incidence was recorded in variety, Patchaikkai. The leaf blight incidence ranged from 16.67 to 22.22 % and the varieties, Njallani green gold and Elarajan were found to be susceptible. Average percent infestation of thrips among these varieties ranged between 2.08 – 28.87%

and of capsule borer ranged between 1.00 – 6.88%

CVT on hybrids

CVT on hybrids of small cardamom consists 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-14from Pampadumpara along with national check Njallani green gold. Among the hybrids under trial highest fresh as well as dry yield per plant was recorded in the hybrid PH 13 (6.30 kg/plant and 1.18 kg/plant respectively) which was on par with PH-14 and Bold × IC 547219 where the dry yield per plant was 0.94 and 0.82 kg/plant, respectively. Cardamom capsules after curing were subjected to grading and different grades obtained in each hybrid is represented in Fig. 13. Among the hybrids, the hybrid PH-13 (Fig.14) which recorded high yield was having highest percentage of first grade capsules (8 mm and above) (65.81 %), which was followed by PH-14 (62.85 %) and Bold × IC 547219 (52.98 %). Rhizome rot incidence ranged from 17.77 to 23.33 % and the maximum PDI was recorded in hybrid (GG×NKE 19) × Bold and leaf blight incidence ranged from 12.22 to 22.22 % and maximum PDI was recorded in SHC 1 and SHC 2. Average percent infestation of thrips on capsules ranged from 2.19 – 11.93 % and of capsule borer ranged between 0.32 – 4.10%.

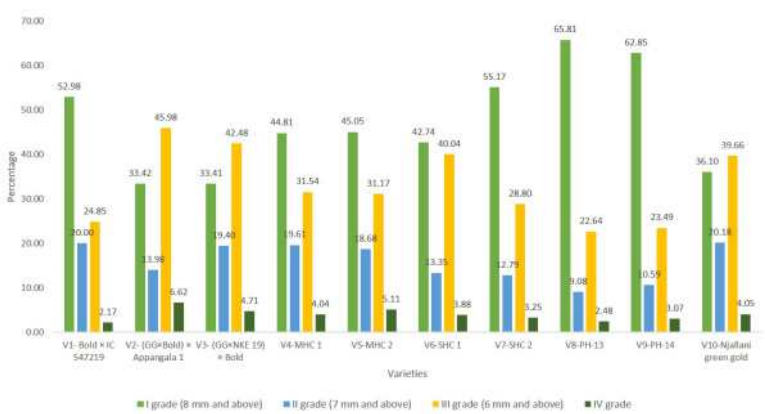


Fig. 13: Different grades of cardamom capsules from the hybrids under trial

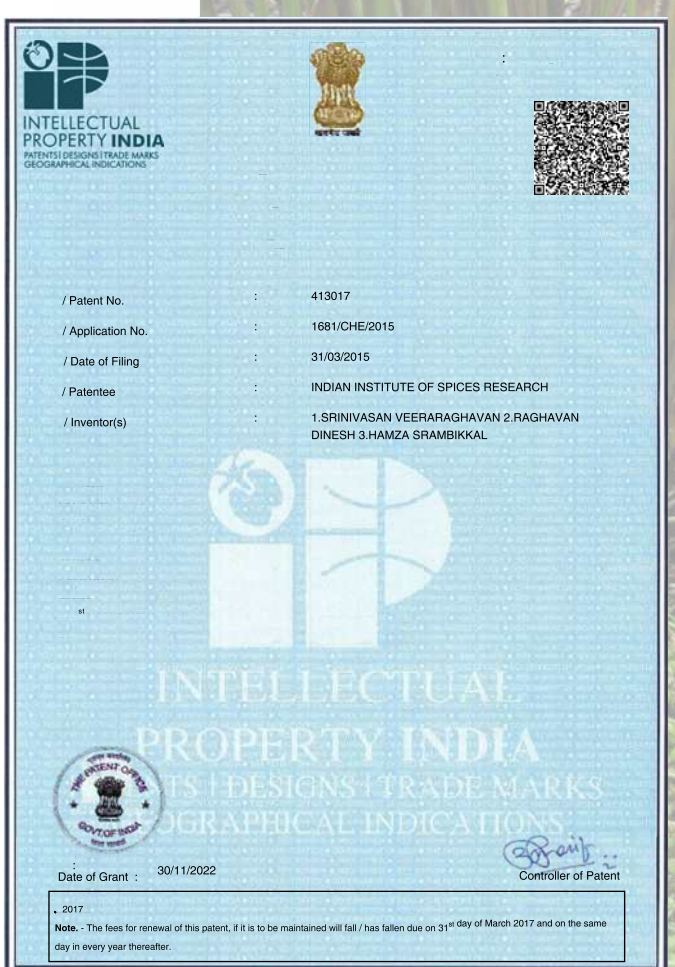
Fig.14:Yielding clump, fresh and dry capsules of high yielding hybrid PH 13

Multi-location trial on leaf blight tolerant lines

Five leaf blight tolerant genotypes *viz*., IC – 349650 IC – 547222, IC – 547156, IC – 349649, IC – 349648 along with resistant checks: Appangala 1, *Njallani* Green Gold and susceptible check - IISR Vijetha. Disease incidence ranged from 11.11 - 21.11 % and maximum disease incidence was recorded in IISR Vijetha.

Micronutrient formulation gets patent

The institute was awarded with a patent for the Micronutrient composition for Cardamom (patent No: 413017) (Fig.15). The designer micronutrient formulation helps to overcome micronutrient deficiencies and meet the physiological and metabolic requirements cardamom. The technology has been successfully field tested and commercialized. The use of micronutrient increases the yield by 10 to 25% and improves the health and vigor of the plants. The formulation is water soluble and compatible with common straight or complex fertilizers.


INTELLECTUAL PROPERTY INDIA
PATENTS | DESIGNS | TRADE MARKS
GEOGRAPHICAL INDICATIONS

/ Patent No. : 413017

/ Application No. : 1681/CHE/2015

/ Date of Filing : 31/03/2015

/ Patentee : INDIAN INSTITUTE OF SPICES RESEARCH

/ Inventor(s) : 1.SRINIVASAN VEERARAGHAVAN 2.RAGHAVAN DINESH 3.HAMZA SRAMBIKKAL

Date of Grant : 30/11/2022

Controller of Patent

Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on 31st day of March 2017 and on the same day in every year thereafter.

Fig.15: Patent for the micronutrient composition for Cardamom

Evaluation of genotypes for yield and quality under moisture stress

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. Moisture stress was imposed in summer from February to April 2022 by withholding irrigation. The control block was irrigated by sprinkler (25mm) once in 12-15 days interval. Plant height (cm), number of non yielding tillers per clump, total number of tillers, number of panicles, panicle length (cm), number of capsule per panicle and yield (kg/ha) were reduced under stress situation.

Accession IC 584058 recorded higher yield in control (619.09 kg/ha) and stress condition (386.45 kg/ha), followed by GGxNKE 12 (492.71 kg/ha) in control and GGxNKE 12 (415.1 kg/ha) under stress. Per cent bold capsule (7mm) ranged from 63.57% (IC 584058) to 52.78% (HS-1) in control and 69.96 % (HS1) to 63.27% (Cl-668) under stress.

Table 3: Drought parameters analysis in different genotypes

	Drought Susceptibility Index (DSI)	Drought tolerance efficiency (DTE) (%)
IC 349537	0.89	70.71
IC 584058	0.98	67.56
GGXNKE-12	0.99	67.23
IC 584078	0.91	69.94
CL 668	1.18	61.25
HS-1	1.11	63.33
APG-1	0.91	70.01
IC 584090	1.12	63.04

Multiplex PCR assay for pathogen detection

Multiplex PCR assay was developed to simultaneously detect *Phytophthora* spp., *Pythium vexans*, and *Rhizoctonia solani* pathogens infecting cardamom using primers designed from the conserved ITS regions of pathogens. The assay could successfully detect the pathogens both singly and in combinations and does not show any cross-reaction with other fungal pathogens of cardamom.

Identification of genotypes for moisture stress through multi-location evaluation

Eight genotypes IC 349537, IC 584058, GG×NKE-12, IC 584078, CL 668, HS-1, APG-1 and IC 584090 were evaluated under both irrigation and moisture stress in four locations viz., ICAR-IISR RS, Appangala, ICRI, Myladumpara , ZAHRS, Mudigere and ICRI RS, Sakleshpura over three years 2019-2022. Pooled analysis for yield over four locations and three years indicated that genotype IC349537 recorded highest yield under both irrigated and moisture stress condition followed by check APG 1(Table 3). IC 349537 recorded the minimum Drought Susceptibility Index (DSI) and maximum Drought Tolerance Efficiency (DTE) (%) of 0.89 and 70.71 %, respectively indicating that the genotype performs well under moisture stress condition (Table 3). The drought tolerant genotype IC 349537 was recommended for release as IISR Manushree (Fig.16).

Fig. 16: Drought tolerant genotype IC 349537

Survey for rhizome rot disease and biocontrol agents

Survey for the second consecutive year in major small cardamom-grown regions of Karnataka showed the rhizome rot disease incidence from 25-40%. Infected samples from different locations showed the presence of *Rhizoctonia solani* and *Fusarium oxysporum*. Six potential biocontrol agents belonging to *Bacillus* spp. were also collected from the different cardamom fields. Among the 27 *Bacillus* spp. screened, *B. safensis*, *B. amyloliquefaciens* showed higher inhibition to *R. solani* and *F. oxysporum*.

Development of RPA assay for cardamom mosaic virus (CdMV)

A rapid assay based on the reverse transcription recombinase polymerase amplification (RT-RPA) was developed for the detection of cardamom mosaic virus (CdMV) causing mosaic disease of cardamom using crude extract and primers designed based on the coat protein gene of the virus. The RT-RPA assay was 10^5 times more sensitive than RT-PCR. The assay was validated using CdMV-infected small cardamom samples from different regions. The developed assay will be useful for the identification of virus-free cardamom plants for propagation to produce virus-free suckers for planting.

Dose optimization of low-risk insecticides against shoot and capsule borer (*Conogethes sahyadriensis*)

Three low-risk insecticides (spinosad, flubendiamide and chlorantraniliprole) and a combination treatment of spraying chlorantraniliprole and spinosad alternatively along with a standard check (quinalphos) were screened under field conditions at the ICAR-IISR-Regional Station, Appangala, for dose optimization (0.3, 0.5 and 1.0 ml/L) against shoot and capsule borer infesting cardamom for the second consecutive year. The results indicated that all the tested low-risk insecticides were effective in controlling the pest at the highest dose tested (1ml/L).

GINGER

Genetic Resources

Six hundred and sixty-eight ginger accessions have been maintained in the field gene bank. In collaboration with ICAR-NBPGR, New Delhi, 26 accessions of Zingiberaceous spices, which includes 18 species under the genera *Amomum*, *Alpinia*, *Boesenbergia*, *Curcuma*, *Globba*, *Hedychium* and *Zingiber* were collected from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam. Eighteen accessions of gingers, which includes *Curcuma inodora*, *C. caulina*, *C. mutabilis*, *Zingiber neesanum* and *Z. diwakarianum* were collected from Konkan region of Maharashtra in the forest areas in Raigad, Ratnagiri, Sindhudurg (Konkan region) and Kolhapur, Sangli, Satara (Western Maharashtra) (Fig.17).

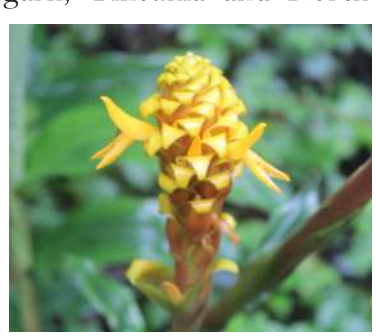
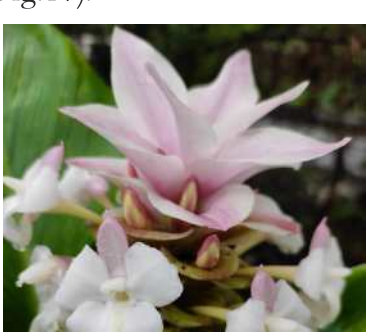


Fig.17 Zingiber diwakarianum

Curcuma inodora



Curcuma caulina

Gingerarium

"Gingerarium" (Fig.18) is an initiative for conserving ginger (*Zingiber officinale* Rosc.) accessions and related species collected from different parts of the country. The garden has been planned as a knowledge centre on Zingibers for researchers, academicians and students. Besides germplasm accessions, the released varieties and farmer's varieties of ginger are also being conserved.

Fig.18: GINGERARIUM

Evaluation of mutants

Nine genotypes (five from ICAR-IISR, four from OUAT and one from IGKV) along with check, IISR Varada were evaluated during 2021-2022. Maximum yield was recorded in R 1.25/4 (50.85 t/ha) and V_1E_4 1 (46.35 t/ha).

Colchicine induced polyploidy

Successful induction of tetraploid (2n=44) was achieved in red ginger, through in vivo colchicine treatment. Emerging rhizome buds were exposed to a range of colchicine concentrations (0.00, 0.05, 0.10, 0.15 & 0.2) for 24 and 48 hrs. Putative polyploids were identified based on the altered morphology, particularly robust, vigorous plants with expanded dark green leaves. The ploidy level of the selected plants was ascertained using flow cytometric technique. The identified tetraploids were compared with the diploids for morphological and physiological characters. Morphological characters, especially leaf

parameters, displayed a substantial increment in the tetraploid genotype. Significant increase in the stomatal length and width was also observed in tetraploids. Tetraploids showed a significantly lower stomatal frequency than diploids. Mean chloroplast count of the tetraploids were higher than the diploids.

Organic farming

Under the evaluation of production systems on ginger, integrated management (75% organic + 25% inorganic) recorded maximum yield of 14.9 t/ha on par with organic (25%) + inorganic (25%) + seed treatment with Beejamrit (BA), Ganajeevamrit (GJA) and Jeevamrit (JA) (13.3 t/ha). The B:C ratio was 1.91 in INM (25% organic + 25% inorganic + seed treatment with Beejamrit (BA), Ganajeevamrit (GJA) and Jeevamrit (JA)) followed by 75% Organic +25% inorganic (1.70).

Spray schedule optimization of low-risk insecticides against shoot borer

Low-risk insecticides such as chlorantraniliprole (0.01%), flubendiamide (0.02%), and spinosad (0.0225%), which were found to be effective earlier and a combination treatment of spraying chlorantraniliprole and spinosad alternatively were evaluated 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. The results indicated no significant difference in efficacy among the insecticides at the tested spray intervals. Estimation of harvest time residues of insecticides indicated that except flubendiamide, all the other insecticides (chlorantraniliprole and Spinosad) were below the quantifiable limit. In the case of flubendiamide, the residues were found to be less (0.016 mg/kg) and below the EU MRL value (0.02 mg/kg) when sprayed at 21 days intervals.

MANGO GINGER

Evaluation of mango ginger genotypes

Nine entries, two from ICAR-IISR, two from OUAT, three from NAU, one each from Dholi and IGKV, respectively along with check, Amba were evaluated during 2019-2020, 2020-2021 and 2021-2022. In the third year of evaluation (2021-2022), Acc. 347 recorded the maximum yield (53.75 t/ha), followed by CAM 2 (53.33 t/ha), which were statically on par. The pooled data over three years indicated maximum yield in Acc. 347 (52.78 t/ha) followed by NVMS 2 (44.73 t/ha). In coordinated varietal trials (CVT), maximum yields were recorded with Acc. 347 and CAM2 (Fig.19).

Fig.19 Rhizome characters of promising mango ginger genotypes

TURMERIC

Genetic resources

One thousand four hundred and four Curcuma accessions are being maintained in the field gene bank.

Phytochemicals, nutraceuticals and bioactivity profiling of different varieties

Studies on phytochemical composition, proximate, mineral and bioactivities were undertaken in 17 Indian turmeric genotypes (Rajendra Sonia, Ranga, Pant Peetab, Dugirala Red, Pitambar, NDH 1, NDH 98, Sona, Kanti, Resmi, Rajapuri, Varna, Suroma, Santra, Salem Local, Mydukkur, and Rajapuri). The genotypes recorded 4.0 to 6.4 % essential oil, 5.51 to 15.65 % oleoresin and 0.25 to 6.41 % curcuminoids. GC-MS analysis revealed 28 compounds with significantly high ar-turmerone (38.6%), curlone (18.07%) and β-sesquiphellandrene (10.79%). The proximate (moisture, ash, protein, fat, and carbohydrates) and mineral (Cu, Mn, Fe, Zn, K, Ca, Mg, P) composition of NDH 1, Rajendra Sonia, and Kanti showed the suitability of these varieties as an alternative source of nutritional supplement. The *in vitro* antioxidant activity by inhibiting DPPH (27.34 µg/ml to 53.11 µg/ml) and in vitro anti-diabetic activity by inhibiting α-glucosidase (32.26 µg/ml to 58.72 µg/ml) proved the use of turmeric in treating life-style diseases.

Screening of genotypes against leaf blotch

206 turmeric genotypes were screened for leaf blotch (*Taphrina maculans*) tolerance under natural epiphytotic conditions. Among the genotypes, 32 breeding lines (which includes seedling progenies and promising selections) were categorized as resistant.

Identification of superior genotypes for colour characteristics

21 turmeric genotypes were evaluated to assess the genotype-genotype x environment influence on colour parameters across three contrasting production environments *viz.*, vertical farming, green house and field conditions. The pooled analysis of variance revealed highly significant variations between genotypes, locations, and genotypes by environment (G×E interaction) for all the colour parameters. The correlation between colour values L*, a*, b*, YIE (Yellowness index) with curcuminoids revealed that in all the three production environments, a* value had significant positive correlation (0.74-0.84 %) with curcuminoids. A two-dimensional GGE biplot was generated using the first two principal components (axis 1 and axis 2), which revealed that the genotypes Acc. 379 and Acc. 849 were stable across environments with low curcuminoids (Fig.20).

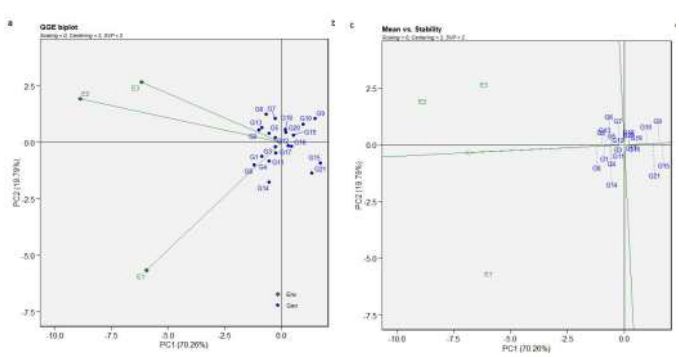


Fig.20: A. GGE Basic plot for a* redness index; B. Mean performance v/s Stability Biplot for a* redness index

CVT on high yield and high curcumin genotypes

Eight entries were evaluated for yield and curcuminoids along with three checks during 2021-2022. Significantly high fresh yield was recorded in IISR Pragati (37.70 t/ha). Maximum curcuminoids content of 5.28% was recorded in CL 272.

CVT on light yellow colour turmeric for specialty market

Nine entries were evaluated for yield along with two checks (one national and one local) during 2021-2022. Maximum fresh yield was recorded in Acc 849 (39.58 t/ha) followed by Acc. 1545 (36.50 t/ha), which were on par.

Genome wide association analysis (GWAS) for important agronomic traits

Genome wide association analysis was carried out to obtain SNPs linked to valuable agronomic characters like curcumin content, rhizome girth and rhizome length in turmeric using 51 genotypes with diverse agro-morphological constitution. The phenotypic observations for these traits were recorded based on field evaluation for two years. The high quality 30438 SNPs filtered based on < 10% of missing data and > 5% of minor allele frequency obtained from ddRAD based genome sequencing of turmeric were utilized for association analysis. Structure analysis performed for the elucidation of population structure revealed subpopulation kinship matrix with K =3. Association analysis resulted in identification of nine significant MTAs (marker-trait associations) for the three phenotypic traits. The number of significant MTAs per trait were as follows: curcumin content (1), rhizome length (5), rhizome girth (3). Further, 1 Kb sequence containing MTAs were extracted and BLAST analysis was performed against the turmeric reference genome that was assembled at the chromosome level. This revealed the chromosomal location of MTAs.

Organic farming

Twelve turmeric varieties (IISR Prathibha, IISR Alleppey Supreme, Varna, Sobha, Sona, Kanthi, Suvarna, Suguna, Sudarsana, IISR Kedaram, IISR Prabha, IISR Pragati) were grown under 100% organic management system; 75% organic and 25% integrated nutrient management, 50% organic and 50% integrated nutrient management and 100% inorganic management respectively. Organic 100% recorded maximum soil organic carbon, nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc and copper contents. Curcumin (4.6%) and oil (5.6%) content were maximum in 75% + INM 25%. oleoresin content (11.8%) was higher in organic that was on par with INM 50% + 50% (11.6%) (Fig.21).

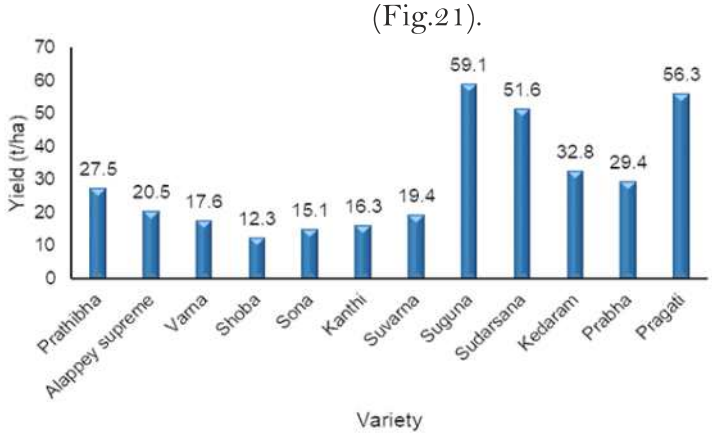


Fig.21: Response of turmeric varieties to 100% Organic farming

Weed management practices under organic production system

Intercropping with cowpea + incorporation of cowpea at 45 DAP, green leaf mulching at 90 DAP and hand weeding at 90 DAP recorded maximum yield (29.5t/ha) and B:C ratio (1.79) in turmeric.

Effect of phosphorus solubilising bacteria (PSB) on soil phosphorus fractions

The microbial solubilization of phosphorus and increase in the amount of plant available phosphorus in soil by two efficient PGPRs was studied with *Bacillus safensis* and *B. cereus* and different levels of sparingly soluble P source on turmeric. At three months after planting, Ca – P contributed the highest percentage share in total P followed by Fe – P, saloid P and Al – P. There was a significant positive correlation between Ca – P and saloid P and a significant negative correlation between Ca – P and Al – P revealing that PSB has solubilized a substantial amount of Ca – P into plant available form.

Land suitability assessment

Land suitability assessment for turmeric in India was analysed taking in to consideration the 5th Assessment Report Scenarios of IPCC. Climatic parameters such as temperature and rainfall and land characteristics such as soil drainage, texture, pH and depth and slope were considered and land suitability assessment was done for 2020 & 2050. The results showed that most parts of Tamil Nadu, Telangana, Andhra Pradesh, Karnataka and some parts of Maharashtra are highly suitable while most of the states except Rajasthan, Uttarakhand, Tripura, Assam, Manipur, Mizoram, parts of Gujarat, Himachal Pradesh, UTs viz. Jammu Kashmir, Leh and Ladakh are moderately suitable for turmeric cultivation (Fig.22).

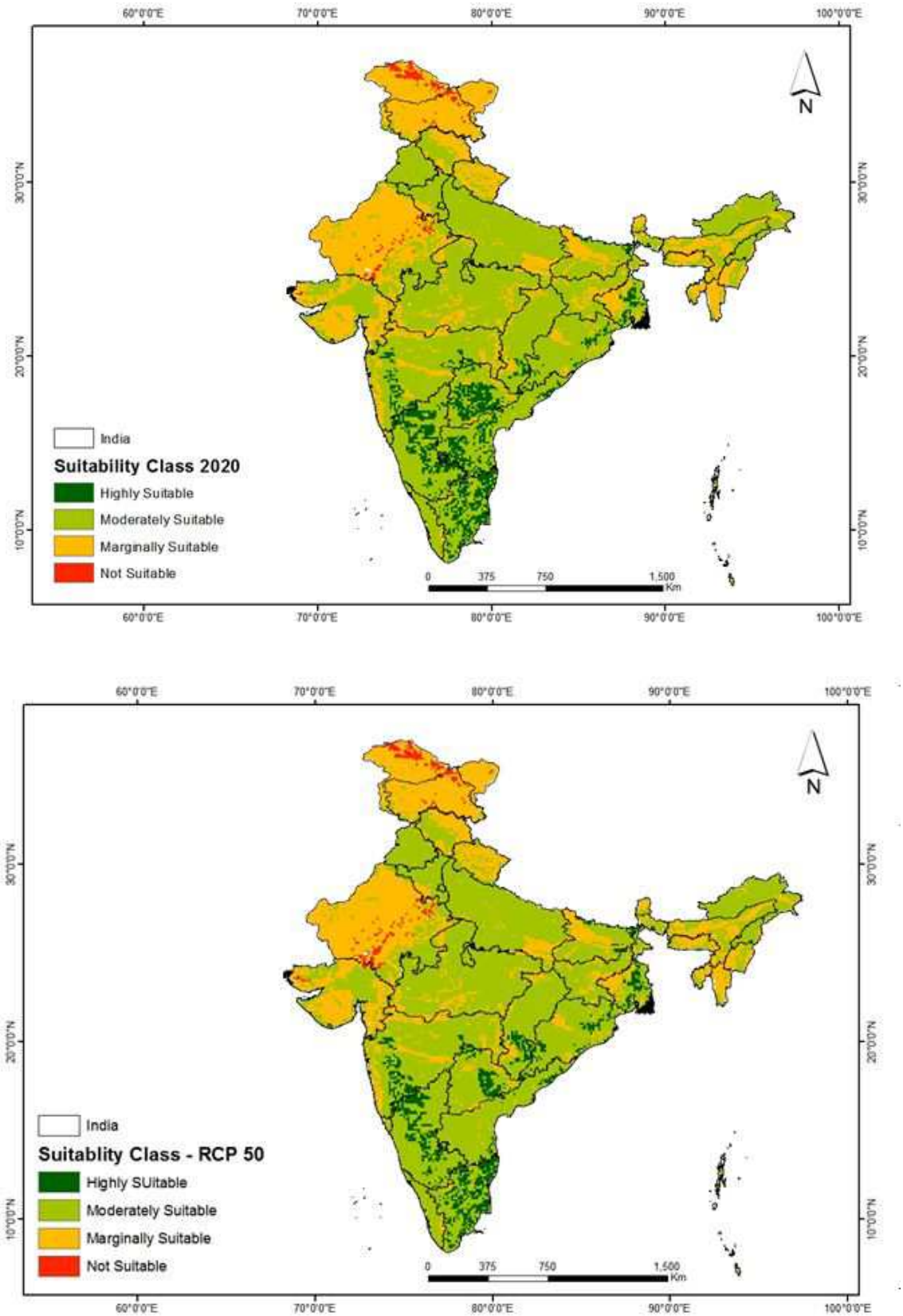


Fig.22: Land suitability assessment in turmeric

Isolation and characterization of non-starch polysaccharide from *Curcuma caesia*

The non-starch polysaccharide fractions of fresh *C.caesia* rhizome showed moderate anti-oxidant activity as determined by DPPH, ABTS and ferrous chelating activity assays. Based on its composition, it was speculated that the polysaccharide present in *C. caesia* is galactoxyloglucan.

Effect of microwave assisted hot air drying on the quality of dried turmeric slices

Microwave assisted hot air drying of turmeric slices (var. Sudarshana) was conducted to determine the quality of dried turmeric slices. Microwave exposure time of 3 min at 620 W showed minimum loss in essential oil and duration of 3 min was taken as optimum for microwave cooking followed by hot air assisted drying at 50°C and the time taken for drying turmeric slices was 14 h compared to fresh samples where the drying time was 16 h.

Greenhouse evaluation of phosphate solubilizing bacteria (PSB)

Application of PSB significantly promoted turmeric growth as evidenced from the enhanced number of tillers, shoot length, number of leaves, dry weight of shoot and root when compared to untreated plants at 60 DAP. Among the treatments, *B. safensis* + *B. cereus* + 75 % P) significantly increased the number of tillers (31.3%), shoot length (43.0%), number of leaves (41.4%), dry root weight (23.7%), dry shoot weight (62.2%) and soil available P (44.8%) compared to application of 75% P (Fig. 23). The treatments *B. safensis* + 75 % P and *B. safensis* + *B. cereus* + 75 % P recorded the maximum yield compared to the sole application of 100% P alone. Among the PSB treatments, available P was found to be significantly higher in the treatments with *B. safensis* + *B. cereus* + 75 % P, *B. safensis* + *B. marisflavi*+ 75 % P and *B. safensis* + 75 % P .

Field evaluation of PSB for soil P solubilization and growth promotion

Combined application of P (75%) and *B. safensis* registered significantly higher rhizome yield of turmeric (Fig. 23). With regard to available soil P, the levels were significantly higher in all the treatments involving combined application of *B. safensis* with 50% or 75% or 100% P. Higher microbial activity in *B. safensis* treatment was confirmed in *B. safensis* + 75% P compared to absolute application of P, as evidenced by higher dehydrogenase and acid phosphatase activities.

Fig. 23. Effect of shortlisted PSB on yield of turmeric clump under field condition (2021) [T1-Control; T2- Bacillus safensis**; T3-** B. safensis **+ 50% P; T4-** B. safensis **+ 75% P; T5-** B. safensis **+ 100% P; T6- 100% P]**

Evaluation of PGPR for Zn solubilization potential

Evaluation of multi-trait PGPR, *Bacillus safensis* for plant growth promotion and Zn solubilization in turmeric under greenhouse conditions showed that combined application of Zn -5 ppm (source –ZnO) + *B. safensis* was found to be superior with an increase in organic carbon, available nitrogen, etc. and microbial parameters like microbial biomass C, N, and dehydrogenase enzyme activity in soil. The rhizome yield increased with increasing levels of Zn applied either alone or in combination with PGPR. Also, higher rhizome Zn concentration was observed in the treatment with *B. safensis* alone (41.3 mg/kg) and with combined application of chemical Zn and *B. safensis* (45.7 mg/ kg).

Field evaluation of *Metarhizium pingshaense* against shoot borer

The efficacy of the *M. pingshaense* against shoot borer infesting ginger and turmeric was carried out for the second year. The fungus was tested at three different doses (10^5, 10^6& 10^7 conidia/ml) along with an insecticide control, chlorantraniliprole (0.01%) at Chelavoor, at a spray interval of 21 days. Spraying the fungus at 1×10^7 conidia/ml was found effective in managing the pest.

Influence of plant phenology and crop duration on the occurrence of shoot borer

The influence of crop duration and phenology with respect to the seasonal incidence of shoot borer infesting turmeric was studied for the second consecutive year at Chelavoor by recording the incidence of the pest at fortnightly intervals. Two short-duration varieties (IISR-Pragathi and Rajendra Sonya), two long-duration varieties (IISR-Prathiba and Alleppey Supreme), and an extra-long duration variety (ACC. 849) of turmeric were used in this study. The infestation started in the first week of August irrespective of the variety and peaked during the second fortnight of September. This information will be used for crop pest modeling to predict the influence of various parameters on the occurrence of the pest and device pest management solutions.

Residues of low-risk insecticides effective against shoot borer

Low-risk insecticides (chlorantraniliprole, flubendiamide and spinosad), which were found to be effective earlier at two different doses (0.3 and 0.5 ml/l) and a combination treatment of spraying chlorantraniliprole and spinosad alternatively (0.5 ml/l) were screened under field conditions at ICAR-IISR Experimental Farm, Peruvannamuzhi for spray schedule optimization at two different spray schedules (i.e. 15 and 30 days interval) against shoot borer infesting turmeric for two years. Residues of insecticides (chlorantraniliprole, flubendiamide, and spinosad) in turmeric from the spray schedule optimization trial were estimated after harvest. The insecticides were below the quantifiable limit in all the treatments indicating the safety of these insecticides for use in turmeric.

Population dynamics of lesion nematode, *Pratylenchus* spp

Population dynamics of lesion nematode *Pratylenchus* spp., infecting turmeric was studied and its population was recorded at monthly intervals from May 2022 to January 2023. The maximum population was recorded during the month of November while the population was minimum during the month of June.

Reaction of Zingiberaceous hosts to *Pratylenchus* spp

Host range of *Pratylenchus* spp., to nine different Zingiberaceous species (*Hedychium coccineum*, *Curcuma amada*, *A. calearata*, *C. zedoria*,

Z. zerumbet, *C. caesia*, *H. coronarium*, *Alpinia galanga* and *A. hypolancum*) was studied under controlled conditions. The results indicated that all the tested species were highly susceptible to the nematode.

Pathogenicity of *Pratylenchus* spp

The damage potential of *Pratylenchus* spp to turmeric var. Pragati was studied by inoculation of nematode population from 0 to 10000 per plant under controlled conditions. Affected plants showed susceptible reaction with a reproductive factor >1 in plants inoculated with >1000 nematodes per plant.

Management of lesion nematode infecting turmeric under field condition

Nematicides such as fluopyram and fluensulfone at two dosages along with carbofuran as control were evaluated for their efficacy against lesion nematode (*Pratylenchus* spp.) under field conditions. Results indicated that the application of fluopyram (0.5 ml/L) effectively reduced the nematode population, rhizome rot incidence, and enhanced the number of tillers and yield.

TREE SPICES

NUTMEG

Conservation

The germplasm repository for nutmeg was added with eight farmer's varieties collected from various districts of Kerala. A high yielding nutmeg accession; IC0645756 was registered with ICAR-NBPGR (INGR22092) for its monoecious character.

DNA fingerprinting

DNA fingerprinting using ISSR primers was carried out in nutmeg varieties IISR Viswashree, IISR Keralashree, Sindhushree and a monoecious cultivar. Among the 45 ISSR primers used, five primers IS-02, ISSR 05, ISSR-14, ISSR-01 and UBC 834 produced distinguishable markers.

Microwave assisted convective drying system for mace

Drying kinetics, modelling and quality evaluation of nutmeg mace under microwave assisted convective drying system indicated that under convective hot air conditions with and without microwave pre treatments to evaluate the kinetics and quality parameters. The drying characteristics data were fitted into thin layer drying models and the two-term exponential model was found to be the best fit model under optimized conditions with R^2 = 0.9986, RMSE = 0.01328 and $\chi 2$= 0.000141. The study concluded that microwave at optimal power of 320 W for 1 minute was found to have better retention of essential oil, oleoresin and color of dried mace and that microwave drying can be applied for faster drying of mace with better quality aspects.

Fig. 24. Microwave assisted convective drying of mace drying of mace

Spice based finger millet products

The effect of various pretreatments on finger millet flour like roasting, steaming and combination of roasting and steaming were studied for the development and standardisation of cookie recipes. Steaming as pretreatment to finger millet flour for 10 min and blending finger millet flour to a concentration of up to 40% as replacement to refined wheat flour produced finger millet cookies of acceptable texture. Spice enriched finger millet cookies were prepared by adding different spices like cardamom, black pepper and spice blend to get unique flavour of each spice (Fig.25).

a.Cardamom b. Black pepper c. Spice blend

Fig.25: Finger millet blended spice flavoured cookies

Volatile composition analysis of *Illicium sp*

A local *Illicum* sp collected from Pasighat region of Arunachal Pradesh was analysed for its volatile composition. The GC-MS profile of the essential oil showed that myristicin was the major constituent of this species as compared to trans-anethole present in *Illicium verum* (star anise). The major volatile constituents identified in the essential oil are listed in Table 4.

Table 4. Major volatile constituents of *Illicium sp*

Volatile components	Relative abundance (%)
Sabinene	1.34
Linalool	13.37
α-terpineol	1.18
Safrole	1.2
Geranyl acetate	1.38
Caryophyllene	3.68
D-Germacrene	3.26
Myristicin	30.05
β-Cadinene	2.88
tau Muurolol	2.12
α-Cadinol	2.8

CINNAMON

Five accessions of wild cinnamon comprising of two species each were collected from Dibrugarh, Tinsukia and North Lakhimpur districts of Assam (Fig. 26) and another species was collected from Baba Budan hills of Karnataka.

Fig. 26. Cinnamomum **sp. collected from Assam**

CLOVE

Two clove accessions, one with bold flower buds and another accession with red pigmented flower buds (Fig. 27)were collected from Tenkasi district of Tamil Nadu. Two accessions of bold clove locally called as Madagascar clove were collected from Nagercoil. A *Syzygium* species was also collected from North Lakhimpur district of Assam.

Fig. 27. Variant of clove with red pigmentation

GARCINIA

Twenty six accessions of *Garcinia* comprising eight species viz., *G. acuminata*, G. assamica, *G. dulcis*, *G. lanceifolia*, *G. pedunculata*, G. *sibeswarii*, *G. xanthochymus* and an unidentified species were collected from Dibrugarh, Tinsukia and North lakhimpur districts of Assam in collaboration with ICAR-NBPGR, New Delhi (Fig.28). Two accessions of *G. talbotii* were collected from Amboli Ghat, Maharashtra. A new germplasm block for *Garcinia* has been established at Experimental Farm, Peruvannamuzhi with 96 collections comprising of 27 species and another block in Chelavoor was established with sixty four accessions comprising of 14 species.

Garcinia pedunculata ***Garcinia sibeswarii*** ***Garcinia dulcis***

Fig.28 Collected *Garcinia* species

ALLSPICE

Unique ISSR markers for distinguishing *Pimenta dioica* from *Pimenta racemosa* have been identified. Among the primers tested, five primers ISSR-12, Primer IS-10, Primer IS-11, IS-02, ISSR-05 produce distinguishable markers.

VANILLA

Conservation

A total of 77 accessions were established in poly house (65 *Vanilla planifolia* and 12 *Vanilla sp*) and in field conservatory at Chelavoor campus. Pollination was carried out in *V.planifolia* population manually and observations on bean traits were recorded. The accession 4766 produced long (22 cm) beans with more fresh weight (38.45 g) followed by the accession 4751 with bean length of 21 cm and fresh weight of 32 g.

Quantification of major flavour compounds

Protocols for quantification of major flavour compounds *viz*., vanillin, p-hydroxybenzoic acid,p-hydroxybenzaldehyde and vanillic acid were standardized. The quality profile of the superior genotypes revealed that the genotype G7 registered more vanillin (1.679%) content while the genotype G8 recorded high content of vanillic acid (0.119%), total phenolics (28.35 mg GAE/g) and soluble sugars (117.34 mg glucose equivalent / g).

In vitro seed germination

In vitro seed germination in vanilla was attempted with different media (Fig.29). Seed germination and production of shoot was observed in the media composition MS+BAP (3 mg L^{-1})+NAA (0.5 mg L^{-1}).

Fig.29 Production of multiple shoots from seeds *in vitro*

GENERAL

Decision Support System for Site Specific Nutrient Recommendation for Spices(IISR-e SOFT)

The software provides fertilizer recommendations for targeted yield based on the factors like initial fertility, nutrient required for per unit yield (NR), contribution of nutrient from soil (CS) and contribution from fertilizer (CF) which were standardized, validated and recommended for major spice crops viz., black pepper, ginger, turmeric and cardamom (Fig.30). It aims to improve fertilizer use efficiency, increase yield and avoid imbalance of nutrients in soil .

Fig 30. Decision Support System for Site Specific Nutrient Recommendation for Spices

Effect of nano ZnO on genesis and regulation of biofilm genes in soil bacterial communities

Nano ZnO (nZnO) and bulk ZnO (bZnO) facilitated profusion of biofilm related genes (BGs) especially at higher Zn levels. In general, nZnO favored enhancement of genes involved in exopolysaccharide biosynthesis and attachment, while bZnO favoured genes related to capsule formation, chemotaxis and biofilm dispersion. Co-occurrence network analysis revealed significant positive correlation between abundances of BGs, multi-drug resistance genes (MDRGs) and mobile genetic elements (MGEs), indicating an enhanced probability for horizontal gene transfer of MDRGs in nZnO polluted soils.

Effect of nano ZnO on bacterial community structure and associated functional pathways

The effect of nZnO on bacterial community structure and associated functional pathways were determined through predictive metagenomic profiling and subsequent validation through Quantitative Realtime PCR in soil spiked with nZnO and bZnO at various levels. The alpha diversity decreased with increasing ZnO level, with more impact under nZnO, while beta diversity analyses indicated a distinct dose- dependent separation of bacterial communities. The dominant taxa including Proteobacteria, Bacterioidetes, Acidobacteria and Planctomycetes significantly increased in abundance, while Firmicutes, Actinobacteria and Chloroflexi decreased in abundance with elevated nZnO and bZnO levels. Redundancy analysis indicated that changes in bacterial community structure instilled a greater dose- rather than size specific response on key microbial parameters. Predicted key functions did not show a dose specific response, and at 1000 mg Zn kg^{-1}, methane metabolism as well as starch and sucrose metabolism were attenuated, while functions involving two component systems and bacterial secretion systems enhanced under bZnO indicating better stress avoidance mechanism than under nZnO.Taxon-function decoupling indicated that the soil bacterial communities deployed adaptive mechanisms under high ZnO, with lesser buffering capacity and resilience of communities under nZnO.

Interrelationships between genera and functional pathways in soils polluted with nano ZnO

The interrelationships between genera and functional pathways under nZnO and bZnO were deduced using co-occurrence network analysis (Fig 31.). The network exhibited five modules under nZnO and six modules under bZnO. Topological properties of co-occurrence network indicated contrasting associations under nZnO and bZnO. Greater values of topological parameters of network and greater negative to positive ratio of connections evident under bZnO indicated a more complex but highly connected and stable network compared to nZnO. Thus, the soil bacterial communities under extreme nZnO stress depicted comparatively lesser functional resilience and stability than corresponding level of bZnO.

DNA fingerprinting and barcoding

Unique DNA markers have been developed for establishing varietal status in two varieties each of aromatic turmeric, black turmeric, turmeric, fenugreek, nigella and ajwain varieties from various AICRPS centers .

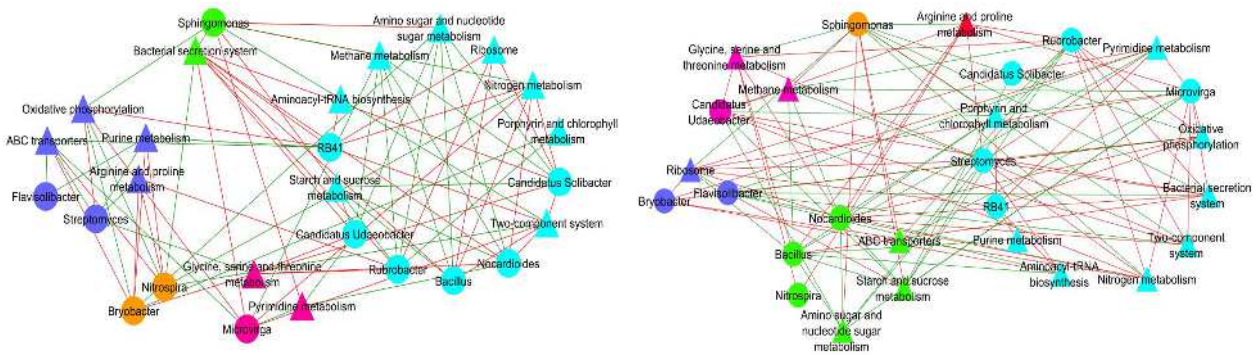


Fig 31. Co-occurrence network indicating the interaction between dominant genera and functional pathway in soils spiked with (a) nZnO and (b) bZnO. Nodes are colored according to modularity classes. Lines connecting two nodes represent a group of significant correlations ($P < 0.05$). Green lines show positive correlations ($R \geq 0.5$); red lines show negative correlations ($R \leq -0.5$). Pathways are indicated in triangle and genera in circles.

Economics and Policy Studies

PESTLE analysis of Indian spice economy

A comprehensive analysis of the spice economy was undertaken using a PESTLE framework identifying the key political, economic, social, technological, legal and environmental aspects of the sector. The study identified the critical role played by policy interventions in balancing the interests of primary producers, constituents of spice industry producers and the consumers. The strong domestic market which consumes nearly 85 per cent of the output, the advantageous demographic dividend, increasing role of mechanization, the increasing concern about food safety, climate change adaptation requirement etc. are some of the key factors in shaping the spice economy in the country.

Pesticide regulation policy in spices

The global reach of Indian spices and the specificity of the spice commodity makes it important to ensure food safety along this entire value chain. In case of spice crops in India, the limited number of both registered pesticides and the absence of maximum residue limits (MRL) for several pesticides were found to have implications for the domestic and international trade of spices. As the world's leading producer and exporter of spices, radical policy interventions and other prudent strategies are required to address the problems faced by the stakeholders in the spice industry. There is an urgent need to enhance the number of registered pesticides used in spices in India, and to set both national and codex MRLs for pesticides, in order to promote sustainable good agricultural practices (GAP). Further, the number of accredited test laboratories need to be increased to ensure effective monitoring of pesticide residues. The approval and registration formalities of biopesticides also need to be eased to address the environmental concerns arising due to over use of chemical pesticides and to ensure food safe spices.

ATIC AND EXTENSION SERVICES

- The advisory services provided by the centre remain popular among the spice farming community. The centre leverages the advances in information communication technologies and has evolved into a single point facilitation centre for farmers and stakeholders visiting the institute. Along with the continued use of virtual modes for providing support services, this year witnessed a significant increase in face to face interactions and direct meetings with the farmers.
- The seed portal of the institute has become fully operational and along with the Visitor management system software, has enhanced the outreach in sale of planting material and other technology inputs.
- One RAWE programme (Research Station Module) was organized for students from Kerala Agriculture University and 55 Educational Training Programmes were organised for scholar community spanning graduate, post graduate and other professional courses.
- The institute participated in ten exhibitions with 50 exhibition days. The exhibitions were leveraged to showcase the cafeteria of technological advances available in the spice crops and has aided in dissemination of novel technologies across the country. The National exhibition on value chain in agriculture at Pune organized by Ministry of Agriculture, Government of India and The Pooppoli exhibition at Regional Agricultural Research Station, Ambalavayal were two important exhibitions in which the institute engaged actively with its clientele.
- The institute conducted 33 customised training programmes of various duration were conducted for the state departments and other organisations on production, crop protection and processing technologies of spices during the year. The training modules and content were designed to cater to the specific needs of the beneficiaries so as to generate enhanced transfer of skills and knowledge leading to desired behavioural changes.
- The institute partnered with AIR Madikeri, Karnataka to develop 8 radio talk modules on various aspects of spice farming. The sessions were broadcasted multiple times benefitting large number of farmers.
- As part of outreach activities institute provided technical support to 26 training programmes at various locations intended for the benefit of spice farming community.
- The institute conducted 26 focused programmes for beneficiaries belonging to Scheduled Caste and Scheduled Tribe. The handholding services provided to the identified beneficiaries include skill enhancement training programmes, distribution of technology inputs and supply of critical inputs for aiding farming operations.
- A collaborative Refresher Training Programme (RTP) on Promoting Spices Crop cultivation and Business opportunities for Established Agripreneurs' under AC&ABC Scheme sponsored by MANAGE for start ups and entrepreneurs during 13-15 September,2022.
- The institute organized a two-day workshop on "Advances in Production and Processing Technologies of Spices" in collaboration with Department of Horticulture, Government of Tripura during 27-28 September, 2022 at Agartala.
- The revenue generation through the sale of planting material of spice crops, bio-inputs and micronutrients and other products from ATIC was 38.8 lakhs during 2022

ATIC Sales revenue -2022

Particulars	Sales revenue
Planting material-NHM	4,15,950
Planting material-General Farm	1,60,910
Farm produce	3,70,329
Diagnostic services	37,500
Micronutrient formulation	4,31,900
Publications	14,735
Trichoderma Biocapsules	10,56,500
Black Pepper PGPR Biocapsules	1,28,100
Ginger Rhizobacteria Biocapsules	2,36,800
Bacillich Biocapsules	5,29,100
Taxes & other miscellaneous items	4,96,433
Total	**38,78,257**

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

The XXXIII Annual Group Meeting of ICAR-All India Coordinated Research Project on Spices (AICRPS) was held during 13-15 October 2022 at Acharya Narendra Deva University of Agriculture & Technology, (ANDUAT), Kumarganj, Ayodhya (UP). The workshop was inaugurated by Dr. N.K. Krishnakumar, Former DDG (Horticulture Science), ICAR, New Delhi. Dr. Bijendra Singh, Hon'ble Vice Chancellor, Acharya Narendra Deva University of Agriculture & Technology (ANDUAT), Kumarganj presided over the function. Dr.V. A Parthasarathy, Former Director, ICAR-IISR, Kozhikode was the Guest of Honour during the occasion.

During the inaugural session the "Best AICRPS Centre Award 2021-22" was presented to AICRPS centre at Sardarkrushinagar Dantiwada Agricultural University, Jagudan.

New varieties recommended for release

Appangala-3 (IISR Manushree), a new small cardamom variety, has been recommended for release by ICAR-AICRPS (Fig.32). The variety was developed by ICAR-IISR Regional station, Appangala, Kodagu, Karnataka. This variety is moisture stress tolerant, with a stable yielding capacity of 550 kg dry capsules/ha under irrigated conditions and 360 kg dry capsules/ha under moisture stress conditions. This variety contains 8.74% essential oil (irrigated conditions) and 8.84% essential oil (moisture stress conditions), with 50% of the capsules having > 8 mm size.

Recommended Technologies

Micronutrient management in cumin

Application of half recommended dose of zinc, iron, manganese and boron as soil application along with their foliar spray is recommended for obtaining higher yield (685 kg/ha) with a high benefit cost ratio of 3.96 in cumin.

Standardization of drip irrigation interval and method of micronutrient fertigation in fenugreek

Drip irrigation at four-day interval along with fertigation of all micronutrients is recommended for higher yield and higher economic returns in fenugreek.

Integrated pest and disease management in cumin

Three foliar sprays of kresoxym methyl 44.3 SC @ 0.044% (First spray at initiation of disease and subsequent sprays at an interval of 15 days after first spray) and two foliar sprays of thiomethoxam 25WG @ 0.0084% (First spray at initiation of aphid infestation and the second spray after 10 days of first spray) were found effective for obtaining higher yield and incremental benefit cost ratio with less blight and aphid incidence.

Fig 32. : Released small cardamom variety

KRISHI VIGYAN KENDRA (KVK)

The KVK, Peruvannamuzhi imparted regular training programmes of various durations in agriculture and allied fields for the farmers, farm women, rural youth and extension functionaries. Total 61 On-campus, 39 Off-campus capacity building trainings were organized by KVK which benefitted more than 3545 participants. Paid training programme on mushroom spawn production and garment making were conducted for rural youth.

Sponsored trainings were organized on establishment of nutrition garden and pest and disease management, kitchen waste management and production of organic manures (sponsor- District Kudumbashree mission), mechanized coconut climbing (sponsor- Coconut Development Board, Cochin), ornamental fish culture and fish health management (sponsor-NABARD), bee keeping (sponsor -HORTICORP) and spices value addition (sponsor-ATARI Bengaluru and IISR).
Six OFTs on"multiplier onion varieties, strawberry varieties, green gram varieties, organic methods for the management of aphids in cowpea, efficacy of different drugs for Bovine Papillomatosis were organized.
Eight FLD programmes were demonstrated on high yielding and mosaic resistant variety of Okra , hybrid napier 'Susthira' in coconut-based homesteads, quality ginger seed production, integrated pest and disease management in paddy, integrated management of Tanjore wilt in coconut , culturing of brackish water fishes and integrated fish culture in coconut based farming systems

The Kendra organized seminar on Agri-Nutri garden during Kerala Farmer's Day (17th August) with expert classes on "cultivation, pest and disease management in vegetables". Rashtria Kisan Diwas was celebrated at KVK on 25November, 2022 and a seminar on "Natural farming and training on pepper planting material production was organized. Soil health awareness programme on 5th December, 2022 was organised with expert classes on soil health management, natural farming and organic pest and disease management by Dr V. Srinivasan, Dr P. Rathakrishnan and Dr K.K. Aiswarya, respectively. Collaborative training programme with CTCRI, Trivandrum on sweet potato cultivation was conducted and classes on Agro techniques, value addition of sweet potato were delivered by Dr G. Byju and Dr D. Jaganathan from CTCRI, Trivandrum.

To commerorate, 75thYear of Independence, KVK, organized trainings, awareness programmes and seminars and participated in live web casting programmes of ICAR viz., Hon'ble PM's address and seminar on "Sustainable Agriculture", nutri-cereals mega convention, PoshanVatika and tree planting campaign and Natural Farming- Pre Vibrant Gujarat Summit 2021.

KVK farmers K.T. Francis, Maruthonkara received Best Coconut farmer award of Coconut Development Board, Kochi and Smt. Bindu Joseph received Pandit Deen Dayal Upadyay Anthyodaya Krishi Puraskar- 2022 of ICAR.

Fig. 23: Ms. Bindu Joseph receiving Pandit Deen Dayal Upadyay Anthyodaya Krishi Puraskar- 2022

Institute Technology Management Unit (ITMU) & Agribusiness Incubation (ABI) Centre

- ITMU& ABI commercialized 9 technologies from January to December 2022. An amount of Rs. 42.75 Lakhs earned as revenue through technology commercialization.
- The technology "A novel method of storing and delivering PGPR/Microbes through biocapsules' was commercialized to Lysterra LLC, Moscow, Russia on 30th June 2022.Dr T. Mohapatra, former Director General, ICAR, presided over the virtual meet on signing of international MoU. ITMU & ABI facilitated the online technology cum know-how transfer to the firm during 6th to 9th Dec 2022.
- Patent granted for the technology 'A micronutrient composition for cardamom and a process for its preparation' (Indian Patent No.413017,dt. 31.03.2015).
- National Biodiversity Authority approval was obtained for the invention 'Granular Lime Formulation and A Process for Its Preparation' Indian Patent Application No.-202241010858
- ITMU organized an awareness programme on Intellectual Property Rights (IPR) under National Intellectual Property Awareness Mission (NIPAM) in collaboration with Indian Patent office, Chennai on 5th January 2022.
- ITMU& ABI arranged a Techno Commercial Assessment meeting with Agrinnivate India Ltd to assess the techno commercial feasibility, preferred modes of technology commercialization and to develop standard terms and conditions for commercialization and product marketing abroad.
- IISR entered into MoA with M/s Bayer Crop Science Pvt Ltd, Maharashtra under collaborative research mode for developing best practices for spice Cultivation/production, crop protection measures.
- ITMU& ABI facilitated five consultancy visit black pepper plantations of various firms in Kerala & Karnataka and earned a revenue of 3.5 lakhs.
- Three of the startup licensees/firms (SRT Agro Science Pvt Ltd, Chhattisgarh, Codagu Agritech, Karnataka, Hi7 Agri Bio solutions, Karnataka) of IISR were selected to participate and exhibit their products in the Agri Start-up Conclave & Kisan Sammelan-2022
- Six startups/ entrepreneurs were enrolled as incubatees during the year 2022 under the ABI unit of ICAR-IISR for development of spice based food products, availing spice processing facility.
- ABI organized an online Refresher Training Programme (RTP) on Spices Cultivation and Business opportunities from 13-15th September 2022 in collaboration with MANAGE, Hyderabad. 55 established agriprenuers from across the country participated in the training program.
- ITMU & ABI supported startups in branding and marketing of spice based value products and other allied products sourced directly from authentic farmers.
- Mallikaappi", a traditional immunity booster composed of spices, widely used by the local people of Kerala was officially launched for commercialization on behalf of incubatee "Suman Research and Rehabilitation Centre", an NGO working for rehabilitating mentally challenged Women at Kozhikode.

T Mohapatra, Director General- ICAR, presided over the virtual meet for signing of international MoU with Lysterra LLC, Russia on 30th June 2022.

Biocapsule technology commercialized to Lysterra LLC, Moscow, Russia.

M/s CodaguAgritech Eco at the venue of Agri Startup Conclave & Kisan Sammelan 2022.

Execution of MoU with M/s Bayer Crop Science Ltd, Maharashtra

Biocapsule technology commercialized to Organic Earth Energy Pvt., Gujarat

- ABI Unit supported startups/registered farmers/licensees through marketing of quality assured spices, value added products, allied products through the sales out SPIISRY and online platform www.spiisry.in and generated an income of Rs. 3.9 Lakhs. Krishidhan nursery, the incubation facility of ABI could support the production and marketing of quality planting materials of spices, plantation crops, fruit crops, medicinal and ornamentals of joint liability groups, licensees, registered farmers to customers. 18 Lakhs worth planting materials have been sold in 2022.
- ITM-BPD members attended various seminars/ webinars for promoting institute technology commercialization and entrepreneurship.
- Principal investigator, IPR delivered lectures various technologies of ICAR-IISR, technology commercialization aspects and agribusiness opportunities in spices sector to startups/ entrepreneurs/farmers as part of training programmes/seminars/webinars.

Commercialization of Technologies

S No	Name of Technology/ Know-How	Name of Contracting Party	Revenue Earned (Rs)
1	Nutmeg variety-IISR Keralashree	Sugandhi JLG, Thrissur, Kerala	25000
2	Nutmeg variety-IISR Viswashree	Sugandhi JLG, Thrissur, Kerala	25000
3	Ginger Variety-IISR Mahima	Ms. Helen T Nabeel M/s Zingiber Agrotech, Kozhikode, Kerala	75000
4	Black pepper variety-IISR Thevam	Sinimol Mary Jacob, M/s Peniel Plants & Spices Nursery, Kottayam, Kerala	50000
5	Turmeric Variety-IISR Prathibha	Ms. GeethaSaleesh, M/s Oleevia Agro farming Private limited, Thrissur, Kerala	50000
6	Nutmeg variety-IISR Keralashree	Mr. Sunil PK, M/s Kesav plantations Thrissur	25000
7	Nutmeg variety-IISR Viswashree	Mr. Sunil PK, M/s Kesav plantations, Thrissur	25000
8	A novel method of storing and delivering PGPR/ microbes t hrough biocapsules	Lysterra LLC, Moscow, Russia	30,00,000
9	A novel method of storing and delivering PGPR/ microbes through biocapsules	Organic Earth Energy Pvt. Ltd,, Ahmedabad, Gujarat	10,00,000

Agricultural Knowledge Management Unit (AKMU)

AKMU facilitates the IT and ICT related activities of the institute and ensures uninterrupted internet connectivity to all divisions/sections and VPN connectivity to IISR Regional station, Appangala, IISR Experimental Farm, Peruvannamuzhi and Krishi Vigyan Kendra, Peruvannamuzhi. AKMU is also taking care of network security aspects, developing websites, regular updation of the institute & AICRP websites. Modified the intranet portal and library portal, uploading institute activities in the social medias, developing and publishing videos in YouTube chanel, maintenance of data center, webservers, databases, technical support to online meetings, webinars, online workshops and Trainings etc. were done. Apart from this AKMU assists in analysis and interpretation of geographical data using ArcGIS & DIVA GIS and statistical analysis of scientific data using SAS, JMP and R software.

Library portal of ICAR-IISR, Kozhikode

IISR-Library

IISR Library strives towards ensuring excellent academic services through online and offline to the users. Library has a collection of 5683 books and 6010 bound journals.

CeRA
IISR Library is part of the Consortium of electronic Resources in Agriculture (CeRA) and more than 3500 full text journals on agriculture and allied subject are accessible. Library providede document delivery service to CeRA users and request from other partners.

JOURNALS
Library has subscribed 25 Indian Journals and eight Foreign Journals during the year in addition to journals accessible under CeRA.

KOHA
Library updated publications to its stock and all the newly added publications were brought in to the Library Automation software 'KOHA' database.

Dspice
The Institutional Digital repository software 'DSpice' was also updated with institute publications.

ICAR - Krishiportal
Updated with reports, research publication and, media resources etc.

Plagiarism detection
Library also provides other academic service like detection of plagiarism in research thesis for Institute users.

हिंदी अनुभाग

राजभाषा कार्यान्वयन समिति की बैठक

वर्ष २०२२ में भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड़ में राजभाषा कार्यान्वयन समिति की बैठक प्रत्येक तिमाही में (२१फरवरी २०२२, १६ जून २०२२, २३ सितंबर २०२२ और २६ दिसंबर २०२२)आयोजित की गयी। समिति द्वारा राजभाषा कार्यान्वयन की गतिविधियों की समीक्षा करके सुधारने के लिए सुझाव दिया गया।

हिंदी कार्यशाला

वर्ष २०२२ में भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान के अधिकारियों तथा कर्मचारियों के लिए चार हिंदी कार्यशालाएं आयोजित की गयीं। इन कार्यशालाओं में 'राजभाषा नीति एवं हिंदी टिप्पणी', 'राजभाषा की लोकप्रियता','राजभाषा कार्यान्वयन के लिए उपयोगी आधुनिक तकनीकियां', 'ई-ऑफीस में हिंदी में टिप्पणी'आदि विषयों पर विभिन्न विशेषज्ञों ने कक्षा चलायी। डॉ. ओ. वासवन, सहायक निदेशक (रा. भा.), आकाशवाणी, कोषिक्कोड, श्री के. के. रामचंद्रन, उपनिदेशक (राजभाषा-सेवानिवृत्त) आयकर विभाग, कोच्चि, श्री. एम. अरविंदाक्षन, वरिष्ठ अनुवाद अधिकारी, कर्मचारी भविष्य निधि संगठन, कोषिक्कोड तथा सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी, भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड़ने क्रमशः १६.०३.२०२२, २३.०६.२०२२, २७.०९.२०२२ तथा १२.१२.२०२२ को विभिन्न कार्यशालाओं में व्याख्यान दिया।

हिंदी पखवाडा 2022

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में दिनांक 14.09.2022से २९.०९.२०२२ की अवधि में हिंदी पखवाडा मनाया गया। राजभाषा विभाग, नई दिल्ली के अनुदेश के अनुसार दिनांक १४ सितंबर २०२२ को हिंदी दिवस एवं हिंदी पखवाडे का उद्घाटन समारोह पंडित दीनदयाल उपाध्याय इंडोर स्टेडियम, सूरत,गुजरात में संपन्न हुआ।हमारे माननीय गृह मंत्री श्री अमित शाह ने समारोह का उद्घाटन किया। प्रस्तुत समारोह में संस्थान का प्रतिनिधित्व करते हुए डा. एन. के. लीला,हिंदी अधिकारी ने भाग ली। हिंदी दिवस के अवसर पर माननीय महानिदेशक डां हिंमांशु पाठक का अपील एवं माननीय गृह मंत्री श्री अमित शाह का संदेश संस्थान की टीवी में प्रदर्शित की और साथ ही इसे संस्थान के स्टाफ सदस्यों की ई-मेल और वाट्सएप ग्रूप में अपलॉड किया गया। इसके अलावा हिंदी दिवस की बधाईयों का स्लाइड वाट्सएप में प्रदर्शित किया।

हिंदी पखवाडा के अवसर पर अनुशीर्षक लेखन,चित्र कहानीलेखन, टिप्पणी एवं मसौदा लेखन, भाषण, वीडियो कमन्ट्री, गीत, कविता पाठ, प्रश्नोत्तरी आदि प्रतियोगिताएंहिंदी मेंआयोजित की थीं। प्रत्येक प्रतियोगिताओं के प्रथम और द्वितीय स्थान पर आनेवालों को पुरस्कार दिया गया। इन प्रतियोगिताओं के अलावा दिनांक २७.०९.२०२२ को हिंदी कार्यशाला आयोजित की। इस में श्री एम. अरविंदाक्षन, वरिष्ठ अनुवाद अधिकारी, कर्मचारी भविष्य निधि संगठन ने **राजभाषा कार्यान्वयन के लिए उपयोगी आधुनिक तकनीकियां** पर व्याख्यान के साथ प्रदर्शन भी दिया था।

हिंदी पखवाडा का समापन समारोह २९ सितंबर २०२२ को डा. सी. के. तंकमणी, निदेशक की अध्यक्षता में संपन्न हुआ। डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं हिंदी अधिकारी ने सबका स्वागत किया। श्री. सुभाष कुमार, प्रबंधक, सेन्ट्रल बैंक ऑफ इंडिया, चेलवूर इस समारोह में मुख्य अतिथि थे। उन्होंने हिंदी भाषा के महत्व एवं विकास यात्रा पर प्रकाश डाला। मुख्य अतिथि के द्वारा पुरस्कार विजेताओं को नकद पुरस्कार प्रदान किया। हिंदी को लोकप्रिय करने के लिए प्रतियोगिताओं के प्रतिभागियों को समाश्वास पुरस्कार के रूप में **हिंदी पढ़ें, लिखें और आगे बढ़ें** मुद्रित पुरस्कार दिया गया। सुश्री एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने हिंदी पखवाडे की रिपोर्ट प्रस्तुत की।

आईसीएआर-आईआईएसआर क्षेत्रीय स्टेशन, अप्पंगला

आईसीएआर-आईआईएसआर क्षेत्रीय स्टेशन, अप्पंगला में विभिन्न कार्यक्रमों के साथ हिंदी सप्ताह मनाया गया। स्टाफ सदस्यों एवं संविदा कर्मियों के लिए हिंदी स्मरण परीक्षा, चित्र रचना एवं उसके लिए हिंदी में अनुशीर्षक लेखन, हिंदी कविता पाठ आदि प्रतियोगिताएं आयोजित कीं। प्रत्येक प्रतियोगिताओं के पहले, दूसरे और तीसरे स्थान पर आने वालों को पुरस्कार दिया गया। दिनांक २८ सितंबर २०२२ को समापन समारोह आयोजित किया। इसमें अध्यक्षता प्रभारी कार्यालय प्रधान डॉ. अक्षिता एच. जे., वैज्ञानिक ने की। डॉ. मुहम्मद फैसल पीरान, वैज्ञानिक ने सभा को संबोधित किया और विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार प्रदान किया। प्रतिभागियों को समाश्वास पुरस्कार भी दिया गया।

नराकास गतिविधियों में सहभागिता

- डॉ. सी. के. तंकमणी, निदेशक एवं सुश्री एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने दिनांक १० जून २०२२ को होटल मरीना रसिडेंसी में आयोजित नगर राजभाषा कार्यान्वयन समिति की ६९वीं अर्धवार्षिक बैठक में भाग लीं।
- सुश्री एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने दिनांक २८ अक्तूबर २०२२ को होटल मरीना रसिडेंसी में आयोजित नगर राजभाषा कार्यान्वयन समिति की ७०वीं अर्धवार्षिक बैठक में भाग लीं।
- सुश्री. एन. कार्तिका, तकनीशियन, श्री विष्णु बी., तकनीशियन ने नगर राजभाषा कार्यान्वयन समिति द्वारा आयोजित हिंदी प्रश्नोत्तरी प्रतियोगिता में भाग लिया और तीसरा पुरस्कार प्राप्त किया।
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• राजभाषा निरीक्षण

श्रीमती सीमा चोपडा, निदेशक (राजभाषा), भारतीयकृषि अनुसंधान परिषद ने १६ अप्रैल २०२२ को संस्थान की राजभाषा गतिविधियों का निरीक्षण किया।

हिंदी प्रशिक्षण/संगोष्ठी/कार्यशाला में प्रतिभागिता

- सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्यतकनीकी अधिकारी ने दिनांक ११ मार्च २०२२ कोबैंक ऑफ इंडिया द्वारा ऑनलाइन माध्यम से आयोजित अखिल भारतीय राजभाषा संगोष्ठी में भाग ली।
- सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने दिनांक ३० मार्च २०२२ कोभाकृअनुप-राष्ट्रीय पादप आनुवंशिक संसाधन ब्यूरो, नई दिल्ली द्वारा 'कंप्यूटर पर हिंदी के प्रयोग के लिए उपलब्ध तकनीकी सुविधाएं' पर आयोजित ऑनलाइन संगोष्ठी भाग ली।
- सुश्री. एन. रबीना, उच्च श्रेणी लिपिक तथासुश्री. एन. कार्तिका, वरिष्ठ तकनीशियन ने केंद्रीय हिंदी प्रशिक्षण संस्थान, नई दिल्ली द्वारा दिनांक १८-२२ जुलाई २०२२ की अवधि मे आयोजित ऑनलाइन हिंदी कार्यशाला में भाग ली।
- डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं हिंदी अधिकारी तथा सुश्री.षजिना ओ., तकनीशियन ने हिंदी शिक्षण योजना द्वारा आयोजित पारंगत परीक्षाउत्तीर्ण की।
- सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्यतकनीकी अधिकारी ने दिनांक २४-२५ अगस्त २०२२ कोभाकृअनुप-केंद्रीय पटसन एवं समवर्गीय रेशा अनुसंधान संस्थान, बैरकपुर, कोलकत्ता में भारतीय कृषि अनुसंधान परिषद के राजभाषा अधिकारियों के लिए 'स्वतंत्रता का ७५ वर्ष और राजभाषा हिंदी का विकास' पर आयोजित दो दिवसीय भाषा उत्सव एवं हिंदी संगोष्ठी में भाग ली।
- डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं हिंदी अधिकारी ने दिनांक १४-१५ सितंबर २०२२ कोराजभाषा विभाग, नई दिल्ली द्वारा पंडित दीनदयाल उपाध्याय इंडोर स्टेडियम, सूरत, गुजरात में आयोजित हिंदी दिवस समारोह एवं द्वितीय अखिल भारतीय राजभाषा सम्मेलन में भाग लिया।
- सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्यतकनीकी अधिकारी ने दिनांक १५ नवंबर २०२२ कोभाकृअनुप-केंद्रीय तटीय कृषि अनुसंधान संस्थान, गोवा में कार्यालय संचालन में राजभाषा का उपयोग पर आयोजित ऑनलाइन कार्यशाला में भाग ली।
- डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं हिंदी अधिकारी तथा सुश्री. एन. प्रसन्नकुमारी, सहायक

मुख्यतकनीकी अधिकारी ने दिनांक २२ दिसंबर २०२२ कोभाकृअनुप-भारतीय मृदा एवं जल संरक्षण संस्थान, देहरादून्द्वारा'तकनीकी विषय में हिंदी में कार्य करना' पर आयोजित ऑनलाइन तकनीकी कार्यशाला में भाग ली।

- सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्यतकनीकी अधिकारी ने दिनांक २३ दिसंबर २०२२ कोभाकृअनुप-राष्ट्रीय कृषि उपयोगी सूक्ष्मजीव ब्यूरो, मऊ, उत्तर प्रदेश द्वारा 'कार्यालय प्रणाली में हिंदी के प्रयोग में स्मार्ट टूल्स' पर आयोजित एक दिवसीय राष्ट्रीय ऑनलाइन हिंदी कार्यशाला में भाग लिया।

हिंदी प्रकाशन

- मसाला समाचार जनवरी-दिसंबर २०२१
- मसाला समाचार जुलाई-दिसंबर २०२१
- मसालों की महक २०२२
- अनुसंधान के मुख्य अंश २०२०
- आईसीएआर-आईआईएसआर के वार्षिक प्रतिवेदन का कार्यकारी सारांश २०२१
- एआईसीआरपीएस वार्षिक प्रतिवेदन का कार्यकारी सारांश २०२१
- राजभाषा रिपोर्ट भारतीय कृषि अनुसंधान परिषद की राजभाषा आलोक २०२१ में प्रकाशित किया।

राजभाषा पत्रिका का विमोचन

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान की राजभाषा पत्रिका **मसालों की महक २०२२**का विमोचन दिनांक २६ दिसंबर २०२२ को संपन्न हुई राजभाषा कार्यान्वयन समिति की बैठक में संस्थान के निदेशक एवं राजभाषा कार्यान्वयन समिति के अध्यक्ष डॉ. आर. दिनेश के द्वाराकिया गया।

HUMAN RESOURCE DEVELOPMENT

i) Trainings/Workshop organized by HRD

Sl. No	Trainings/Workshop particulars	Duration	No: of Participants
1.	Online training programme on 'Data Digitalization and Visualization'	22-24 February 2022	81
2.	Online workshop on 'Life Science meets Programming'	13-15 September 2022	15
3.	'Functional skill training programme' for Technicians and Skilled Support Staff	10 - 12 August 2022	10

ii) Training and Capacity Building of ICAR-IISR Employees

Name	Training particulars	Duration	Institute
Dr. C.K. Thankamani	Hindi Workshop on Popularization of Official Language	23-June-2022	ICAR- IISR, Kozhikode
Dr. N.K. Leela			
Dr. A. Jeevalatha			
Dr. C. Sarathambal			
Dr. Divya P. Shyamaladevi			
Dr. Alagupalamuthirsolai			
Ms. Sona Charles			
Dr. Alagupalamuthirsolai	Irrigation system and advancement	19 to 21-July-2022	NIPHM, Hyderabad
Dr. C.K. Thankamani	Training Programme on ICAR-Service Rules	12- August-2022	ICAR- IISR, Kozhikode
Dr. R. Dinesh			
Dr. A. Ishwara Bhat			
Dr. K. Kandiannan			
Dr. N.K. Leela			
Dr. K. Krishnamurthy			
Dr. P Rajeev			
Dr. T E Sheeja			
Dr. E Jayashree			
Dr. D. Prasath			
Dr. C M Senthil Kumar			
Dr. V. Srinivasan			
Dr. C. Sarathambal			
Dr. C.N. Biju			
Dr. P.S. Divya			

Dr. Lijo Thomas			
Dr. K. Anees			
Dr. R Praveena			
Dr. A Jeevalatha			
Dr. C Sellaperumal			
Dr. Sharon Aravind			
Mr. V A Muhammed Nissar			
Ms. R Sivaranjani			
Mr. Mukesh Sankar			
Ms. Sona Charles			
Ms. P.V. Alfiya			
Dr. Alagupalamuthirsolai			
Dr. Honnappa Asangi			
Dr. M. S. Shivakumar			
Dr. S. Aarthi			
Dr. R. Gobu			
Dr. H. J. Akshitha			
Ms. P.V. Alfiya	Workshop on response Surface Methodology (online)	18 to 20-August-2022	ICAR-NAARM, Hyderabad
Dr. R. Gobu	Online Workshop on Life Science meet Programming	13 to 15 September 2022	ICAR- IISR, Kozhikode
Dr. C.K. Thankamani	Contract labour Minimum wages act	20- October-2022	ICAR-IISR, Kozhikode
Dr. R. Dinesh			
Dr. A. Ishwara Bhat			
Dr. K. Kandiannan			
Dr. N.K. Leela			
Dr. K. Krishnamurthy			
Dr. P. Rajeev			
Dr. Ankei Gowda			
Dr. T. E. Sheeja			
Dr. E. Jayashree			
Dr. D. Prasath			
Dr. C. M. Senthil Kumar			
Dr. V. Srinivasan			
Dr. C. Sarathambal			
Dr. C.N. Biju			
Dr. P.S. Divya			
Dr. Lijo Thomas			
Dr. K. Anees			
Dr. R. Praveena			

Dr. A. Jeevalatha			
Dr. C. Sellaperumal			
Dr. Sharon Aravind			
Mr. V. A. Muhammed Nissar			
Dr. Balaji Rajkumar			
Dr. Muhammed Faisal Peeran			
Ms. R. Sivaranjani			
Ms. Sona Charles			
Ms. P.V. Alfiya			
Dr. AlagupalamuthirSolai			
Dr. Honnappa Asangi			
Dr. M. S. Shivakumar			
Dr. S.R. Maneesha			
Dr. S. Aarthi			
Dr. R. Gobu			
Dr. H. J. Akshitha			
Dr. N.K. Leela	Pesticide Residue Analysis using both GC-MS/MS and LSC-MS/MS	31 -October-2022 to 4 -November-2022 (5 Days)	Quality Evaluation Laboratory Spices Board, Kochi
Dr. K. Anees			
Dr. M. S. Shivakumar	Training Workshop on Analysis of Multi-Environment Trials (On-line Mode)	03 to 8-November-2022	ICAR-NAARM, Hyderabad

Technical

Name	Training particulars	Duration	Institute
Mr. John George	Hindi Workshop on Popularization of Official Language	23-June -2022	ICAR- IISR, Kozhikode
Mr. K. Jayarajan			
Mr. R. Bharathan			
Mrs. N. Prasanakumari			
Mr. A. Sudhakaran			
Dr. Priya George			
Mrs. N. Karthika			
Dr. I. P. Vijesh Kumar			
Mrs. 0. Shajina			
Mr. B. Vishnu			
Mrs. 0. Shajina	Functional Skill Training	10 to 12 August	ICAR- IISR,

Mr. B. Vishnu Mr. C.M. Nikhil Mr. P.B. Ranjith	Programme for Technicians and Skilled Support Staff	2022	Kozhikode
Mr. John George Mr. R. Bharathan Mr. K. Jayarajan Mrs. N. Prasanakumari Mr. E. S. Sujeesh Mr. A. Sudhakaran Mr. K. Krishnadas Ms. P. K. Chandravally Dr. Priya George Mr. I. P. Vijesh Kumar Ms. N. Karthika Mr. O. G. Sivadas Mr. V. S. Binoy Ms. Rejina P. Govind Mr. B. T. Hareesh Mr. A. R. Rasmish Mr. B. Vishnu Ms. O. Shajina Mr. C. M. Nikhil Mrs. P. N. Kausalya Mr. P.B. Ranjith	Training Programme on ICAR-Service Rules	12-August - 2022	ICAR- IISR, Kozhikode
Mr. Vijesh Kumar	Online Workshop on Life Science meet Programming	13-15 September 2022	ICAR- IISR, Kozhikode
Mr. H.C. Rathish	Competency Enhancement training programme on Motivation, Positive thinking and Communication skill for the technical officers (T-5 and above) of ICAR Institute	13 to16- September - 2022	ICAR-NAARM, Hyderabad
Mr. John George Mr. R. Bharathan Mr. K. Jayarajan Mrs. N. Prasanakumari Mr. E.S. Sujeesh Mr. A. Sudhakaran Mr. K. Krishnadas Ms. P. K. Chandravally Dr. Priya George Mr. I. P. Vijesh Kumar Ms. N. Karthika Mr. O. G. Sivadas Mr. V. S. Binoy Ms. Rejina P Govind Mr. B. T. Hareesh Mr. A. R. Rasmish	Contract labour Minimum wages act	20- October 2022	ICAR-IISR, Kozhikode

Mr. B. Vishnu Ms. O. Shajina Mr. C. M. Nikhil Mrs. P. N. Kausalya Mr. P.B Ranjith			
Ms. N. Karthika	Pesticide Residue Analysis using both GC-MS/MS and LSC-MS/MS	31 -October-2022 to 4 -November-2022 (5 Days)	Quality Evaluation Laboratory Spices Board, Kochi
Mr. B. Vishnu	Training programme on "Selection, Adjustment, Operation, and Maintenance of Agricultural Implements for field and Horticultural Crops"	29 December 2022 to 07 January 2023	ICAR- CIAE Bhopal

Administration

Name	**Training particulars**	**Duration**	**Institute**
Mr. T. E. Janardhanan Mrs. C. K. Beena Mr. V. C. Sunil	Hindi Workshop on Popularization of Official Language	23- June -2022	ICAR- IISR, Kozhikode
Mr. T. E. Janardhanan Ms. C. K. Beena Mr. P. Sundaran Mr. V. C. Sunil Mr. V. V. Sayed Mohammed Ms. M. Seema Ms. N. Rebeena Mr. P. K. Rahul Mr. P. T. Jayaprakash Mr. K Faisal	Training Programme on ICAR-Service Rules	12- August-2022	ICAR- IISR, Kozhikode
Mr. T. E. Janardhanan Ms. C. K. Beena Mr. P. Sundaran Mr. V. C. Sunil Mr. V. V. Sayed Mohammed Ms. M Seema Ms. N. Rebeena Mr. P. K. Rahul Mr. P. T. Jayaprakash	Contract labour Minimum wages act	20-October -2022	ICAR-IISR, Kozhikode

Mr. K. Faisal			

Skilled Support Staff

Name	Training particulars	Duration	Institute
Mr. K.P AbhiBalagopal	Online training programme on - Cyber Security for officials of Government of India, (35th Batch)	27- May- 2022	Ministry of Electronics and Information Technology (MeitY).
Mr. K. P. AbhiBalagopal	Hindi Workshop on Popularization of Official Language	23- June- 2022	ICAR- IISR, Kozhikode
Mr. K.P AbhiBalagopal Mr. K.P. Sachin Mr. V. Vijesh	Functional Skill Training Programme for Technicians and Skilled Support Staff	10 to 12 - August -2022	ICAR- IISR, Kozhikode
Mr. K.P. AbhiBalagopal Mr. V. Vijesh Mr. K.P. Sachin	Contract labour Minimum wages act	20- October- 2022	ICAR-IISR, Kozhikode

iii) Seminar/Symposium/Conferences attended by employees

Name	Seminar/Symposium/conference/Workshop	Date
Dr. R. Praveena	International conference on Plant pathology: Retrospect and Prospects, Indian Pathological Society, Jaipur	23 to 26 - March- 2022
Dr. K. Kandiannan	National Conference on Climate Resilient and Sustainable Development of Horticulture, ASM foundation, New Delhi & CSAU&T, Kanpur	28 to 31- May- 2022
Dr. C. K. Thankamani Dr. Alagupalamuthirsolai	International conference on Water Environment Management at CWRDM, Kozhikode	22 to 24- June- 2022
Dr. R. Gobu	Symposium Commemorating birth bicentenary of Gregor Johann Mendel, IARI, New Delhi	19 to 21- July- 2022
Dr. A. Jeevalatha Dr. Alagupalamuthirsolai Dr. C. Sarathambal	International Conference on Advances in Agriculture and food system towards sustainable development goals (AAFS-2022), University of Agricultural Sciences, Bengaluru during (Online)	22 to 24- August- 2022

Dr. C. Sarathambal	Annual International Conference of Association of Microbiologists of India (AMI), University of Mysore, Mysore	21to 23-September-2022
Dr. P. Rajeev	National Conference on Tribal Horticulture, Dr. YSR Horticultural University, West Godavari	17 to 18-October - 2022
Dr.Alagupalamuthirsolai	International Conference on Physiological and molecular mechanisms for abiotic stress tolerance in plants, University of Calicut, Kerala	26 to 28 - October- 2022
Dr. E. Jayashree Ms. P.V. Alfiya	International Symposium on India @2047: Agricultural Engineering Perspective, TNAU, Coimbatore	09 to 11-November-2022
Ms. Sona Charles Dr. I.P. Vijesh Kumar	National Conference on Enhancing Competitiveness of Horticulture through Technology Innovations, ICAR-CPCRI, Kasaragod	17 to 18-November-2022
Ms. Sona Charles	21st International Conference in Bio informatics (In CoB 2022), Asia Pacific BioInformatics Network (Online)	21 to 23 – November-2022
Dr. H.J. Akshitha Dr. M.S. Shivakumar Dr. Mohammed Faizal Peeran Dr. C. Sellaperumal Dr. S.R. Maneesha Dr. S.J. Ankegowda Dr. D. Prasath	National Symposium on Horticultural Crops of Humid Tropics for Nutritional and Livelihood Security (NSHCHT)-2022, Chettalli	02 to 03 - December-2022
Dr. C.K. Thankamani	National conference on Natural farming systems and biodiversity conservation under changing climate scenario, CAU-Imphal	5 to 7-December-2022
Dr. Sharon Aravind		

Ph.D. awarded

Student	Topic	University	Guide
Ms. P. Prashina Mol	Studies on *Pythium* species associated with yellowing of black pepper (*Piper nigrum* L.)	University of Calicut	Dr. T. E. Sheeja
Ms. K.P. Subila	Diversity and characterization of curcumin biosynthetic genes and transcription factors from *Curcuma* spp	University of Calicut	Dr. R. Suseela Bhai

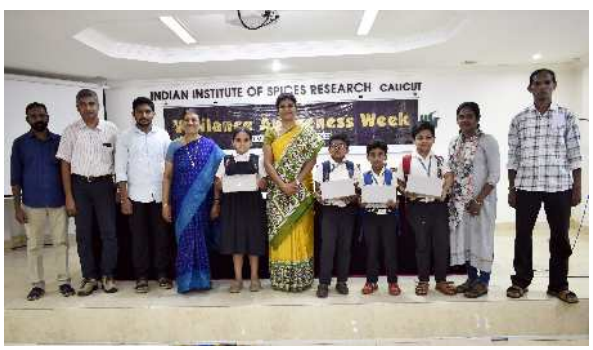
Ph.D. registrations

Sl. No	Name	Guide	Subject
1.	Ms. T.E. Arya	Dr. T.E. Sheeja	Botany
2.	Ms. Fathima Dilkush	Dr. C. Sarathambal	Microbiology
3.	Ms. N.P. Krishnapriya	Dr. K. Anees	Biochemistry
4.	Mr. T.S. Titto Mendez	Dr. K. Anees	Food Science and Technology

MAJOR EVENTS

Vigilance Awareness Week

ICAR-Indian Institute of Spices Research (IISR), Kozhikode, Kerala observed Vigilance Awareness Week (VAW)-2022 from 31 October- 6 November 2022. On 31st October, 2022 Dr. D. Prasath (Pr. Scientist & Vigilance Officer) addressed the staff and briefed about the VAW 2022. Dr. C.K. Thankamani, Director, administered integrity pledge to the staff members Vigilance Awareness Rally was organized on 2nd November 2022 at 10.00 am. Dr C.K. Thankamani, Director, ICAR-IISR flagged off the rally in front of the main building and around 100 staff and student members were present in the rally. The valedictory function of VAW- 2022 was held on 4th November 2022 and Chief Guest of the function, Smt. Nirmala Devi (IPoS), Post Master General, Kozhikode, Kerala shared her thoughts about Vigilance Awareness among public.



Swachhta Activities

Swachhta 2.0, was conducted from 02-31 October, 2022 at ICAR-IISR, Chelavoor. Regional Station, Appangala, Experimental Farm at Peruvannamuzhi and KVK, Peruvannamuzhi. The items which are no longer used were identified in various Divisions of ICAR-IISR, Kozhikode and farm were collected, segregated and auctioned. For efficient disposal of waste, the vermicompost unit was rebuilt at Maruthonkara by the staff of KVK. As a part of Swachhta campaign, roadside cleaning was undertaken at ICAR-IISR, Experimental Station at Peruvannamuzhi and Regional Station, Appangala involving the local residents. To facilitate good health among the staffs, the area proposed for volley ball court at ICAR-IISR Experimental Farm, Peruvannamuzhi was cleaned by removing the overgrown grasses, scraped and levelled the land. As a part of Swachhta cleanliness drive, drawing competition was conducted among contractual staffs on the topic "Clean Indian, Green India" at Regional Station, Appangala.

The fortnight celebration of Swachhta Pakhwada (16 to 31 December 2022) was enriched with diverse activities like cleanliness drives, competitions for school students, awareness programmes, visit to the adopted village under Mera Gaon Mera Gaurav, establishing kitchen garden etc. All the programmes were conducted on the theme "Swachhta and clean India". The valedictory programme of SwachhtaPakhwada 2022 was held on 30 December 2022 at ICAR-Indian Institute of Spices Research (Headquarters), Kozhikode. During the occasion, Dr. R. Dinesh, Director of the Institute, emphasized on the importance of cleanliness drives and the need to implement such programmes in a sustainable manner.

The valedictory programme of Swachhta Pakhwada 2022 was also organized at ICAR-IISR, in which Dr. S. J. Ankegowda, Head, Similarly, the staff of ICAR-IISR Experimental Farm and ICAR-IISR Krishi Vigyan Kendra, Peruvannamuzhi also organized the valedictory programmes which was followed by establishment of terrace garden and wick system of irrigation for vegetables like okra, amaranthus, brinjal and chilli.

Value Addition and EDP in Spices

A training programme sponsored by ICAR-Agricultural Technology Application Research Institute (ATARI), Bengaluru on 'Value Addition and Entrepreneurship Development in Spices' was held at ICAR – IISR, Kozhikode during 13 – 15 December 2022. About 20 participants mainly entrpreneurs identified by various KVK's from Karnataka and Kerala were present for the training programme. Dr. R. Dinesh, Director, ICAR-IISR, inaugurated the training programme and Dr.Thimappa K., Principal Scientist and Nodal Officer, ICAR-ATARI, Bengaluru felicitated during the inaugural session of the training programme on 13 Dec 2022. The programme included theory and practical sessions followed by field visit to ICAR-IISR, Experimental farm at Peruvannamuzhi. During the training programme, Dr. C.K. Thankamani, Dr. P Rajeev, Dr. E. Jayashree, Dr.Anees, Dr.Lijo Thomas, Dr. P. Ratha Krishnan, Ms. Alfiya P.V and Ms. A. Deepthi handled various sessions on post harvest processing, quality aspects and entrepreneurship development.

Fit India Freedom Run

Launch of FIT India Freedom Run 3.0 at ICAR-IISR, Kozhikode, ICAR-IISR Regional Station, Appangala and ICAR-IISR Experimental Farm, Peruvannamuzhi. At ICAR-IISR, Kozhikode Dr. CK Thankamani, Director inaugurated the run.

Fourth Dr.Y.R. Sarma Memorial Lecture

Dr Y R Sarma Memorial Trust and ICAR Indian Institute of Spices Research (ICAR-IISR) jointly organised 6th Dr. Y. R. Sarma Memorial lecture to honour Dr. Y. R. Sarma, an eminent scientist who worked on the management of diseases of spices and plantation crops. Dr. P. Chowdappa, Former Vice Chancellor, Bharatiya Engineering, Science & Technology Innovation University

(BESTIU), Andhra Pradesh delivered the memorial lecture on "Modern insights into Phytophthora evading control efforts". Dr Y R Sarma Memorial Trust - Best Farmer Award for 2022 was presented to Shri. P. V. Jose, Pullan House, Potta, Chalakudy, Thrissur district, Keralain recognition of his untiring efforts in promoting scientific management of pest and disease in spice-based cropping system among the farming community.. The Young Scientist Award for 2022 was presented to Dr Mohammed Faisal Peeran, Scientist, ICAR IISR, Regional Station, Appangala, for significant contributions in developing disease management strategies in spices. The Best Ph.D Thesis Award for 2022 is presented to Dr.Revathy K .

International Women's Day

ICAR- Indian Institute of Spices Research, Kozhikode celebrated International Women's Day on 8thMarch 2022. IISR fraternity expressed their unity in their dress code (Blue) and stood up for the # Break the Bias. Women Cell also organized an inspirational talk on "Swayamsidha: Growing beyond Equality" by Dr. Priya Nair Rajeev, Associate Professor, IIM, Kozhikode. The meeting was presided over by Dr. J. Rema, Director & Chairperson (Women Cell). The chief guest highlighted on how self sustained women should be, to achieve her dreams and importance of self assessment and self motivation. She also highlighted the development of under privileged women through micro enterprises, which can bringgreat changes in their socio-economic status.

World Environment Day

World Environment Day was organized at ICAR-Indian Institute of Spices Research, Kozhikode and an awareness lecture on "Mazhayarivu – Know the nature" was delivered by Shri. T. V. Krishna Prakash, noted Environmentalist. He stressed the importance of creating awareness about the role, relevance and human dependence on environment among the younger generation. The programme was followed by planting of cinnamon seedlings for establishing a new cinnamon block at the institute headquarters.

RAC Meeting

The third meeting of IX Research Advisory Committee of ICAR- Indian Institute of Spices Research, Kozhikode was held on 27th and 28th July, 2022. The meeting was chaired by Dr. N. K. Krishnakumar, former DDG (Horticultural Science), ICAR, New Delhi. The members of the RAC committee included Dr. H.C. Bhattacharya, Dr. Jitendra Kumar, Dr. Umesh Srivastava, Dr. V.G. Malathi, Dr. V. C. Mathur, Dr. Vikramaditya Pandey, ADG (Horticulture) and IMC members, Mr. Jayachandran and Mr. NanjundanBhojan.Dr. N.K. Krishnakumar inaugurated an essential oil extraction unit installed at ICAR-IISR, Chelavoor campus,. He also launched a web based application, IISR-eSOFT, a soil test based fertilizer recommendation for targeted yield of spices. Dr. Jitendra Kumar released food products viz., spice enriched finger millet cookies and ice-creams with finger millet as an ingredient flavored with ginger, turmeric and black pepper

Foundation Day

ICAR Indian Institute of Spices Research celebrated its Foundation Day, marking the occasion with several new initiatives. The foundation day programmes were inaugurated by Dr. A K Singh, Deputy Director General, (Horticultural Sciences) ICAR, New Delhi. Dr. S Jayasree Chairperson, Standing Committee (Health), Kozhikode Corporation, and former Principal, Govt arts and science college, Kozhikode was the guest of honour of the day . The meeting was presided by Dr. Vikramadithya Pandey, Assistant Director General (Horticultural Science II), ICAR.The foundation day lecture was delivered by Dr. Manoj P Samuel, Executive Director, Centre for Water Resources Development and Management (CWRDM), Kozhikode on the topic "Water- Quantity and quality management strategies in view of changing climate scenario'

Anti-terrorism Day

Anti-Terorrism Day 2022 was observed in a befitting manner by taking pledge solemnly. Staff members of ICAR-IISR, Kozhikode, ICAR-IISR, Regional station , Appangala, ICAR- IISR Experimental Farm and ICAR-Krishi Vigyan Kendra were participated in the event.

Webinar on Production Technology In Black Pepper

In commemoration of 75th Anniversary of India's Independence, ICAR-Indian Institute of Spices Research, Regional Station, Appangala, Madikeri organized webinar on "Production technology and biotic stress management in black pepper" for the members of Malenadu Agriculture Community, Thirthahalli, Shivamogga on 10.03.2022 through google meet platform.

RESEARCH PUBLICATIONS

1. Aarthi S, Suresh, J and Prasath D. 2022. Estimates of genetic variability, inter-character association, and path analysis in turmeric over environments. Journal of Spices and Aromatic Crops. 31 : 56-64.
2. Akshitha HJ, Prasath D, Umesha K, Mohammed Faisal P and Venkataravanappa V. 2022. Molecular characterization of ginger genotypes using RAPD and SSR markers. Journal of Horticultural Sciences. 17 : 95-102.
3. Aswathi AP, Raghav SB and Prasath D. 2022. Assessment of genetic variation in turmeric (*Curcuma longa* L.) varieties based on morphological and molecular characterization. Genetic Resources and Crop Evolution. 70: 147-158.
4. Bhai, R. S., Jeevalatha, A., Biju, C.N., Vinitha, K.B., Cissin, J., Rosana, O.B., Fayad, A., Praveena, R., Anandaraj, M., and Eapen, S.J. 2022. Sympatric occurrence of sibling *Phytophthora* species associated with foot rot disease of black pepper in India. Brazilian Journal of Microbiology53 : 801–818.
5. Bhat, A. I., Mohandas, A., Sreenayana, B., Archana, T.S., Jasna, K. 2022. Piper DNA virus 1 and 2 are endogenous pararetroviruses integrated into chromosomes of black pepper *(Piper nigrum* L). Virus Disease. 33:114–118.
6. Bhat, A.I., Aman, R. and Mahfouz, M. (2022) Onsite detection of plant viruses using isothermal amplification assays. Plant Biotechnology Journal, 20 : 1859-1873.
7. Biju, C.N., Bhat, A.I., Naveen, K.P. and Prasath, D. 2022. Identification of virus-free ginger germplasm accessions through symptomatology and molecular assay. Indian Phytopathology. 75:1143–1149.
8. Biju, CN, Krishnamurthy, KS and Bhat, AI. 2022. Physiological and biochemical response of ginger varieties to virus infection. Plant Physiology Reports. 27: 171–179.
9. Dinesh,R.,Srinivasan, V., Praveena, R., Subila, K.P., George, P., Das, A., Shajina, O., Anees, K., Leela, N.K., Haritha, P. 2022.Exploring the potential of P solubilizing rhizobacteria for enhanced yield and quality in turmeric (*Curcuma longa* L.). Industrial Crops and Products 189, 115826.
10. Dona AJ, Bhabhina NM, Vishudha M, Aarthi S, Sial P, Leela NK and Prasath D. 2022. Geographical indication turmeric (*Curcuma longa* L.): Comparative analysis of quality, nutraceuticals and bioactivities. Journal of Spices and Aromatic Crops. 31: 45-55.
11. Eapen SJ, Thomas L, Praveena R, Senthil Kumar CM. 2022. Pesticide regulation policy and global food safety for Indian spices. Journal of Consumer Protection and Food Safety, 17: 407–410.

12. George JK, Fayad MA, Shelvy S, Sheeja TE, Eapen SJ, Charles S, Rai A and Kumar D. 2022. Dataset of De Novo hybrid berry transcriptome profiling and characterization of Piper species (*Piper nigrum* and *Piper longum*) using Illumina and Nanopore sequencing. Data in brief. 42: 108261.

13. Jayashree E and T John Zachariah. 2022. Thin layer modeling for drying of black pepper in an agricultural waste fired dryer, The Pharma Innovation Journal, 11(6): 735-739.

14. Jayashree E and Nejma Basheer. 2022. Quality variation of turmeric during polishing in a power operated turmeric polisher. Journal of Spices and Aromatic Crops, 31(1): 34-44.

15. Jayashree Ettannil and Thondiath John Zachariah. 2022. Modeling for thin layer drying of black pepper (*Piper nigrum*) in a reverse flow dryer. Journal of Food Process Engineering. 46, e,14202

16. Jeevalatha, A., Zumaila, F., Biju, C.N. and Peeran, M.F. 2022. Multiplex PCR assay for simultaneous detection of *Phytophthora*, *Pythium* and *Fusarium* associated with foot rot and yellowing diseases of black pepper. Journal of Spices and Aromatic Crops, 31: 92-96.

17. Jeevalatha, A., Zumaila, F., Biju, C.N., Punya, K.C. 2022. Duplex recombinase polymerase amplification assay for simultaneous detection of *Pythium* spp. and *Ralstonia pseudosolanacearum* from ginger rhizomes, Crop Protection, 161:106057.

18. Neenu Maria George, Raghav SB and Prasath D. 2022. Direct in vitro regeneration of medicinally important Indian and exotic red ginger *(Zingiber officinale* Rosc.) and genetic fidelity assessment using ISSR and SSR markers. *In vitro* Cellular & Developmental Biology –Plant. 58: 551-558.

19. Nysanth N S, Divya, S., Nair, C.B., Anju, A.B., Praveena, R., Anith, K.N. 2022. Biological control of foot rot (*Phytophthora capsici* Leonian) disease in black pepper (*Piper nigrum* L.) with rhizospheric microorganisms, Rhizosphere,23,100578.

20. Prasath D, Nair RR and Anisha Babu R. 2022. Effect of colchicine induced tetraploids of ginger (*Zingiber officinale* Rosc.) on cytology, rhizome morphology, and essential oil content. Journal of Applied Research on Medicinal and Aromatic Crops, 31,100422.

21. Praveena R,Srekha K, Revathy R, Srinivasan V, Sarathambal C, Priya George, Subila K P, Dinesh R. 2022. New rhizobacteria strains with effective antimycotic compounds against rhizome rot pathogens and identification of genes encoding antimicrobial peptides. Rhizosphere, 22, 100515.

22. Praveena, R., Kozhamburath, A., Jeevalatha, A., Bhat, A.I. and Krishnamurthy, K.S. 2022. Association of *Exserohilum rostratum* with ginger: Morphological characterization, phylogenetic relationships and pathogenicity assays. Australasian Plant Pathology. 51: 333–344.

23. Revathy, K.A., Jiby, M.V and Bhat, A.I. 2022. Coat protein-mediated resistance to cucumber

mosaic virus subgroup IB in black pepper (*Piper nigrum* L.). In Vitro Cellular & Developmental Biology–Plant. 58:351–360.

24. Ankegowda S.J., M. Alagupalamuthirsolai, R. Sivaranjani, Mohammed Faisal Peeran, K.S. Krishnamurthy & M.S. Shivakumar (2022): Variability in essential oil constituents, antioxidant activities and yield of elite small cardamom lines (*Elettaria cardamomum* Maton) under moisture deficit stress, Journal of Essential Oil Bearing Plants, 25: 1062-1076

25. Sarathambal, C., Dinesh, R., Srinivasan, V., Sheeja, T.E., Jeeva, V., Manzoor, M. 2022. Changes in bacterial diversity and composition in response to co -inoculation of Arbuscular mycorrhizae and Zn solubilizing bacteria in turmeric rhizosphere.Current Microbiology. 79 :4.

26. Sarathambal, C., Jeevalatha, A., Sivaranjani, R., Biju, C.N., Charles, S., Srinivasan, V., George, P., Peter, B. and Radhika, R. 2022. Arbuscular mycorrhizal colonization alters biochemical, molecular defense responses and root exudate composition against *Phytophthora capsici* infection in black pepper. Rhizosphere. 25:100651.

27. Sarathambal, C., Srinivasan, V., Dinesh, R., Jeevalatha, A., Prabhu, G. and Shahana, A.P. 2022. Bajra Napier Hybrid: a perennial grass is an effective host for mass multiplication of Arbuscular Mycorrhizal inoculum. Range management & Agroforestry. 43 : 80-87.

28. Senthil Kumar CM, Jacob TK, Devasahayam S, Sharon D'Silva, Geethu C. 2022. Field evaluation of *Lecanicillium psalliotae* and development of an integrated pest management strategy against *Sciothrips cardamomi*. Biological Control, 165: 104822.

29. Sheeja TE, Praveena R,Vijesh Kumar IP, Sarathambal C, Shajina O, Hridya Vijay, Nandana Rajeev, PrashinaMol P, Sreena CP, Srinivasan V, Dinesh R. (2022) A novel Zn transporter gene (ClZIP1) from turmeric (*Curcuma longa* L.) and expression analysis in presence of a Zn-solubilizing bacteria. Plant Molecular Biology Reporter. 40:500–515.

30. Shivakumar MS, Aarthi S, Akshitha HJ, Saji KV, Krishnamurthy KS and Sasikumar B. 2022. Characterization of black pepper (*Piper nigrum* L.) varieties and landraces/farmers' selections for spike and berry traits. Journal of Spices and Aromatic crops. 31: 134-142

31. Sivaranjani R and Zachariah TJ (2021). Elicitors induced changes in essential oil constituents of turmeric (*Curcuma longa* L.) rhizome. Journal of Horticultural Sciences. 7: 237-244.

32. Sivaranjani. R, Zachariah TJ, Alagupalamuthirsolai M and Thankamani CK (2022). Foliar Spray of Elicitors on Physiology and Quality Responses in Turmeric (*Curcuma longa* L.). Indian Journal of Agricultural Research. 56 : 567-572.

ONGOING PROJECTS

- **Project I: Characterizing genetic resources to identify core collections and their long-term conservation**

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

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

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

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

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

Project II: Genomics assisted breeding for trait specific varieties in spices

1. Gen. XXXI (813): Breeding black pepper for high yield, quality and resistance to stresses (2012-2025) [Dr. M.S. Shiva Kumar, Dr. K. V. Saji, Dr. K.S. Krishnamurthy, Dr. R. Gobu&Mr.Mukesh Sankar S.] [External support: Dr. A. Jeevalatha & Dr. S. J. Ankegowda]

2. 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, Dr. Mohammed Faisal Peeran & Dr. HonappaAsangi]

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

4. Biotech. XV (813): Identification and characterization of gene editing targets for disease resistance in ginger (2021-2024)(Dr. P. S. Divya, &Dr. C.N. Biju) (External support: Dr. T.E. Sheeja & Dr. D. Prasath)

5. 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]

6. ICAR-CIB-III: Genomics-assisted identification of trait-specific markers for major biotic and abiotic stresses and development of core collections of black pepper (2021-2026) (Dr. T. E. Sheeja, Dr. A.I. Bhat, Dr. K.S. Krishnamurthy, Dr. A. Jeevalatha, Dr. M.S.Shivakumar, Ms. Sona Charles, Dr. R. Gobu, Dr. U.B.Angadi & Dr. Sunil Kumar)

7. DUS project (2010-2023) [Dr. K. V. Saji, Dr. D. Prasath, Dr. S. Aarthi & Dr. H.J. Akshitha] (External support: Dr. M. S. Shivakumar & Dr. HonnappaAsangi)

8. Biotech. XVI (813): Development of data-driven pipelines and tools for multiple high throughput sequencing data from spices (2022-2025) (Ms. Sona Charles & Dr. T. E. Sheeja)

Project III: Enhancing input-use efficiency and productivity in spices through smart farming

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 & Dr. M.S. Shivakumar]

2 .
SSC VI (813): Nutrient cycling and soil C sequestering potential of spice crops under different management systems (2011-2023) [Dr. V. Srinivasan, Dr. R. Dinesh & Dr. S.J. Ankegowda](External support: Dr. M. Alagupalamuthirsolai)

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 & Dr. C. Sarathambal](CCPI: Dr. V. Sajith, NIT-K)

4. ICAR Mega Seed Project (Agr. XXXVII(813): Production of nucleus planting materials of improved varieties of spice crops (2006-2025) [Dr. K. Kandiannan, Dr. V. Srinivasan, Dr. P. Rajeev, Dr. Sharon Aravind,Dr. Ljio Thomas, Dr. HonnappaAsangi& Dr. H. J. Akshitha] (External support: Dr. S.J. Ankegowda, Dr. K.V. Saji, Dr. D. Prasath, Dr. R. Praveena,Dr. M. Alagupalamuthirsolai & Mr. V. A. Muhammad Nissar)

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

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 & Dr.M.Murugan)

7. Biochem. X (813): Study on spike abscission: Developing chemically induced method for harvesting black pepper (*Piper nigrum* L.) (2018-2023) [Dr. Anees, K.,Dr. K.S. Krishnamurthy & Dr. C. N. Biju]

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)

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]

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]

11. NICRA-CPPHT 1: NICRA Strategic Component Project: Climate change impact, mitigation and climate resilience studies in black pepper, ginger and turmeric (2021-2026) [Dr K.S. Krishnamurthy, Dr U. Surendran, Dr V. Srinivasan, Dr N.K. Leela, Dr M. Alagupalamuthirsolai & Dr Sharon Aravind]

Project IV: Value addition in spices through post-harvest interventions and product diversification

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)

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

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) & Ms.Alfiya P]

Project V: Ensuring food safety in spices through value chain management

4. 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 & Ms. R. Sivaranjani]

5. 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]

Project VI: Bio-intensive management of pests and diseases in spices

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

2. Integrated management of mealy bug (Pseudococcidae: Hemiptera) infesting black pepper (2019 – 2024) [Dr. M. Balaji Rajkumar & Dr. C. M. Senthil Kumar]

3. KSCSTE-CP-1: Development of a *Metarhizium* sp.based bio-pesticide formulation for the

control of shoot borer, *Conogethespunctiferalis* infesting cardamom, ginger and turmeric (2021-2024)[Dr. C. M. Senthil Kumar, Dr. M. Balaji Rajkumar & Dr. R. Praveena]

4. Nema. VII (813): Prevalence of lesion nematodes in turmeric growing tracts of India and their economic significance (2018-2023) [Dr. C. Sellaperumal, Dr. Santhosh J Eapen & Dr. R. Praveena]

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]

6. Path. XXVIII (813): Novel strategies for managing bacterial wilt and soft rot diseases of ginger (2018-2024) [Dr. C. N. Biju, Dr. Mohammed FaizalPeeran & Dr. Divya P.S.]

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)

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)

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]

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

11. SERB CP I: Development of on-site detection kits for viruses and oomycetes infecting black pepper (*Piper nigrum*) (2021-2024) [Dr.A. Ishwara Bhat and Dr. A. Jeevalatha]

12. Path XXXII (813): Diversity analysis, survival studies and management of *Pythium spp* infecting ginger(2023-2026) [Dr. R. Praveena, Dr. C. N. Biju & Dr. A Jeevalatha]

13. Nema. VIII (813): Multimodal approach to manage nematode pests infesting Ginger (*Zingiber officinale* Rosc.) (2023-2028) [Dr. Manimaran, B.,Dr. C. Sellaperumal & Dr. Gobu] (External support: Dr. D. Prasath, Dr. A. Ishwara Bhat, Dr. C.N.Biju, Dr. R. Praveena & Dr. C. Sarathambal)

Project VII:Empowering spice stakeholders through skilling, entrepreneurship management and policy inputs

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)

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)

3. DBT - Kisan Biotech Hub Project (2020-2023) (Dr.V. Srinivasan, Dr. Lijo Thomas & Dr. P. Rajeev)

Other Externally Funded Projects

1. Institute Technology Management –Business Planning and Development Unit

2. RKVY- CIB-1: Production and popularization of orthotropic shoots and bush pepper for increasing black pepper productivity (2022-2023) [Dr M S Shivakumar, Dr. S. J. Ankegowda, Dr. H.J. Akshitha, Dr. HonnappaAsangi ,Dr. Mohammed Faisal Peeran & Dr. K. V. Saji]

3. RKVY-CP-1: Establishment of an advanced facility for production of beneficial microflora for sustainable spice production in malnad region (2021 – 2024) [Dr. Mohammed Faisal Peeran, Dr Balaji Rajkumar, Dr. S. J. Ankegowda & Dr. H.J. Akshitha]

4. RKVY-CP-2: An advanced centre for mass production of beneficial microflora for sustainable agriculture (2021 – 2024) [Dr. Santhosh J Eapen, Dr. R. Praveena, Dr. C. M. Senthil Kumar & Dr. C. Sarathambal]

STAFF LIST

SCIENTIFIC STAFF, KOZHIKODE

1.	Dr. R Dinesh	Director
2.	Dr. C K Thankamani	Principal Scientist (Agronomy) Head I/C
3.	Dr. N K Leela	Principal Scientist (Org. Chemistry)
4.	Dr. K Kandiannan	Principal Scientist (Agronomy)
5.	Dr. K S Krishnamurthy	Principal Scientist (Plant Physiology)
6.	Dr. A Ishwara Bhat	Principal Scientist (Plant Pathology) & HD I/C
7.	Dr. K V Saji	Principal Scientist (Eco. Botany) & HD I/C
8.	Dr. P Rajeev	Principal Scientist (Agri. Extension) & HD I/C
9.	Dr. V Srinivasan	Principal Scientist (Soil Science)
10.	Dr. T E Sheeja	Principal Scientist (Biotechnology)
11.	Dr. E Jayashree	Principal Scientist (Agricultural Engineering)
12.	Dr. D Prasath	Principal Scientist (Horticulture)
13.	Dr. C M Senthil Kumar	Principal Scientist (Agricultural Entomology)
14.	Dr. C N Biju	Senior Scientist (Plant Pathology)
15.	Dr. Lijo Thomas	Senior Scientist (Agricultural Economics)
16.	Dr. Divya P.S	Senior Scientist (Agricultural Biotechnology)
17.	Dr. Anees K	Senior Scientist (Plant Biochemistry)
18.	Dr. R Praveena	Senior Scientist (Plant Pathology)
19.	Dr. Jeevalatha A	Senior Scientist (Crop Protection)
20.	Dr. C Sarathambal	Senior Scientist (Agricultural Microbiology)
21.	Dr. C Sellaperumal	Senior Scientist (Nematology)
22.	Dr. Sharon Aravind	Scientist (Spices Plantation Medicinal & Aromatic Plants)
23.	Dr. Maneesha S R	Scientist (Fruit Science)
24.	Dr. Muhammed Azharudheen T P	Scientist (Genetics & Plant Breeding)
25.	Dr. S Aarthi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
26.	Mr. V A Muhammed Nissar	Scientist (SPMAP)
27.	Ms. R Sivaranjani	Scientist (Plant Biochemistry)
28.	Dr. Gobu R	Scientist (Genetics & Plant Breeding)
29.	Ms. Sona Charles	Scientist (Agricultural Bioinformatics)
30.	Ms. Alfiya P V	Scientist(Agriculture Structure & Process Engg.)
31.	Mr. Mukesh Sankar S	Scientist (Genetics & Plant Breeding)
32.	Dr. Manimaran B	Scientist (Nematology)

ADMINISTRATIVE STAFF, CHELAVOOR

1.	Sri. T E Janardhanan	Senior Administrative Officer
2.	Sri. Babu R.K	Senior Finance & Accounts Officer
3.	Sri. P Sundaran	Administrative Officer
4.	Ms. C K Beena	Private Secretary
5.	Sri. Sunil V.C	Assistant Administrative Officer
6.	Sri. V VSayed Mohammed	Assistant Administrative Officer
7.	Ms. M Seema	Upper Division Clerk
8.	Ms. Rebeena N	Upper Division Clerk
9.	Mr. P K Rahul	Upper Division Clerk

TECHNICAL, CHELAVOOR

1.	Mr. John George	Chief Technical Officer
2.	Mr. R. Bharathan	Chief Technical Officer
3.	Mr. K Jayarajan	Chief Technical Officer
4.	Ms. N Prasannakumari	Asst. Chief Technical Officer
5.	Mr. A Sudhakaran	Senior Technical Officer
6.	Mr. K Krishnadas	Technical Officer
7.	Ms. P K Chandravally	Technical Officer
8.	Ms. Priya George	Technical Officer
9.	Mr. Vijesh Kumar I.P	Technical Assistant
10.	Ms. N Karthika	Senior Technician
11.	Mr. O G Sivadas	Senior Technician
12.	Mr. V S Binoy	Senior Technician
13.	Mr. Vishnu B	Technician
14.	Ms. Shajina O	Technician

SUPPORTING STAFF, CHELAVOOR

1.	Mr. Abhi Balagopal K P	Skilled Support Staff

IISR EXPERIMENTAL FARM, PERUVANNAMUZHI (TECHNICAL)

1.	Mr. E S Sujeesh	Asst. Chief Technical Officer
2.	Mr. PavanGowda M	Senior Technical Officer
3.	Mr. T R Sadasivan	Senior Technical Assistant
4.	Ms. Rejina P Govind	Senior Technician
5.	Mr. Hareesh B T	Senior Technician
6.	Mr. Rasmish A R	Senior Technician
7.	Mr. Nikhil C M	Technician
8.	Mrs. P N Kausalya	Technician

- **ADMINISTRATIVE**

1. Mr. K Faisal — Personal Assistant

SUPPORTING STAFF

1. Mr. Vijesh V — Skilled Support Staff

KVK - SCIENTIFIC

1. Dr. P Ratha Krishnan — Programme Coordinator

KVK - TECHNICAL

1. Dr. P S Manoj — Chief Technical Officer (SMS-Horticulture)
2. Dr. S Shanmugavel — Chief Technical Officer (SMS -Veterinary Science)
3. Mr. K M Prakash — Chief Technical Officer (SMS - Agronomy)
4. Dr. B Pradeep — Asst. Chief Technical Officer (SMS - Fisheries)
5. Ms. A Deepthi — Asst.Chief Technical Officer (SMS - Home Science)
6. Dr. K K Aiswariya — Asst. Chief Technical Officer (SMS - Plant Protection)
7. Mr. T C Prasad — Technical Officer (Driver-cum-Mechanic)
8. Mr. C K Jayakumar — Technical Officer (Programme Assistant)(Computer)

KVK – SUPPORTING

1. Mr. C Ravindran — Skilled Support Staff

IISR – REGIONAL STATION, APPANGALA

SCIENTIFIC

1. Dr. S J Anke Gowda — Head I/C R. Station, Appangala
2. Dr. Balaji Rajkumar — Scientist (Agri. Entomology)
3. Dr. Muhammed Faisal Peeran — Scientist (Plant Pathology)
4. Dr. H J Akshitha — Scientist (SPMAP)
5. Dr. Honnappa Asangi — Scientist (SPMAP)
6. Dr. M S Shivakumar — Scientist (Genetics & Plant Breeding)

ADMINISTRATION

1. Mr. P T Jayaprakash — Upper Division Clerk

TECHNICAL

1. Sri. H C Rathish — Technical Officer (Driver)
2. Sri. N Cholurappa — Senior Technician
3. Sri Ranjith P.B — Technician

SUPPORTING

1. Sri. Marigowda — Skilled Support Staff
2. Mr. Sachin K.P — Skilled Support Staff

Rainfall data 2022

ICAR – Indian Institute of Spices Research, Main campus, Kozhikode

Month	Rainfall (mm)	Number of rainy days
January	21.4	1
February	0.0	0
March	7.8	2
April	132.3	7
May	418.3	18
June	327.4	15
July	599.2	22
August	386.2	13
September	270.5	13
October	121.0	8
November	132.7	6
December	97.2	4
Total	**2514.0**	**109**

ICAR-IISR Experimental Farm, Peruvannamuzhi

Month	Rainfall (mm)	Number of rainy days
January	0.0	0
February	0.0	0
March	56.0	5
April	114.5	11
May	563.0	23
June	650.2	25
July	1382.5	28
August	895.2	22
September	524.6	13
October	354.3	15
November	245.2	12
December	36.6	3
Total	**4822.1**	**157**

ICAR- IISR, Regional Station, Appangala, Madikeri

Month	Rainfall (mm)	Number of rainy days
January	0.0	0
February	0.0	0
March	0.0	0
April	102.6	7
May	314.0	13
June	208.8	17
July	1284.0	29
August	932.4	25
September	260.8	19
October	191.8	14
November	45.2	4
December	9.2	2
Total	**3348.8**	**130**

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

NATIONAL AWARD OF EXCELLENCE FOR AGRICULTURAL INSTITUTIONS

SARDAR PATEL OUTSTANDING ICAR INSTITUTION AWARD 2021
(For Small Institute Category)

ICAR-Indian Institute of Spices Research, Kozhikode, Kerala

CITATION

ICAR-Indian Institute of Spices Research, Kozhikode, Kerala has been awarded Sardar Patel Outstanding ICAR Institution Award 2021 in the category of Small Institute. The ICAR-Indian Institute of Spices Research (ICAR-IISR), Kozhikode, Kerala is an institute with international repute with primary focus on developing sustainable, cutting-edge technologies for spice cultivation in its mandate crops and product diversification through value addition. As the custodian of the world's largest repository of germplasm in its mandate crops, the institute has been able to harness this priceless asset for furthering its prioritized interventions. The genetic gains embedded in the varieties developed by the institute enhance profitability of spice farming for primary producers. The institute has displayed a steadfast commitment to technology development with focus on prioritized needs of its clientele. The solutions and technology inputs ranging from microbial encapsulation process, designer micronutrients, product processing protocols and comprehensive management packages for diverse ecosystems and farming systems are both critically acclaimed and widely adopted. The institute also house the largest spice research network in the country (AICRPs) that engages in nationwide collaborative and interdisciplinary research in spices. The technology disseminated, and extension services offered by the institute has remained sensitive to emerging needs of its stakeholders and has made visible and distinct impact across the country. The institute has successfully played the role of facilitator in harnessing the commercial potential offered by the spice value chains by handholding commercial ventures and start-up entrepreneurs. A special focus on socially and geographically disadvantaged stakeholder community has resulted in a host of effective intervention programmes targeting improvement in the quality of life for the vulnerable communities. With its persistent pursuit of research excellence, the institute has played a decisive and fundamental role in shaping the spice economy of the country and in making India a global leader in spice sector. An ISO 9001:2015 certified institution, ICAR-IISR stand testimony to the immense societal benefits from engineering to a creative blend of innovative science, quest for excellence and commitment to national

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