भाकृअनुप
ICAR

1975 - 2025 ICAR-INDIAN INSTITUTE OF SPICES RESEARCH KOZHIKODE

Spicing up the Nation's progress

वार्षिक प्रतिवेदन
ANNUAL REPORT
2024

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PREFACE

It is with immense pride and gratitude that I present the Annual Report of ICAR-Indian Institute of Spices Research for 2024, a year of special significance as we celebrate the Golden Jubilee of our Institute. For 50 years, we have dedicated ourselves to advancing research, innovation, and contributing to the growth of the spice economy in India. Our journey has been marked by stellar achievements and transformative contributions that have shaped the spice sector.

The year2024 has been remarkable, with key milestones reaffirming our commitment to scientific excellence and technology dissemination. We issued 38 licenses for various technologies, demonstrating increasing industry interest in our research. Collaborative partnerships with institutions such as ICAR-CTCRI and ICAR-NBAIR, and a strategic agreement with the Spices Board, have bolstered our outreach and impact, ensuring that our research reaches spice-growing regions across the country.

A significant highlight of the year was the release of two new spice crop varieties: IISR Surasa, a ginger variety developed through a farmer participatory approach, and IISR Surya, a turmeric variety distinguished by its unique light yellow colour. These varieties represent our commitment to addressing farmers and consumers' needs through targeted breeding and varietal improvement programs.

Despite these achievements, 2024 presented challenges, particularly the devastating landslide in Wayanad. This tragedy highlighted the ecological sensitivities associated with spice farming, strengthening our resolve to promote research that mitigates climate risks and reduces the ecological footprint of spice cultivation.

Our efforts in the North Eastern Hill (NEH) region have gained momentum through collaborations with public and NGO sectors, particularly in strengthening seed supply chains. Tata Trust-funded interventions and a Memorandum of Understanding with the Meghalaya Farmer Empowerment Commission have played a crucial role in enhancing seed systems and expanding our presence in the region.

Entrepreneurship development in the spice sector remains a priority, with programs like 'UDAYAM' fostering agripreneurship among women, youth, and students. Our training initiatives continue to be in high demand, equipping stakeholders with marketable skills. The management of Intellectual Property (IP) has become increasingly important for research institutions. Our efforts in identifying, valuing, and protecting intellectual assets have yielded positive results.

I extend my heartfelt gratitude to Dr. Himanshu Pathak, Director General of ICAR and Secretary DARE, for his continuous support and guidance. I also express my sincere thanks to Dr. S K Singh, Deputy Director General (Horticultural Sciences), for his invaluable leadership and encouragement. Special thanks to Dr. Sudhakar Pandey, Assistant Director General (Flowers, Vegetables, Spices, Medicinal Plants), for his valuable insights and support. My sincere thanks to the editors for their meticulous efforts in compiling this report.

With determination and optimism, we look forward to another year of impactful research and continued contributions to the spice sector.

Kozhikode
31 January 2025

R. Dinesh
Director

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कार्यकारी सारांश

काली मिर्च

आई आई एस आर, प्रायोगिक प्रक्षेत्र, पेरुवण्णामुषि, कोषिक्कोड, केरल में तीन हज़ार पांच सौ अक्सेशनों का रखरखाव किया जा रहा है। वैकल्पिक जर्मप्लासम साइट, सीएचईएस, चेताली, कर्नाटक में 542 अक्सेशनों का रखरखाव किया जा रहा है।

भारत के विभिन्न भागों से इक्कीस पाइपर अक्सेशनों को एकत्र करके जर्मप्लासम संग्रह में जोड़ा गया, जिसमें गोवा से लिये लीफ टिप म्यूटन्ट अक्सेशन भी शामिल है।

सैंतालीस नवीन जीन आधारित एसएसआर मार्करों का उपयोग करके 22 पाइपर जीनोटाइप के बीच आनुवंशिक विविधता और वर्गीकरण संबंधों के विश्लेषण से सभी पाइपर प्रजातियों में इन मार्करों की उच्च क्रॉस प्रजाति हस्तांतरणीयता का पता चला, जिसमें पाइपर मैग्नोफिकम में 56.1% से लेकर पी. आर्गिरोफिलम में 97.6% तक स्थानांतरणशीलता शामिल है।

प्रिंसिपल कम्पोनन्ट अनालिसिस और UPGMAआधारित क्लस्टरिंग ने पाइपर जीनोटाइपों को अलग- अलग समूहों में विभाजित किया, जो पैटेर्न भौगोलिक उत्पत्ति, वृद्धि की आदत और स्पाइक अभिविन्यास के आधार पर अपेक्षित संघों के अनुरूप थे। पाइपर प्रजातियों के बीच संबंधों की जोड़ीदार तुलना मेंपी. लोंगम और पी. हैपनियम, पी. कोलुब्रिनम और पी. मैग्निफिकम और पी. एटेनुआटम और पी. आर्गीरोफिलम के बीच सबसे निकट आनुवंशिक संबंध देखा गया।

मोर्फो फिसियोलोजिकल और उपज-संबंधी लक्षणों के लिए आनुवंशिक परिवर्तनशीलता के विश्लेषण से पता चला कि अक्सेशन 7211, अक्सेशन 1495, 1343 और 4132 के साथ कम स्टोमाटों कीसंख्या, उच्च मोम मात्रा, इष्टतम स्पाइक लंबाई, उच्च सेटिंग प्रतिशत, कुशल दैहिक अनुकूलन और सीमित पानी में स्थिर उपज जैसी विशेषताएं हैं। ये गुण उन्हें सूखा प्रतिरोधी प्रजनन के लिए आशाजनक उम्मीदवार बनाते हैं।

काली मिर्च किस्मों की जड़ की रूपात्मक और शारीरिक विशेषताओं से पता चला कि आईआईएसआर शक्ति, आईआईएसआर तेवम, और पौर्णमी में द्वितीयक जड़ों की संख्या सबसे अधिक थी, प्राथमिक जड़ की लंबाई सबसे लंबी थी, सबसे अधिक ज़ाइलम वाहिकाएं, सबसे चौडी स्टील और प्रति क्रॉस-सेक्शन में जड़ के रोमों की संख्या सबसे अधिक थी। ये विशेषताएं संभवत: अजैविक और जैविक दोनों तरह के तनावों के प्रति उनकी सहनशीलता के लिए जिम्मेदार है।

पोषक तत्वों की कमी वाले काली मिर्च के पौधों में DHN और SOD (Cu/Zn) जीनों के विभेदक अभिव्यक्ति विश्लेषण से संकेत मिलता है कि पोषक तत्वों से उपचारित पौधों की तुलना में अनुपचारित पौधों में DHN (0.182167) और SOD (Cu/Zn) 1 (0.276114) दोनों जीनों के लिए अभिव्यक्ति का स्तर काफी अधिक था।

रूपात्मक, जैव रासायनिक और डीएनए फिंगरप्रिंटिंग विश्लेषण के आधार पर मेघालय में उगाई जाने वाली लोंग पेप्पर की पहचान पाइपर पीपुलोइड्सके रूप में की गई। अद्वितीय रूपात्मक विशेषताएं, विशिष्ट रासायनिक प्रोफाइल, आर्थिक व्यवहार्यता और अंतर-फसल प्रणालियों के लिए उपयुक्तता पी. पीपुलोइड्स को इस क्षेत्र के लिए एक आशाजनक वैकल्पिक फसल के रूप में स्थापित करती है।

शीघ्र पकने वाली काली मिर्च की संकर किस्म 'आईआईएसआर चंद्रा' को 23 गैर-विशिष्ट लेइसेंसिंग समझौतों के माध्यम से व्यावसायिक खेती के लिए उपलब्ध कराया गया है।

ग्यारह काली मिर्च जीनोटाइपों के खेत मूल्यांकन में जीनोटाइप अक्से. 4226, 1277 और 1495 ने दैहिक और उपज मापदंडों के आधार पर सबसे अच्छा सूखा सहनशीलता का प्रदर्शन किया।

सुपारी, नारियल और जायफल पर काली मिर्च

फाइटोफ्थोरा वियुक्तियां, पी. कैप्सीसी वियुक्ति 09-03 और पी. ट्रॉपिकालिस वियुक्ति 98-177 के क्रॉस संक्रमण अध्ययन से पता चला कि वे जायफल पर अत्यधिक रोगजनक थे।

फाइटोफ्थोरा कैप्सीसी और पी. ट्रापिकालिस संक्रमित काली मिर्च में हैप्लोटाइप्स का विश्लेषण करने पर माइटोकॉन्ड्रियल और न्यूक्लियर जीन से कुल 30 हैप्लोटाइप्स की पहचान की गई। न्यूक्लियर जीन जैसे *EF1-α*, एनोलेस *HSP90*, *TigA* और *Ura3* और माइटोकोन्ड्रियलजीन जैसे *Cox2* और*Nad5*में अद्वितीय हैप्लोटाइप्स शामिल होता है, जिनमें EF1-αसबसे अधिक विविधता दिखाता है।

पी. कैप्सीसी और पी. ट्रॉपिकालिस वियुक्ति के साथ कवकनाशी संवेदनशीलता के अध्ययन ने डायथियोकार्बोमेट्स (इप्रोवालिकार्ब-प्रोपिनेब 0.2%, प्रोपिनेब 0.25%, सिमोक्सानिल मैंकोज़ेब 0.2%, मेटालक्सिल मैंकोज़ेब 0.125%) बेनज़ामाइड्स (फ्लोपिकोलिडे-प्रोपानोकार्ब 0.125%), कोप्पर ऑक्सिक्लोराइड (0.25%) और बोर्डियो मिश्रण (1%) के प्रति संवेदनशील दिखाई।

फाइटोफ्थोरा स्पीसीस और पिथियम स्पीसीस के एक साथ पता लगाने के लिए एक ड्युप्लक्स रीकॉम्बिनेस पॉलीमरेज़ एम्प्लिफिकेशन-लेटरल फ्लो एसे (आरपीए-एळएफए) प्रोटोकॉल विकसित किया गया।

छानबीन अध्ययनों से संकेत मिला कि जर्मप्लासम अक्सेशनों 7492, 7445, 7457, 7467, 7439, 7657, 7482, ने फाइटोफ्थोरा कैप्सीसी के प्रति प्रतिरोध दिखाया और 7548,7585, 7492, 7445, 7503, 7563, 7401, 7478, 7577, 8043, 7457 आदि अक्सेशनों ने पी. ट्रॉपिकालिस के प्रति प्रतिरोध दिखाया।

काली मिर्च किस्म श्रीकरा से एनपीआर३ जीन को प्रवर्धित, क्लोन और अनुक्रमित किया गया और काली मिर्च जीनोम डेटाबेस के विरुद्ध प्राप्त अनुक्रम के विश्लेषण से चार अलग-अलग आइसोफॉर्म की पहचान की गई। एनपीआर 3 जीन अनुक्रम का उपयोग CRISPR/Cas के माध्यम से जीनोम संपादन के लिए गाइड RNA (gRNA) को डिज़ाइन करने के लिए किया गया।

भारत में पहली बार काली मिर्च विषाणु एफ (बीपीवीएफ) की पहचान की गई तथा इसके संपूर्ण जीनोम का अनुक्रमण किया गया। बीपीवीएफकी संवेदनशील पहचान के लिए आरटी-पीसीआर और आरटी-रीककॉम्बिनेज़ पॉलीमरेज़ एम्प्लिफिकेशन (आरटी-आरपीए) पर आधारित नैदानिक परीक्षण विकसित किया गया।

पाइपर येल्लो मोटिल वायरस का पता लगाने के लिए लेटरल फ्लॉ इम्यूनो एस्से प्रोटोकॉल (एलएफआईए) विकसित किया गया था।

राडोफोलस सिमिलिस, मेलोयिडोगाइन इनकोग्निटा और प्राटिलेंकस स्पीसीस के प्रति नेमटिसाइड फ्लुओज़ाइनडोलिज़िन के इन विट्रो छानबीन करने परएम. कोग्निटा, आर. सिमिलिस और प्राटिलेंकस स्पीसीस का मृत्यु दर क्रमश: 100, 94 और 50 प्रतिशत अंकित किया गया।

पोल्लु बीटल (लंका रामकृष्णै) के प्रति नई पीढ़ी के कम जोखिम वाले कीटनाशकों की जांच से पता चला कि क्लोरेंट्रानिलिप्रोल 0.3 मि. लि./लि. को कीट प्रबंधन में प्रभावी पाया गया।

खेत की परिस्थितियों में जड़ मीली बग प्लानोकोकस लिलासिनस के प्रति कम जोखिम वाले कीटनाशकों के दूसरे वर्ष के मूल्यांकन से सूचित किया कि क्लोथियानिडिन 50 WDG @ 1g/Lके प्रयोग से ड्रेंचिंग के बाद२०वें दिन मीली बग की अधिकतम संख्या में कमी आई, इसके बाद स्पाइरोटेरामाट 15.31 OD @ 1 mL/L का प्रयोग किया गया।

इलायची

आईआईएसआर क्षेत्रीय स्टेशन, अप्पंगला के राष्ट्रीय सक्रिय जर्मप्लासम साइट (एनएजीएस) में छ: सौ पच्चीस अक्सेशनों का रखरखाव किया जा रहा है।

नमी-तनाव-सहिष्णु इलायची प्रजातियों के मूल्यांकन परीक्षणों से पता चला कि प्रजाति 584058-3 ने सबसे अधिक उपज दी, जिसमें प्रति पौधा 860 ग्राम ताज़ा उपज और 149 ग्राम सूखी उपज थी।

इलायची संकर की सीवीटी मेंसंकर बोल्ड×आईसी 547219 ने सबसे अधिक उपज अंकित की, जिससे 2784.1 कि.ग्रा./हेक्टर ताज़ा उपज और 517.7 कि. ग्रा./हेक्टर सूखी उपज प्राप्त हुई, उसके बाद (जीजी×बोल्ड)×अप्पंगला1(1310.0 कि.ग्रा./हेक्टर ताज़ा, 285.1 कि. ग्रा./हेक्टर सूखी

उपज) का स्थान रहा।

पांच पर्ण ब्लाइट-सहिष्णु जीनोटाइपें-आईसी 349650, आईसी 547222, आईसी 547156, आईसी 349649 और आईसी 349648, प्रतिरोधी चेक अप्पंगला१, न्जंल्लानी ग्रीन गोल्ड और एक संवेदनशील चेकके साथ बहुस्थानीय परीक्षण ने 10.6% से 22.8% तक रोग का प्रकोप दिखाया, जिसमें आईसी 547222 में सबसे कम आपतन और आईआईएसआर विजेता में सबसे अधिक आपतन था।

छोटी इलायची की किस्मों, आईआईएसआर मनुश्री (कर्नाटक और केरल के लिए अनुशंसित) और आईआईएसआर कावेरी (कर्नाटक के लिए अनुशंसित) को भारत सरकार, कृषि और किसान कल्याण मंत्रालय द्वारा अधिसूचित किया गया।

मानसून से पूर्व और पश्चात् टेबुकोनाज़ोल@1मि. लि./लि या मेटालक्सिल+मैंकोज़ेब @1.25 ग्राम/लि. का छिडकाव करने से इलाची में प्रकंद गलन का आपतन काफी कम हो गया।

मानसून पूर्व टेबुकोनाज़ोलछिड़काव (1 मि.लि./लि) और मानसून पश्चात् बैसिलस एट्रोफेस और बैसिलस एमिलोलिक्विफासिन्स (0.5%) का छिड़काव और ड्रेंचिंग करने पर प्रकंद गलन का प्रकोप सबसे कम हो गया, तथा रोग सूचकांक (पीडीआई) 10% रहा।

हेक्साकोनाज़ोल 5% एस सी के साथ पत्तियों पर दो बार छिडकाव करने से, एक मानसून से पहले (जून) और एक मानसून के बाद (सितंबर),इलायची के पर्ण ब्लाइट रोग का प्रभावी ढ़ंग से प्रबंधन किया गया।

कम जोखिम वाले कीटनाशकों (स्पिनोसाद, फ्लूबेंडियामाइड, क्लोरेंट्रानिलिप्रोल @ 1.0 मि. लि./लि. और एक नीम आधारित वनस्पति कीटनाशक (3.0 मि. लि./लि) के छिडकाव अनुसूची i). जनवरी-फरवरी, मार्च-अप्रैल और सितंबर -अक्तूबर और ii) फरवरी-मार्च और सितंबर-अक्तूबर प्ररोह और कैप्स्यूल क्षति को कम करने में प्रभावी थे।

बडी इलायची

फूरकी रोग पैदा करने वाले कार्डमोम बुशी ड्वार्फ वाइरस (सीबीडीवी) का तेज़ी से पता लगाने के लिए एक रीकॉम्बिनेज़ पॉलीमरेज़ एम्प्लिफिकेशन (आरपीए) परख विकसित की गई थी। आर पी ए परख पारंपरिक पी सी आर की तुलना में 1000 गुना अधिक संवेदनशील और तेज़ थी, जो बड़े पैमाने पर इंडेक्सिंग के लिए इसकी उपयुक्तता को दर्शाता है।

अदरक

फील्ड जीन बैंक में छह सौ अड़सठ अक्सेशनों का रखरखाव किया जा रहा है।

रोग सहिष्णु के लिए अदरक की प्रजातियों पर सीवीटी ने दिखाया कि अदरक म्यूटेंट आर 1.25/4 ने सबसे अधिक उपज (15.6 टन/हेक्टर) अंकित की, जो कि नियंत्रण, आईआईएसआर वरदा के बराबर थी। कृत्रिम टीकाकरण अध्ययन से पता चला है कि अदरक म्यूटेंट आर 1.25/4 और एचपी 0.5/2 ने क्रमश: पिथियम माइरियोटिलम और रालस्टोनिया सोलानसीरम के प्रति हल्की संवेदनशीलता प्रदर्शित की।

इन विट्रो पौधों (ऊतक संवर्धन से प्राप्त) और इन विवो पौधों (प्रो-ट्रे में उगाए गए) के दैहिक अध्ययन से पता चला कि पौधों की पत्ती की संरचना एक समान थी, लेकिन स्पंजी पेरेनकाइमा की मोटाई, रंध्र घनत्व, तेल कोशिकाओं, वायु नलिकाओं और संवहनी बंडल वितरण में भिन्नता थी।

पौधों की वृद्धि, विकास, कीट एवं रोग प्रतिरोधकता तथा अजैविक तनाव सहिष्णुता में शामिल एक्सईटी 23 जीन का पीसीआर प्रवर्धन, अनुक्रमण और संरचनात्मक मॉडलिंग किया गया।

विभिन्न प्रबंधन प्रणालियों में मृदा पोषक तत्व उपलब्धता के अध्ययनों से पता चला कि एकीकृत पोषक तत्व प्रबंधन (आईएनएम) उपचार में ऑर्गानिक कार्बन और कैल्शियम का उच्चतम स्तर था, जबकि फॉस्फोरस, कॉपर, मैंगनीस और आयर्न ऑर्गानिक प्रणालियों में प्रचुर मात्रा में थे। ऑर्गानिक 75% उपचार में उच्चतम एसिड फॉस्फेट गतिविधि देखी गई, जबकि क्षारीय फॉस्फेट गतिविधि आईएनएम 50+50% उपचार में सबसे अधिक थी।

एक स्प्रे-सूखे अदरक नींबू रस पाउडर तैयार किया गया, और इसके कार्यात्मक गुणों को निम्नानुसार

निर्धारित किया गया: आर्द्रताग्राहिता 54.66%, गीलापन 67 सेकेंड, जल में घुलनशीलता 84.63%, जल अवशोषण सूचकांक 0.72, प्रवाहशीलता 14.50 और संयोगशीलता 1.75 आदि है।

दस मिनुट के लिए कॉपर ऑक्सिक्लोराइड (0.4%) का उपयोग करके वैक्युम समावेश प्रकंद-जनित राल्स्टोनिया प्स्यूडोसोलानसीरम को नष्ट करने में सबसे प्रभावी था, जिससे 60% रोग-मुक्त पौधे प्राप्त हुए।

मृदु सड़न आपतन पर रोपण की तिथि के प्रभाव का अध्ययन करने से पता चला कि मार्च में जल्दी रोपण करने से, देर से रोपण की अपेक्षा रोग आपतन और पिथियममृदा की आबादी में काफी कमी देख ली।

सरसों, अमरांथस, फ्रेंच बीन, लोबिया और ज्वार जैसी गैर-पोषक फसलों के साथ फसल चक्र के मृदु सड़न की आपताओं पर प्रभाव से यह संकेत मिला कि लोबिया और सरसों के साथ रोपण से बीज अंकुरण में वृद्धि हुई तथा रोग आपतन कम हुआ।

नई पीढ़ी के कवकनाशक जैसे क्रेसोक्सिम मीथाइल+मैंगोसेब, क्रेसोक्सिम मीथाइल+क्लोरोतलोनिल, फ्लोपिकोलिडे+फोस्टाइल-एआई और प्रोपिनेब को पिथियम स्पीसीस के प्रति हरित गृह स्थिति में प्रभावी पाया गया।

मृदु सड़न रोग के लिए एकीकृत रोग प्रबंधन कार्यक्रम के खेत मूल्यांकन ने प्रदर्शित किया कि 30 दिन के अंतराल पर जैव एजेंट (बी. सर्फेसिस, बी. एमाइलोलिक्विफासिन्स और टी. अस्परेल्लम) के अनुप्रयोगों के साथ लोबिया और सरसों फसल चक्रण से मृदा में पिथियम की संख्या में उल्लेखनीय कमी आई, अंकुरण में सुधार हुआ और मृदु सड़न आपतन में कमी आई।

अर्बुस्कुलार माइकोरिज़ल कवक (एएमएफ) के साथ टीकाकरण करने पर अदरक की वृद्धि, टिल्लरिंग, और पोषक तत्व ग्रहण करने में वृद्धि हुई, मृदु सड़न का आपतन कम हुआ और एम. इनकोगनिटा (जे२) के प्रवेश में काफी बाधा आई।

एंडोफाइटिक बैक्टीरियल अर्क के साथ उपचार किए गए पी. मिरियोटिलम और पी. डेलियेंस के स्कैनिग इलेक्ट्रॉन माइक्रोस्कॉपी (एसईएम) विश्लेषण से पता चला कि रूपात्मक परिवर्तन में खुरदरी, झुर्रीदार सतह, हाइफल टूटना, विखंडन, बाहरी परत का छिलना और असामान्य संरचनात्मक विन्यास का भी प्रदर्शन हुआ।

जीवाणु स्ट्रेन जैसे, बासिलस मेगाटेरियम, बी. आर्यभट्टै और बी. सेरस सूत्रकृमि मेज़बान के प्रवेश को रोकने में प्रभावी थे

फ्लोपिराम @1250 मि. लि./हेक्टर के प्रयोग से एम. इनकोग्निटा और प्राटिलेंचस स्पीसीस की जनसंख्या कम हो गई।

अदरक और हल्दी में संक्रमितसी. पंक्टिफरालिस के प्रबंधन के लिए एकीकृत कीट प्रबंधन (आईपीएम) पैकेज ने सूचित किया कि कीटनाशकों (क्लोरेंट्रानिलिप्रोल, स्पिनोसाद और लाम्बडा सिहालोथ्रिन) और नीम उत्पाद के साथ मेटारिज़ियम पिंगशेंस के तरल फार्मुलेशन के संयोजन का प्रयोग प्ररोह बेधक को नियंत्रित करने में प्रभावी था।

हल्दी

भा.कृ.अनु.प.-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में 1404 कुरकुमा स्पीसीसों के जर्मप्लासम अक्सेशनों का रखरखाव किया जा रहा है।

सात काली हल्दी जीनोटाइपों पर सीवीटी करने पर सूचित किया कि अक्सेशन 751 ने सबसे अधिक उपज अंकित की।

आईआईएसआर सूर्या, एक उच्च उपज देने वाली हल्के पीले रंग की हल्दी किस्म ज़ारी की गई। इस किस्म की विशेषता यही है कि इसमें अनोखा स्वाद है और जिंजीबरेन, β-सेस्क्विफेलान्ड्रीन, 1-8 सिनोल और α-हुमुलिन जैसे छोटे बाष्पशील यौगिकों की उच्च मात्रा होती है। यह औसतन 29 टन/हेक्टर ताज़ा उपज देता है औरइसमें 2-3% कुरकुमिन होता है।

अतिरिक्त लंबी और मोटी हल्दी प्रजातियों के लिए 61 जीनोटाइपों का मूल्यांकन किया गया और उनमें से आठ जीनोटाइप (अक्से. 636, अक्से.761, अक्से. 979, अक्से.1035, अक्से. 1037, अक्से. 596, अक्से.599 और अक्से.612) को आशाजनक पाया गया।

भारत में हल्दी की खेती के लिए स्थल

उपयुक्तता विश्लेषण से पता चलता है कि 2050 तक मध्य प्रदेश, महाराष्ट्र और छत्तीसगढ़ के कुछ जिले मध्यम उपयुक्त से अत्यधिक उपयुक्त में परिवर्तित हो जाएंगे, जबकि हिमाचल प्रदेश और पंजाब के कुछ जिले अत्यधिक उपयुक्त से मध्यम उपयुक्त में परिवर्तित हो जाएंगे।

विभिन्न जैविक कृषि प्रणालियों के मूल्यांकन में 100% जैविक प्रबंधन के अंतर्गत एसिड फॉस्फेट और क्षारीय फॉस्फेट की बढ़ी हुई गतिविधि अंकित की गई, जबकि एकीकृत पोषक तत्व प्रबंधन (75% जैविक+25% अजैविक)के अंतर्गत उच्चतम डिहाइड्रोजनेस गतिविधि अंकित की गई।

काली मिर्च, हल्दी, चारा घास, (सीओ 3, सीओ 4) टैपिओका, केला, लोबिया और नारियल जैसी फसलों के साथ एकीकृत जैविक कृषि प्रणाली मॉडल और डेयरी इकाई ने प्रति एकड़ 1.96 लाख रुपए का लाभ कमाया।

हल्दी के प्राकृतिक कृषि पद्धति प्रयोगों में सबसे अधिक कुरकुमिन मात्रा (5.64%) अंकित की गई, जबकि नीम एस्ट्रा के साथ एकीकृत फसल प्रबंधन (50% जैविक+ 50% अजैविक) के परिणामस्वरूप सबसे अधिक ओलियोरसिन मात्रा (11.1%) और एआई-एनपीओएफ पद्धति में अधिकतमताज़ा प्रकंद उपज (18.6 टन / हेक्टर) और तेल मात्रा (4.9%) अंकित की गई।

हल्दी के टुकडों को गर्म हवा से सहायता प्राप्त इन्फ्रारेड से सुखाने के लिए आदर्श परिस्थितियों में 750 W की इनफ्रारेड शक्ति और रश्मि 55±1.24 °Cके गर्म हवाके तापमान का उपयोग करना शामिल था। इन परिस्थितियों में, पारंपरिक धूप में सुखाने की तुलना में सुखाने का समय लगभग 40% कम हो गया।

कुरकुमिन आकलन के लिए एक संशोधित प्रॉटोकॉल विकसित किया गया, जिसमें जांच सोनिकेशन का उपयोग करके कुरकुमिन का निष्कर्षण, उसके बाद स्पेक्ट्रोस्कोपिक निर्धारण शामिल है।

हल्दी ओलिओरसिन-संसेचित एरोरूट स्टार्च फिल्मों को विकसित किया गया और कई मापदंडों के लिए मूल्यांकन किया गया, जिसमें वज़न, मोटाई, गीलापन, सूजन

सूचकांक, घुलनशीलता, जल बाष्प पारगम्यता रंग मूल्य, फैटी एसिड मुक्त सामग्री पेरोक्साइड मूल्य, गर्मी सील करने की क्षमता और कुल प्लेट गिनती शामिल है।

वैक्युम घुसपैठ के साथ गर्म पानी के उपचार ने हल्दी के प्रकंदों में घाव सूत्रकृमि को प्रभावी ढ़ंग से नियंत्रित किया।

पौधों की फिनोलोजी और किस्मों का प्ररोह बेधक आपतन पर प्रभाव देखा गया, जिसमें प्रतिभा, प्रगति और अक्से. 849 में अगस्त की शुरूआत में कीटों का प्रकोप अंकित किया गया, जबकि राजेंद्र सोनिया और आलप्पी सुप्रीम में यह अगस्त के मध्य में दिखाई पडी। आलप्पी सुप्रीम और अक्से. 849 में सबसे अधिक प्रकोप अक्तूबर की शुरूआत में देखा गया, जबकि राजेंद्र सोनिया और प्रतिभा में इसका चरम प्रकोप नवंबर में हुआ। किस्मों में से, अक्से. 849 में सबसे अधिक कीट बाधा अंकित की गई, जबकि राजेंद्र सोनिया में सबसे कम।

वेनिला

कुल 77 अक्सेशनों (65 वेनिला प्लैनिफोलिया और 12 वेनिला प्रजातियां) को संरक्षित किया जा रहा है।

आधी ताकत के एमएस+0.5 मि. ग्रा. /लि. एनएए के मीडिया संयोजन का उपयोग करके इन विट्रो बीज अंकुरण में टीकाकरण के 60 दिनों के बाद अधिक संख्या में जड़ें और पत्तियां विकसित हुई।

वैनिला में प्रमुख स्वाद यौगिकों की मात्रा निर्धारित करने के लिए एक विधि विकसित की गई, जिसमें वैनिलिन, पी.हाइड्रोक्सिबेन्ज़ाइक एसिड, पी. हाइड्रॉक्सिबेंजाइलडिहाइड और वैनिलिक एसिड शामिल है।

वृक्ष मसाले

जायफल

जायफल के खेत जीन बैंक में 163 अक्सेशनों का रखरखाव किया जा रहा है।

मिरिस्टिका की एक वन्य प्रजाति, एम. बडोमीको कर्नाटक के कोडगु जिले से और एम. मलबारिका एक नये अक्सेशन को केरल के इटुक्कि जिले से एकत्र किया गया।

दो एकलिंगी प्रजातियों (अक्से. 562, अक्से.590)

तथा एक मादा प्रजाति (अक्से. 530) सहित तीन आशाजनक अक्सेशनों को एआईसीआरपीएस के अंतर्गत समन्वित प्रजाति परीक्षण के लिए प्रस्ताव किया गया।

चार मिरिस्टिका स्पीसीस जैसे एम. फ्राग्रन्स, एम. अन्डमानिका, एम. मलबारिका और एम. माग्निफिका को अलग करने के लिए क्लोरोप्लास्ट जीनोम आधारित बहुरूपीमार्करों को विकसित किया गया।

जायफल जावित्री को गर्म हवा की सहायता प्राप्त इनफ्रारेड सुखाने की विधि विकसित की गई, जिसमें सुखाने का समय 7 घंटे तक कम हो गया, जिससे नमी की मात्रा 55.6±0.7% से घटकर 8.3±0.2% हो गई।

जायफल के छिल्के के रस के पाउडर को छिड़काव से सुखाने के लिए प्रक्रिया मापदंडों को प्रतिक्रिया सतह पद्धति का उपयोग करके अनुकूलित किया गया। अनुकूलित परिस्थितियों में, छिड़काव-सूखे पाउडर की नमी की मात्रा 3.58% पाई गई।

जायफल जावित्री के वैक्युम सुखाने के लिए वैक्युम ट्रे-ड्रायर (क्षमता : 20-30 कि. ग्रा.) उपयोग करके विभिन्न वायु तापमानों पर मूल्यांकन किया गया और वैक्युम के तहत 4 घंटे के अंदर जावित्री की नमी की मात्रा 55.60% के प्रारंभिक मूल्य से 7-8% तक कम हो गई।

दालचीनी

दालचीनी के खेत जीन बैंक में 172 अक्सेशनों का रखरखाव किया जा रहा है।

क्लोरोप्लास्ट जीनोम आधारित आणविक मार्करों को सी. वीरम और सी. मलबाट्रम में अंतर करने के लिए विकसित किया गया।

लौंग

ज़ान्जिबार लौंग और सामान्य लौंग के बीच प्राकृतिक संकरण देखी गई, जिसके परिणामस्वरूप ऐसी संतति प्राप्त हुई जिसमें संकर शक्ति प्रदर्शित हुई। एसएसआर मार्करों का उपयोग करके जीनोटाइपिंग विश्लेषण ने प्रारंभिक-फूल वाले, सशक्त पौधों की संकर प्रकृति को स्थापित किया, जिसने कली के वज़न में भी वृद्धि प्रदर्शित की।

आलस्पाइस

इन विट्रो अध्ययन पर रालस्टोनिया प्स्यूडोसोलानसीरम के विरुद्ध पिमेन्टा रेसिमोसासगंध।

तेल की जीवाणुरोधी गतिविधि यूजिनोल और चैविकोल जैसे बाष्पशील घटकों की उपस्थिति के कारण होता है, जो जीसी-एमएस विश्लेषण में उच्च सांद्रता में पाए गए थे।

सामान्य

चूना आधारित बारीक सूत्रीकरण अर्थात् ट्राइकोलाइम, बैक्टोलाइम, बैक्टोजिप्सम और ट्राइकोजिप्सम को मिट्टी के पीएच को सुधारने और सूक्ष्मजीवों के वितरण को सुविधाजनक बनाने के लिए विकसित किया गया।

केएसबी 1 (पैन्टोयासाइप्रिपेडी) और केएसबी 6 (बासिलस सेरेस) जीवाणु वियुक्तियों ने हरित गृह स्थितियों में पोटैशियम (के) को गतिशील करने और पौधों की वृद्धि को बढ़ावा देने में आशाजनक पाया गया।

नवीन खाद्य उत्पादों के विकास के लिए फलों और सब्जियों में मसाला अर्क और प्राकृतिक रंगों के संसेचन केलिए एक प्रयोगशाला-स्तरीय वैक्युम संसेचन इकाई विकसित की गई।

अदरक पर जीवाणु संघ (राउलटेला टेरिगेना, बैसिलस सफेंसिस, एसिनेटोबैक्टर स्पीसीस और बी. एमिलोलिक्विफेसिन्स) का खेत मूल्यांकन अदरक पर 75% और 50% एनपीकेज़ेडएन के साथ संयुक्त उपचार में प्रकंद उपज में वृद्धि देखी गई। इन उपचारों के परिणामस्वरूप प्रकंद गलन के आपतन में कमी आई और डिहाइड्रोजनस गतिविधि में सुधार हुआ।

तापमान सहनशील ट्राइकोडेरमा वियुक्तियों के ग्रीनहाउस मूल्यांकन से काली मिर्च की वृद्धि उच्च सापेक्ष जल मात्रा (आरडब्ल्युसी), और कुल घुलनशील प्रोटीन के स्तर में वृद्धि देखी गई।

एम. पिंगशाएंसे द्वारा संक्रमण से संबंधित एंज़ाइमों का उत्पादन, जिसमें कैटिनेस, प्रोटीएज़ (सबटिलिसिन - जैसे पीआर1 और ट्रिप्सिन -जैसे पीआर२) और लाइपेस शामिल है जिसकी कीट क्यूटिकल से पूरित मीडिया में महत्वपूर्ण रूप से वृद्धि हुई, जो सबस्ट्रेट -निर्भर अपरगुलेशन को

दिखाता है।

चिलो इन्फ्यूसकैटेलस, सी. सैकरिफैगसइंडिकस के लेट-इंस्टार लार्वा के विरुद्ध एम. पिंगशाएंसेकी औसत घातक सांद्रता (LC_{50})और सी. पार्टेलसक्रमश: $4.6x10^5$, $1.7x10^5$ और $9.5x10^5$ कोनिडिया/एम एल थे।

कोनोगीथसपंक्टिफरालिस से वियुक्त किए गए एन्टोमोपैथोजनिक कवक मेटारिज़ियम पिंगशेंसIISR-EPF-14, ज़िंक(Zn)घुलनशीलता को बढ़ाता है और पौधों की वृद्धि को बढ़ावा देने वाले गुणों जैसे आईएए उत्पादन, अमोनिया साइडरोफोरस फोस्फेट घुलनशीलता और हाइड्रोलाइटिक एंज़ाइम गतिविधि को बढ़ाता है।

दो कम जोखिम वाले कीटनाशकों, क्लोरेंट्रानिलिप्रोल और स्पिनोसाद का आदरक और हल्दी की फसलों पर 2 x अनुशंसित मात्रा (1.0 मि.लि./लि.) और काली मिर्च पर क्लोरेंट्रानिलिप्रोल का 2 x अनुशंसित मात्रा (1.0 मि. लि./लि.)पर मूल्यांकन करने पर फाइटोटॉक्सिसिटी लक्षण प्रकट नहीं हुए।

काली मिर्च की 21 उदाहरण किस्मों को कोषिक्कोड और सीएचईएस, चेत्ताली में संरक्षित किया जा रहा है। क्षेत्रीय स्टेशन, अप्पंगला में पंद्रह इलायची उदाहरण किस्मों का रखरखाव किया जा रहा है। अदरक की तेईस और हल्दी की पैंतीस उदाहरण किस्मों को रखरखाव करके संवर्धन किया जा रहा है।

अदरक और हल्दी की नई उम्मीदवार किस्मों का मूल्यांकन किया जा रहा है। कर्नाटक में काली मिर्च की किस्मों, एमडीबीपी 16 (छत्तीसगढ़), वीजे 1, वीजे 2, वीजेइ और वीजे 4 को साइट पर डीयुएस परक्षण मूल्यांकन आयोजित किया गया।

बडी इलायची क्षेत्र के एसडब्ल्युओटी विश्लेषण ने उद्योग को मज़बूत करने के लिए संभावित रणनीतियों के रूप में किसान सामूहिकता को मज़बूत करने, बुनियादी ढांचे के विकास में निवेश, न्यूट्रास्यूटिकल अनुप्रयोगों की खोज, बाज़ार प्रीमियम सुरक्षित करने के लिए बड़ी इलायची के जैविक उत्पादन प्रोफाइल का लाभ उठाने और उत्पादन क्षेत्रों में विषाणु का पता लगाने हेतु किट का उपयोग करने की पहचान की।

प्रभाव अध्ययनों से पता चला है कि अदरक की किस्में आईआईएसआर महिमा और वरदा अपनी उच्च शुष्क उपज प्राप्ति और अंतिम उत्पाद की बेहत्तर गुणवत्ता के कारण पसंदीदा विकल्प के रूप में उभर रही है। इन किस्मों ने प्रमुख सूखी अदरक उत्पादक क्षेत्रों में पारंपरिक "मारन" किस्म की जगह ले ली है।

डीएनए फिंगरप्रिंटिंग और बारकोडिंग सुविधा ने आम अदरक किस्म (आईआईएसआर अमृत) छोटी इलायची किस्मों (आईआईएसआर कावेरी और आईआईएसआर मनुश्री) और अदरक किस्म (आईआईएसआर सुरासा) के लिए डीएनए फिंगरप्रिंटिंग तैयार किए गए, जिससे सीवीआरसी/एसवीआरसी द्वारा उनकी अधिसूचना में मदद मिली।

एनजीएस के लिए डेटा विश्लेषण और विजुलाइज़ेशन टूलकिट विकसित किया गया, जो बुनियादी सांख्यिकी, विजुलाइज़ेशन, सामान्यीकरण, विभेदक अभिव्यक्ति विश्लेषण और सहसंबंध प्रोफाइलिंग से सुसज्जित है।

संस्थान ने हितधारक समुदायों के लिए विभिन्न अवधि के प्रशिक्षण कार्यक्रम आयोजित किए। प्रशिक्षण कार्यकम महिलाओं, ग्रामीण युवाओं और प्राथमिक उत्पादकों को उच्च स्तरीय कौशल और उद्यमिता सहायता हस्तांतरित करने पर केंद्रित थे।

एससीएसपी कार्यक्रम के तहत, संस्थान ने कई कौशल विकास प्रशिक्षण सत्र आयोजित किए, जिससे लगभग 1,000 व्यक्तियों को सशक्त बनाया गया। इसने आलंकारिक मछली पालन के लिए एफआरपी के टैंक और मधुमक्खी के छत्ते जैसे उपकरण प्रदान करके विविध आजीविका को भी बढ़ावा दिया, साथ ही बीज सामग्री, सूक्ष्म पोषक मिश्रण और जैव कैप्स्यूल जैसे आवश्यक इनपुट भी प्रदान किए।

एनईएच कार्यकलाप पे मेघालय, त्रिपुरा और मिज़ोरम में उन्नत बीज किस्म आईआईएसआर वरदा के लिए बीज आपूर्ति श्रृंखला विकास कार्यक्रम शुरू किया गया।

टाटा ट्रस्ट परियोजना के तहत अग्र पंक्ति प्रदर्शनी (एफएलडी) [126संख्या] को 10 राज्यों (तमिलनाडु, ओडीशा, आंध्रा प्रदेश, गुजरात, राजस्थान, उत्तर प्रदेश, उत्तराखंड, नागालैंड,

मिज़ोरम और असम) में लागू किया जा रहा है, जो उन्नत कृषि प्रौद्योगिकियों की श्रेष्ठता, विशेष रूप से उन्नत जैव इनपुट के एकीकरण और कृषि संबंधी प्रथाओं के परिशोधन को प्रदर्शित करता है।

इस अवधि के दौरान, आईसीएआर-आईआईएसआर द्वारा अडतीस (३८) लाइसेंस ज़ारी किए गए और 58.83 लाख रुपए का राजस्व उत्पन्न हुआ।

भा.कृ.अनु.प.-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड, केरल को मसाला गुणवत्ता और जैविक खाद परीक्षण प्रयोगशालाओं के लिए मानक आईएसओ/आईईसी 17025-2017 के अनुसार राष्ट्रीय परीक्षण और अंशांकन प्रयोगशाला प्रत्यायन बोर्ड (एनएबीएल) द्वारा मान्यता प्राप्त है।

मसालों के लिए स्थान विशिष्ट पोषक तत्व अनुशंसा (स्पाइस फर्ट) (एसडब्ल्यु-19375/2024) के लिए कॉपीराइट प्रदान कियागया, मसालों के लिए हॉट एयर असिस्टड इन्फ्रारेड ड्रायर (डिज़ाइन संख्या 420100-001) और वैक्युम इंप्रेग्नेशन यूनिट (420102-001) के लिए डिज़ाइन पेटेंट प्रदान किए गए।

EXECUTIVE SUMMARY

BLACK PEPPER

Three thousand five hundred and eleven accessions are being maintained at the Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala. At the alternative germplasm site at CHES, Chettalli, Karnataka, 542 germplasm accessions are being maintained.

Twenty-one *Piper* accessions were collected from different parts of India and added to the germplasm repository including a leaf tip mutant accession from Goa.

An analysis of genetic diversity and taxonomic relationships among 22 *Piper* genotypes using 47 novel gene-based SSR markers revealed high cross-species transferability of these markers across all *Piper* species, with transferability ranging from 56.1% in *Piper magnificum* to 97.6% in *P. argyrophyllum*.

Principal component analysis and UPGMA-based clustering separated the *Piper* genotypes into discrete groups, with patterns that corresponded to expected associations based on geographical origin, growth habit and spike orientation. Pairwise comparison of relationships between *Piper* species revealed closest genetic relationship between *P. longum* and *P. hapnium*, *P.colubrinum* and *P.magnificum* and *P.attenuatum* and *P.argyrophyllum*.

The analysis of genetic variability for morpho-physiological and yield-related traits revealed that Accession 7211, along with Accessions 1495, 1343, and 4132, exhibited characteristics such as low stomatal number, high wax content, optimal spike length, high setting percentage, efficient physiological adaptations, and stable yield under water-limited conditions. These traits make them promising candidates for breeding programs on improving drought resilience.

Root morphological and anatomical characteristics of varieties revealed that the IISR Shakthi, IISR Thevam, and Pournami had the highest number of secondary roots, longest primary root length, most xylem vessels, widest stele, and the greatest number of root hairs per cross-section. These features are likely responsible for their tolerance to both abiotic and biotic stresses.

Differential expression analysis of DHN and SOD (Cu/Zn) genes in nutrient-deficient plants indicated that untreated plants had significantly higher expression levels for both the DHN (0.182167), and SOD (Cu/Zn)1(0.276114) genes compared to nutrient-treated plants.

Based on morphological, biochemical, and DNA fingerprinting analyses, long pepper cultivated in Meghalaya was Identified as *Piper peepuloides*. The unique morphological characteristics, distinct chemical profile, economic viability, and suitability for intercropping systems position *P. peepuloides* as a promising alternative crop for the region.

'IISR Chandra', an early-maturing hybrid, has been made available for commercial cultivation through 23 non-exclusive licensing agreements.

Field evaluation of 11 genotypes for drought tolerance showed that the genotypes Acc 4226, 1277, and 1495 performed best based on physiological and yield parameters.

Cross-infectivity studies of *Phytophthora* isolates, *P. capsici* isolate 09-03 and *P. tropicalis* isolate 98-177 on arecanut,

coconut, and nutmeg revealed that they were highly pathogenic on nutmeg.

Analysis of haplotypes in *P.capsici* and *P. tropicalis* revealed a total of 30 haplotypes from the mitochondrial and nuclear genes. The nuclear genes such as *EF1-α*, *enolase*, *HSP90*, *TigA* and *Ura3* and mitochondrial genes such as *Cox2* and *Nad5* incorporates unique haplotypes with EF1-α showing the greatest diversity.

Fungicide sensitivity studies with *P. capsici* and *P. tropicalis* isolates showed sensitivity to dithiocarbamates (iprovalicarb-propineb 0.2%, propineb 0.25%, cymoxanil-mancozeb 0.2%, metalaxyl-mancozeb 0.125%), benzamides (fluopicolide-propamocarb 0.125%), copper oxychloride (0.25%), and Bordeaux mixture (1%).

A duplex Recombinase Polymerase Amplification–Lateral Flow Assay (RPA-LFA) protocol for the simultaneous detection of *Phytophthora* spp. and *Pythium* spp. was developed.

Screening studies indicated that the accessions 7492, 7445, 7457, 7467, 7439, 7657, 7482 showed resistance against *P.capsici* and the accessions 7548, 7585, 7492, 7445, 7503, 7563, 7401, 7478, 7577, 8043, 7457 against *P. tropicalis*.

The NPR3 gene from the variety, Sreekara was amplified, cloned and sequenced and the analysis of the obtained sequence against the black pepper genome database identified four distinct isoforms. The NPR3 gene sequence was utilized to design the guide RNA (gRNA) for genome editing through CRISPR/Cas.

The occurrence of black pepper virus F (BPVF) was identified in India for the first time, and its complete genome was sequenced.Diagnostic assays based on RT-PCR and RT-recombinase polymerase amplification (RT-RPA) were developed for the sensitive detection of BPVF.

A Lateral Flow Immunoassay protocol (LFIA) was developed for the detection of *Piper Yellow Mottle Virus.*

Screening of new generation low-risk insecticides against pollu beetle (*Lanka ramakrishnai*) indicated that chlorantraniliprole @ 0.3 ml/L was effective in managing the pest.

Second year evaluation of low-risk insecticides against root mealy bug *Planococcus lilacinus* under field conditions indicated that application of clothianidin 50 WDG @ 1g/L reduced maximum number of mealy bugs on the 20th day after drenching followed by spiroteramat 15.31 OD @ 1 mL/L .

CARDAMOM

Six hundred twenty-five accessions are being maintained in the National Active Germplasm Site (NAGS) of IISR, Regional Station, Appangala.

Evaluation trials of moisture stress-tolerant lines showed that line 584058-3 produced the highest yield, with 860 g of fresh yield and 149 g of dry yield per plant.

CVT on hybrids showed the hybrid Bold × IC 547219 recorded the highest yield, producing 2784.1 kg/ha fresh yield and 517.7 kg/ha dry yield followed by (GG × Bold) × Appangala 1 (1310.0 kg/ha fresh, 285.1 kg/ha dry yield) .

A multilocation trial with five leaf blight-tolerant genotypes—IC 349650, IC 547222, IC 547156, IC 349649, and IC 349648—along with resistant checks Appangala 1, Njallani Green Gold, and a susceptible check, showed disease incidence ranging from 10.6% to 22.8%, with the lowest incidence in IC 547222 and the highest in IISR Vijetha.

The varieties, IISR Manushree (recommended for Karnataka and Kerala) and IISR Kaveri (recommended for Karnataka), were notified by the Government of India, Ministry of Agriculture and Farmers' Welfare .

Pre and post-monsoon spraying and drenching with tebuconazole @ 1 ml/L or metalaxyl + mancozeb @ 1.25 g/L significantly reduced rhizome rot incidence.

Pre-monsoon spray and drench with tebuconazole (1 ml/L) followed by a post-monsoon spray and drench with *Bacillus atrophaeus* and *B. amyloliquefaciens* (0.5%), resulted in the lowest rhizome rot incidence, with a percent disease index (PDI) of 10%.

Application of two rounds of foliar spray with hexaconazole 5% SC, one pre-monsoon (June) and one post-monsoon (September), effectively managed leaf blight disease.

Spray schedule optimization of low-risk insecticides (spinosad, flubendiamide, chlorantraniliprole @ 1.0 ml/L) and a neem based botanical insecticide (3.0 ml/L) with a standard check (quinalphos @ 2.0 ml/L) indicated that the spray schedules) January–February, March–April, and September–October, and (ii) February–March and September–October were effective in reducing the shoot and capsule damage.

LARGE CARDAMOM

A recombinase polymerase amplification (RPA) assay was developed for the rapid detection of cardamom bushy dwarf virus (CBDV) causing *foorkey* disease.The RPA assay was 1000 times more sensitive and faster than conventional PCR, indicating its suitability for large-scale indexing.

GINGER

Six hundred and sixty-eight accessions are being maintained in the field gene bank.

CVT for disease tolerance showed that the mutant R 1.25/4 recorded the highest yield (15.6 t/ha), which was on par with the control, IISR Varada. Artificial inoculation studies revealed that the ginger mutants R 1.25/4 and HP 0.5/2 exhibited mild susceptibility to *Pythium myriotylum* and *Ralstonia solanacearum*.

Anatomical studies of *in vitro* plants (tissue culture-derived) with *in vivo* plants (pro-tray grown) showed that plants had a similar leaf structure but differed in spongy parenchyma thickness, stomatal density, oil cells, air canals, and vascular bundle distribution.

PCR amplification, sequencing and structural modelling of the XET 23 gene involved in plant growth, development, pest and disease resistance and abiotic stress tolerance was conducted.

Soil nutrient availability studies across different management systems showed that Integrated Nutrient Management (INM) treatment had the highest levels of OC and Ca, while P, Cu, Mn, and Fe were most abundant in organic systems. The highest acid phosphatase activity was observed in the Organic 75% treatment, while alkaline phosphatase activity peaked in the INM 50+50% treatment.

Vacuum infiltration using copper oxychloride (0.4%) for 10 minutes was found effective in eliminating rhizome-borne *R. pseudosolanacearum* yielding 60% disease-free plants.

The influence of date of planting on soft rot incidence showed that early planting in March significantly reduced disease

incidence and *Pythium* soil population compared to late planting.

Influence of crop rotation with non-host crops like mustard, amaranthus, French bean, cowpea and sorghum on soft rot incidence indicated that planting with cowpea and mustard enhanced seed germination, and reduced disease incidence.

New generation fungicides like., kresoxim methyl +mancozeb, kresoxim methyl + chlorothalonil, fluopicolide + kosetyl-Al and propineb were found effective against *Pythium* spp under greenhouse conditions

Field evaluation of the integrated disease management schedule for soft rot disease demonstrated that crop rotation with cowpea and mustard, along with bioagent applications (*B. safensis*, *B. amyloliquefaciens*, and *T. asperellum*) at 30-day intervals, significantly reduced the *Pythium* soil population, improved germination, and decreased soft rot incidence.

Inoculation with arbuscular mycorrhizal fungi (AMF) enhanced growth, tillering, and uptake, reduced induced soft rot incidence and significantly inhibited *M. incognita* (J2) penetration into roots.

Scanning electron microscopy (SEM) analysis of *P. myriotylum* and *P. deliense* treated with endophytic bacterial extracts showed morphological alterations like rough and wrinkled surfaces, hyphal rupture, fragmentation, peeling of the outer layer, and abnormal structural formations.

Bacterial strains *viz.*, *Bacillus megaterium, B.aryabhattai,* and *B. cereus* were effective in inhibiting nematode host penetration.

Application of fluopyram @1250 ml/ha reduced the population of *M. incognita* and *Pratylenchus* sp.

Integrated Pest Management (IPM) package for the management of *C. punctiferalis* indicated that application of insecticides (chlorantraniliprole, spinosad and lambda cyhalothrin) and a neem product in combination with a liquid formulation of *Metarhizium pingshaense* was effective in controlling shoot borer.

TURMERIC

1404 *Curcuma* spp. germplasm accessions are being maintained at ICAR-IISR, Kozhikode.

CVT on seven black turmeric genotypes indicated that Acc. 751 recorded highest yield.

IISR Surya, a high-yielding light-yellow coloured variety was released.The variety is distinguished by a unique flavor, with high levels of minor volatile compounds such as zingiberene, β-sesquiphellandrene, 1,8-cineole, and α-humulene. It yields an average of 29 t/ha of fresh produce and contains 2–3% curcumin.

Sixty-one genotypes were evaluated for extra-long and bold turmeric lines and eight genotypes (Acc. 636, Acc. 761, Acc. 979, Acc. 1035, Acc. 1037, Acc. 596, Acc. 599, and Acc. 612) were found to be promising.

Site suitability analysis suggested that, by 2050, certain districts in Madhya Pradesh, Maharashtra, and Chhattisgarh are expected to transition from moderately suitable to highly suitable, while a few districts in Himachal Pradesh and Punjab will shift from highly suitable to moderately suitable.

Integrated organic farming system model maintained with crops like black pepper, turmeric, fodder grasses (CO-3, CO-4), tapioca, banana, cowpea, and coconut and dairy unit generated a profit of Rs 1.96 lakhs per acre.

Natural farming package experiments recorded the highest curcumin content (5.64%) whereas Integrated Crop Management (50% organic + 50% inorganic) with *Neem Astra* resulted in the highest oleoresin content (11.1%) and the AI-NPOF package recorded maximum fresh rhizome yield (18.6 t/ha) and oil content (4.9%).

The ideal conditions for drying turmeric slices with hot-air assisted infrared involved using an infrared power of 750 W and a hot air temperature of 55±1.24 °C. Under these conditions, the drying time was reduced by about 40% compared to conventional sun drying.

Turmeric oleoresin-impregnated arrowroot starch films were developed and evaluated for several qualitative parameters.

Hot water treatment with vacuum infiltration effectively controlled lesion nematodes in turmeric rhizomes.

The impact of plant phenology and varieties on shoot borer incidence indicated pest occurrence in early August for Prathibha, Pragati, and Acc. 849, while in Rajendra Sonia and Alleppey Supreme, it appeared in mid-August. Among the varieties, Acc. 849 recorded the highest pest incidence, while Rajendra Sonia had the lowest.

VANILLA

A total of 77 accessions (65 *Vanilla planifolia* and 12 *Vanilla* sp.) are being conserved.

In vitro seed germination using the media combination of half strength MS + 0.5 mg L^{-1} NAA resulted in more number of roots and leaves, 60 days after inoculation.

A method for quantifying key flavor compounds in vanilla, including vanillin, p-hydroxybenzoic acid, p-hydroxybenzaldehyde, and vanillic acid was developed and standardized.

TREE SPICES

NUTMEG

The field gene bank consists of 163 accessions.

A wild species of *Myristica*, *M. beddomei* and a new accession of *M. malabarica* were collected from Kodagu district, Karnataka and Idukki district, Kerala respectively.

Three promising accessions including two monoecious lines (Acc 562, Acc 590) and a female type (Acc 530) were proposed for Coordinated Varietal Trial under the AICRP on spices.

Chloroplast genome-based polymorphic markers were developed to distinguish four *Myristica* species *viz.*, *M. fragrans*, *M. andamanica*, *M. malabarica* and *M. magnifica*.

Hot-air assisted infrared drying ofmace was carried out with drying time reduced to 7 hours, decreasing the moisture content from 55.6±0.7% to 8.3±0.2%.

Process parameters for spray drying rind juice powder were optimized using response surface methodology. Under the optimized conditions, the moisture content of the spray-dried powder was found to be 3.58%.

Vacuum drying of mace using vacuum tray dryer (capacity: 20–30 kg) was evaluated at different air temperatures and the moisture content of mace decreased from an initial value of 55–60% to 7–8% within 4 hours under vacuum .

CINNAMON

The field gene bank is being maintained with 172 accessions.

Chloroplast genome-based molecular markers were developed to differentiate *C. verum* and *C. malabatrum*.

CLOVE

Natural crossing was observed between Zanzibar clove and normal clove, resulting in progenies that exhibited hybrid vigor. Genotyping analysis using SSR markers established the hybrid nature of the early-flowering, vigorous seedlings, which also displayed increased bud weight.

ALLSPICE

In vitro studies on anti-bacterial activity of *Pimenta racemosa* essential oil against *R.pseudosolanacearum* is probably due to the presence of volatile constituents such as eugenol and chavicol, which were found in higher concentrations on GC-MS analysis.

GENERAL

Novel granular lime-based formulations *viz*., Tricholime, Bactolime, Bactogypsum and Trichogypsum were developed to ameliorate soil pH and facilitate microbial delivery.

Bacterial isolates KSB 1 (*Pantoea cypripedii*) and KSB 6 (*Bacillus cereus*) showed promising results in their ability to mobilize potassium (K) and promote plant growth under greenhouse conditions.

A lab-scale vacuum impregnation unit was developed for the impregnation of spice extracts and natural colours into fruits and vegetables for the development of novel food products.

Field evaluation of bacterial consortia (*Raoultella terrigena*, *Bacillus safensis*, *Acinetobacter* sp., and *B. amyloliquefaciens*) on ginger demonstrated increased rhizome yield in treatments with consortia combined with 75% and 50% NPKZn. These treatments also resulted in reduced rhizome rot incidence and improved dehydrogenase activity.

Greenhouse evaluation of temperature tolerant *Trichoderma* isolates under varying moisture levels (100%, 75%, 50%, and 25% FC) resulted in enhanced black pepper growth with higher relative water content (RWC), proline and total soluble protein levels.

Production of infection-related enzymes, including chitinases, proteases (subtilisin-like Pr1 and trypsin-like Pr2), and lipases by *M. pingshaense* was significantly enhanced in media supplemented with insect cuticle, indicating substrate-dependent upregulation.

The median lethal concentration (LC_{50}) of *M. pingshaense* against late-instar larvae of *Chilo infuscatellus*, *C. sacchariphagus indicus* and *C. partellus* were 4.6×10^5, 1.7×10^5 and 9.5×10^5 conidia /mL, respectively.

The entomopathogenic fungus *M.pingshaense* IISR-EPF-14, isolated from *C.punctiferalis*, enhanced Zn solubilization, enhanced plant growth through IAA production, ammonia, siderophores, P solubilization, and hydrolytic enzyme activity.

Evaluation of two low risk insecticides, chlorantraniliprole and spinosad, at their 2× recommended dose (1.0 ml/L) on ginger and turmeric and chlorantraniliprole at 2× recommended dose (1.0 ml/L) on black pepper, did not express phytotoxicity symptoms.

Twenty-one example varieties of black pepper are being conserved at Kozhikode and CHES, Chettalli. Fifteen cardamom example varieties are being maintained at Regional Station, Appangala. Twenty-three example varieties of ginger and 35 of turmeric are being maintained and multiplied.

On site DUS test evaluation was conducted

for the black pepper varieties, MDBP 16 (Chhattisgarh), VJ1, VJ2, VJ3 and VJ4 at Karnataka.

SWOT analysis of the large cardamom sector identified strengthening farmer collectivization, investing in infrastructure development, exploring nutraceutical applications, leveraging large cardamom's organic production profile to secure market premiums and deploying virus detection kits in production zones as potential strategies for strengthening the industry.

Impact studies showed that ginger varieties IISR Mahima and Varada emerging as the preferred choices due to their high dry recovery and superior visual quality of the final produce. These varieties have largely replaced the traditional "Maran" variety in key dry ginger-producing regions.

DNA fingerprinting and barcoding facility generated fingerprints for Mango Ginger variety (IISR Amrit), Small Cardamom varieties (IISR Kaveri and IISR Manushree), and Ginger variety (IISR Surasa), aiding their notification by the CVRC/SVRC.

The Data Analysis and Visualization Toolkit for NGS equipped with basic statistics, visualization, normalization, differential expression analysis, and correlation profiling was developed.

The institute organized training programmes of various duration for its stakeholder communities. The training programmes focussed on transferring high end skills and entrepreneurship support to women, rural youth and primary producers.

Under the SCSP program, the institute organized several skill development training sessions, empowering around 1,000 individuals. It also promoted diversified livelihoods by providing equipment such as bee hives and FRP tanks for ornamental fish farming, along with essential inputs like seed material, micronutrient mixtures, and bio-capsules.

As a part of NEH activities, a programme for Seed supply chain development of improved ginger variety, IISR Varada was initiated in three states, Meghalaya, Tripura and Mizoram.

Under the Tata Trusts project, Front Line Demonstrations (FLDs) [126 nos]are being implemented across 10 states (Tamil Nadu, Odisha, Andhra Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Uttarakhand, Nagaland, Mizoram and Assam, demonstrating the superiority of improved farming technologies, especially through integration of advanced bio-inputs and the refinement of agronomic practices.

During the period thirty-eight (38) licenses were issued for various technologies developed by ICAR-IISR and a revenue of 58.83 Lakhs was generated.

The institute was accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL) in accordance with the standard ISO/IEC 17025:2017 for its Spices quality and Organic Manure testing laboratories.

The institute was granted with copyright for Site Specific Nutrient Recommendation for Spices (Spice Fert) (SW-19375/2024) two design patents for Hot air assisted Infrared dryer for spices (Design No - 420100-001) and Vacuum impregnation Unit (420101-001).


INDIAN INSTITUTE OF
SPICES RESEARCH
KOZHIKODE
ഭാരതീയ സുഗന്ധവിള ഗവേഷണ സ്ഥാപനം
भारतीय मसाला फसल अनुसंधान संस्थान
INDIAN INSTITUTE OF SPICES RESEARCH

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 (*Garcinia gummi-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.3570.60 lakhs during the year. The

institute earned revenue through sale of planting materials, biocontrol agents, trainings, publications and consultancy services etc.

STAFF

The Institute has a sanctioned strength of 47 Scientific, 35 Technical, 31 Administrative and 31 Supporting Staff, of which 37, 24, 17 and 04 of Scientific, Administrative, Technical and Supporting Staff, respectively are in position. The KVK has a sanctioned strength of 01 scientific, 11 technical, 02 administrative and 02 supporting staff.

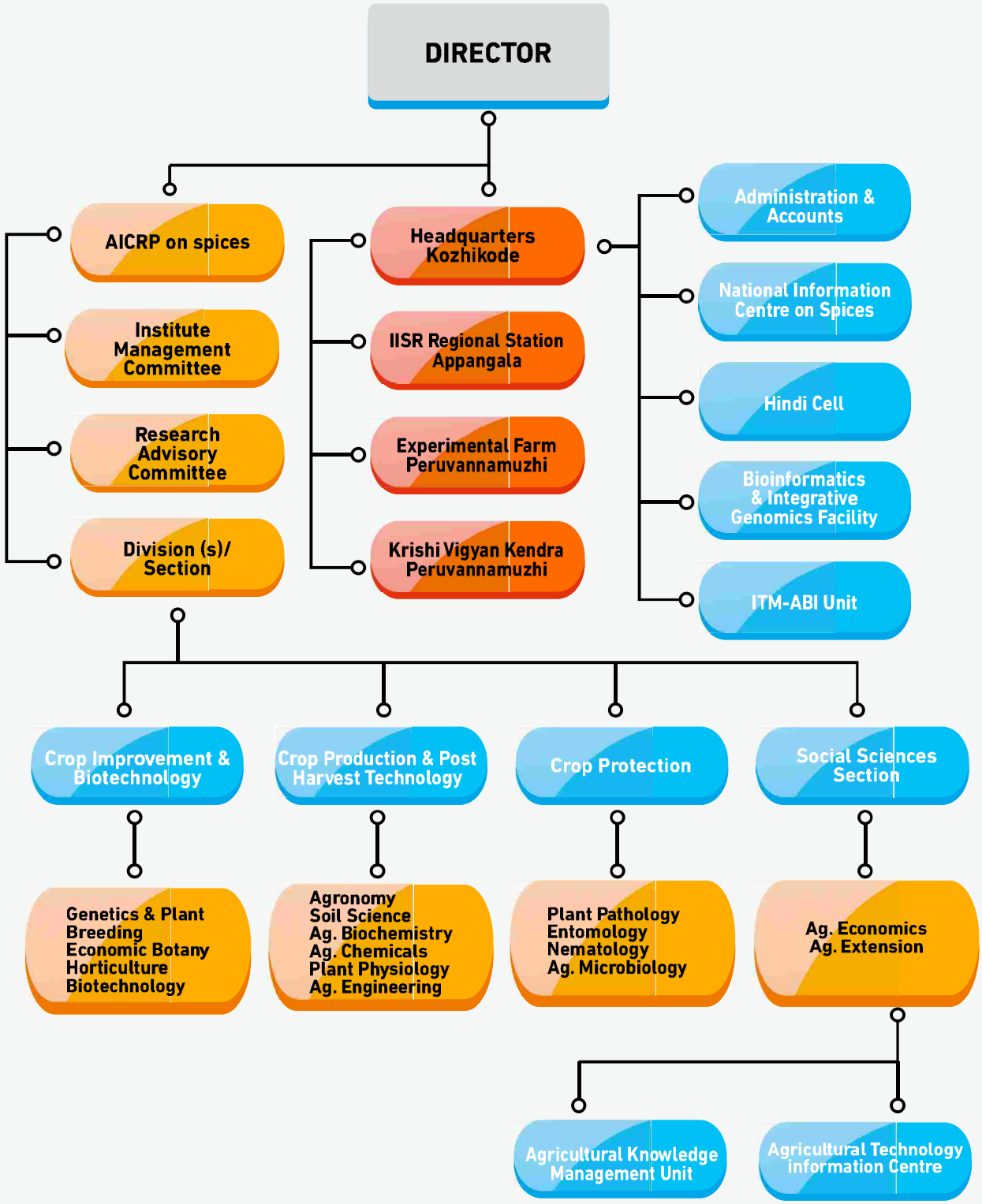
Staff position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Director	1	1			1	-
Scientist	47	31	01	05	37	10
Technical	35	16	05	03	24	11
Administration	31	14	01	01	16	15
Supporting	31	01	01	01	03	28
Total	**144**	**62**	**8**	**10**	**80**	**64**

Staff position of KVK

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientific	01	-	01	-	01	-
Technical	11	-	07	-	07	04
Administration	02	-	01	-	01	01
Supporting	02	-	01	-	01	01
Total	**16**	-	**10**	-	**10**	**06**

Organizational Chart



PAST ACHIEVEMENTS

Black pepper

About 4053 accessions are being maintained at ICAR-IISR, Chelavoor; Experimental Farm, Peruvannamuzhi as well as in alternate sites (Appangala and Chettalli of Karnataka). Sixteen accessions of various *Piper* spp., including *Piper nigrum, P. hapnium, P. galeatum, P. barberi* (IUCN-listed endangered species), *P. mullesua, P. velaudhanii, P. hookeri, P. hymenophyllum* and *P. argyrophyllum*, were newly added to the collection. A total of 107 hybrid seeds successfully germinated by hybridization between five varietal cross combinations. An early maturing hybrid variety with high fruit set and long spikes was developed and released as IISR-Chandra. Nonexclusive licence agreements were signed with five nurseries in Kerala and two from Karnataka for its commercial production. The most effective measures for evaluating cultivar performance were observed to be Average Yield Relative Environment Maximum (YREM) and Best Linear Unbiased Predictor (BLUP). Genotypes with YREM values < 0.41 and BLUP values < 1.50 kg/ vine can be considered as inferior, while those with YREM values >0.66 and BLUP values >2.9 kg/ vine can be considered as superior.

Major pests, pathogens, viruses and their insect vectors and nematodes affecting pepper were characterized and documented. Mating type analysis of eight *P. capsici* isolates *viz.*, 98-81, 01-04, 02-20, 05-06, 06-12, 07-03 18-12, 20-05 and eight *P. tropicalis* isolates *viz.*, 97-55, 98-93, 03-07, 06-17, 09-01, 11-29, 13-23 and 13-53 with A1 (ATCC 2338) and A2 (ATCC 4034) reference isolates indicated that the isolates belong to the A1 mating type. Sensitivity of *P. capsici* (05-06) and *P. tropicalis* (98-93) isolates towards new molecule fungicides showed that fluopicolide-fosetyl-Al and copper sulphate pentahydrate completely inhibited the mycelial growth at 0.3% and 0.5%, respectively. A recombinase polymerase amplification-lateral flow assay (RPA-LFA) protocol for the detection of *Phytophthora* spp. and *Pythium* spp. was developed. Differential expression of effector genes during *P. capsici* infection showed that few R x LR effector genes were up regulated at the early stage of infection.

The structure of two highly up-regulated RxLR effectors (RxLR29 and RxLR132) was predicted and protein-protein docking was performed with the DRB4 gene of *Arabidopsis* and CMPG1 gene of *Solanum lycopersicum*, respectively. Duplex recombinase polymerase amplification-lateral flow assay (RPA-LFA) for detection of PYMoV and cucumber mosaic virus (CMV) was developed. The detection limit of RT-RPA-LFA was 10^{-2} dilution and the assay will be useful to identify virus-free mother plants. Pre- and post-monsoon application of fluopyram@ 0.5ml/L reduced nematode population by 95% compared to single application.

Screening of new generation low-risk insecticides against pollu beetle (*Lanka ramakrishnai*) indicated that chlorantraniliprole @ 0.3 ml/L was found to be effective in managing the pest.

Evaluation of low-risk insecticides against root mealy bug *Planococcus lilacinus* under field conditions indicated that application of

clothianidin 50 WDG @ 1g/L reduced maximum number of mealy bugs on the 20th day after drenching (83.4%) followed by spiroteramat 15.31 OD @ 1 mL/L (74.8%).

Cardamom

Six hundred and twenty-eight accessions are being maintained in the National Active Germplasm Site (NAGS) of IISR, Regional Station, Appangala. Hybrid progenies were developed by hybridization between (Appangala–1, IISR Avinash, *Njallani* green gold and IC 584058) and (IC 349606, IC 547167, IC 349364 and IC 349358). CVT on farmer's varieties *viz.*, Arjun, Wonder Cardamom, Panikulangara green bold no.1, Thiruthali, Elarajan, Pachaikkai, Pappalu, Njallani green gold, PNS Gopinathfor three years revealed that Panikulangara Green Bold No. 1 (301.65 kg/ha) recorded the highest yield followed by Thiruthali (273.86 kg/ha).

Multilocation trials with 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 showed that the disease incidence (%) ranged from 11.66 to 23.33, with maximum incidence in IISR Vijetha. the germplasm line IC 584058 (INGR23102) with compact flowering genotype, bold capsules (80% of the capsules are >7 mm) and moisture tolerance was registered with Plant Germplasm Registration Committee (PGRC) of ICAR.

An assay based on reverse transcription-recombinase polymerase amplification combined with lateral flow assay (RT-RPA-LFA) was optimized for the specific and sensitive detection of cardamom mosaic virus (CdMV) using crude extract from the plants.

Dose-response studies of arbuscular mycorrhizal fungi (AMF) (*Rhizophagus irregularis*) showed enhanced plant growth and nutrient uptake.

A process patent was granted for the invention 'A micronutrient composition for cardamom and a process for its preparation' (Patent No.413017).

Ginger

Six hundred and sixty-eight accessions are being maintained in the field gene bank. Differential transcriptome analysis of *Ralstonia* infected and uninfected samples was performed and 446 transcripts were differentially expressed. Functional annotation of DE genes using homology relationship identified 227 annotated transcripts.

Application of nano urea as foliar spray @ 0.4 % combined with 50 % N as RDF increased the yield and use efficiency of applied N. Nano urea as foliar spray combined with 50 % N as soil application resulted in 33.0 % and 66.9 % increase in fresh rhizome yield over RDF (100 % N) in 0.2 % and 0.4 % of nano urea treatments, respectively.

Lac resin-based coating for fresh rhizome to enhance the shelf life, coupled with sterilization using sodium hypochlorite revealed that the fresh rhizomes can be stored at 20°C up to four months with market acceptable traits. The operating conditions for the production of spray dried ginger-lime juice powder were optimized using response surface methodology.

R.pseudosolanacearum formed microcolonies or co-aggregates 2 h post incubation and biofilm formation was noticed 3 h after incubation on the rhizome scales. Bacterial endophytes from wild relatives of ginger, *B.amyloliquifaciens*, *B. velenzensis*,*Pantoea hercicii*, *Priestia megaterium*, *Pseudacidovorax intermedius* were identified and evaluated against *P.*

myriotylum and *P. deliense.* Out of 19 cultivars and germplasm accessions screened for resistance against root-knot nematode, *M. incognita,* cultivars *Jamaica* and *Queensland* and accessions 17, 578, 891, and 9073 were found to be resistant.

Mango ginger

Based on the three-year coordinated varietal trial (CVT) , Acc. 347 recorded the highest average yield of 31 t/ha and a potential yield of 45.75 t/ha was released as IISR Amrit. This genotype is characterized by a light-yellow core, desirable flavor with myrcene (55.54%) and β pinene (14.53%) and with essential oil content of 0.32%.

Turmeric

One thousand four hundred and four accessions are being maintained at ICAR-IISR, Kozhikode. CVT on high yield and high curcumin indicated that CL 272 (23 t/ha) and the two check varieties (IISR Pragati, IISR Prathibha) recorded higher yield. CVT on light yellow colour for specialty market indicated that Acc 849 had the highest yield of 36.17 t/ha followed by Acc. 1545 (31.17 t/ha). Flow Cytometry ploidy study of 92 turmeric genotypes indicated that 83 were triploids and nine were tetraploids. Thirteen accessions of Salem Local (Erode and Salem district of Tamil Nadu) and seven accessions of Mydukkur (Andhra Pradesh) were evaluated for extra-long and bold lines and the accession SL5 recorded maximum yield followed by SL3.

Response of genotypes for yield and quality under different production systems showed that greenhouse conditions were the best for fresh yield in the order of IISR Pragati>Rajendra Sonali>NDH 8>CO-3. Site suitability analysis in Kerala for 2050 under various SSP scenarios showed that 28 % of area were highly suitable; 41% of area were moderately suitable and 11 % were not suitable for turmeric cultivation.

The farming system model consisting of organic cultivation of crops such as coconut (65 cents), fodder (15 cents), turmeric (10 cents), tapioca, banana, vegetable cow pea (2.5 cents each) with livestock (2 HF cows and calves) yielded a net income of Rs 1.89 lakhs per acre per year and the model was found to be economically viable. Cost of cultivation for the model plot was Rs 2.57 lakhs per acre. Natural farming package including seed treatments with Beejamrit, and application (soil drenching) of Jeevamrit & Ghanajeevamrit at monthly intervals till 120 DAP, intercropping with cowpea and residue mulching recorded maximum content of curcumin (5.3 %) and essential oil (4.6 %).

Chemo-profiling of essential oils showed that rhizome oil of *C. amada* was mainly constituted by myrcene (63 %) and β-pinene (8.6 %) whereas curzerenone (17.5 %), germacrone (13.9 %) furanodienone (13 %) and furanodiene (7 %) dominated in the leaf oil. *C. aromatica* rhizome oil was dominated by camphor (18.5 %), curdione (11.4 %), furanogermenone (7.5 %), 1,8-cineole (8.6 %) and isoborneol (6.7 %), whereas its leaf oil was mainly constituted by 1,8-cineole (16%), camphor (11.0%) curdione (11.9%) and furanogermenone (6.2%). Encapsulation of turmeric extract using ionic gelation showed that highest release of curcumin was observed in the sample prepared with 0.5 % chitosan with 0.15% turmeric extract at 5th hour of incubation. A non-chemical methodology for identifying adulteration in spice essential oils using optical properties was developed.

An interaction study between *Pratylenchus* spp and *Pythium* spp showed that simultaneous inoculation of nematode and *Pythium* resulted in the highest percentage of rhizome rot (80%) and yellowing of leaves (90%). Influence of plant phenology and time of planting on the occurrence of shoot borer (*Conogethes punctiferalis*)

indicated that in early planted crop (May), the incidence of the pest was first observed in the third week of July and the infestation reached its peak during last week of September.

Vanilla

A total of 77 accessions (65 *Vanilla planifolia* and 12 *Vanilla* sp.) are being conserved. Twenty-two genotypes of accessions (11), Andaman collection (2), Wayanad collection (2) and other *Vanilla* spp. (7) were characterised using 11 SSR markers. *In vitro* seed germination of 150 day old beans in different media compositions showed protocorm like bodies (PLBs) in the cultures with BM/orchid medium+ 2,4-D (2 mg/L). BM/orchid medium supplemented with growth regulators like BAP (1 mg/L) + NAA (0.5 mg/ L) under dark conditions regenerated into more shoots, whereas the same media without any growth regulators maintained under light got regenerated into more roots.

Tree spices

A wild dominant species of *Myristica* swamps, *M. magnifica* was collected. The species is characterised by stilt roots which emerge from the base of the main trunk and bend downwards to support the tree. F_1 Hybrids were produced in five cross combinations *viz*; Keralashree × Konkan Sanyukta, Keralashree × Acc 590, Keralashree ×Acc 562, Viswashree× Acc 590, Viswashree ×Acc 562. Studies on the effect of microwave pre-treatments on drying of mace showed that microwave at optimal power of 320 W was found to have better retention of essential oil, oleoresin and colour of dried mace. A eugenol infused membrane for packaging chilli and nutmeg was developed and evaluated.

Eight accessions of cinnamon comprising of *C. verum C. riparium*, *C. malabatrum* and three unidentified species were collected and maintained.

Two accessions of clove including a high yielding and regular bearer and a pink flowered variant were collected from farmer's plot in Kannur district. Studies on mechanical drying of clove indicated that a temperature of 55 °C was optimum for drying with maximum essential oil and oleoresin content of 11.2 and 16.9 %, respectively. Plant-hormone based formulation for chemically induced harvesting was developed. The cost of harvesting using this method comes to around Rs.65/kg on dry weight basis.

Three accessions of *garcinia* namely *G. morella, G. wightii* and *G. gummi-gutta* were collected and maintained.

SEM studies on anti-bacterial activity of *Pimenta racemosa* essential oil against *R. pseudosolanacearum* showed structural alterations of cell membrane, breakage of cells, indentation of cellular membrane and blubbing on bacterial surfaces.

General

A granular lime-based *Trichoderma* formulation named 'Tricholime' was developed and a process patent was filed after trials under greenhouse and field conditions. Consortia of *Raoultella terrigena*, *B. safensis*, *Acinetobacer* sp. and *B. amyloliquefaciens* were evaluated on turmeric plants under field conditions. Among the six temperature-tolerant *Trichoderma* isolates, the isolate *T. harzianum* (IISR APT2) recorded highest production of hydrolytic enzymes *viz*., protease (578.12 µg/mL), glucanase (1325.61 µg/mL) and chitinase (1325.61 µg/mL).HPLC and LCMS analysis of culture extracts indicated that three isolates of APT2 (*T. harzianum),* KA15 (*T. lixii)* and NAIMCC0049 (*T. asperellum*) produced peptaibol. LC-MS analysis recorded maximum alamethicin concentration (14.84

ppb) for the isolate, IISR APT2 (*T. harzianum).*

Combined application of *B.safensis* with different levels of $ZnSO_4$ significantly increased the number of tillers, shoot length, number of leaves, dry root weight, and shoot weight compared to the application of 100% $ZnSO_4$ and absolute control.

Compatibility studies of insecticides with *M. pingshaense* indicated that, flubendiamide, imidacloprid, spinosad and chlorantraniliprole were found to be compatible, whereas quinalphos, malathion, lambda cyhalothrin and neem oil inhibited the growth of the fungus. Among the fungicides tested, tebuconazole, metalaxyl, and copper hydroxide were found to inhibit the growth of *M. pingshaense*, whereas mancozeb and copper oxychloride were found to be less harmful to the growth and development of the fungus.

A new species of entomopathogenic fungus, *Metarhizium indicum* which derives its species name after its Indian origin was found to induce epizootics in garcinia leafhopper, *Busoniomimus manjunathi*. The new species was characterized based on its distinct morphological features and multi-gene analyses.

A zebrafish animal facility was established to undertake research on pharmacological properties of extracts and compounds isolated from spices.

Twenty one example varieties of black pepper are being conserved at Kozhikode and CHES, Chettalli. Fifteen cardamom example varieties are being maintained at Regional Station, Appangala. Twenty-three example varieties of ginger and 35 of turmeric are being maintained and multiplied. A comprehensive database scheme for drought transcriptome including the differentially expressed gene information from black pepper is being developed. The database includes 2780 DEGs and 58 DEmiRNAs.

A Shiny based module of Data Analysis and Visualization Toolkit for performing PCA and correlation profiles of samples for meta-analysis was developed. Also, a Data Analysis and Visualization Toolkit is under development in R that enables intuitive exploration, multidimensional analyses and visualization of genomic data from any NGS experiment.

The Kisan Seva Kendra'- Bio Input Resource Centre facility was established for the sale of farm bio inputs of various ICAR institutes as a facilitation service for farmers to access high end input technologies from ICAR system

The ITMU cell issued 37 licenses for various technologies and four license agreements for utilizing the spice processing facility at the institute. The institute organized 52 training programmes of various duration for its stakeholder communities. The training programmes focussed on transferring high end skills and entrepreneurship support to women, rural youth and primary producers. Socially and geographically vulnerable groups were supported with training programmes focussing exclusively on tribal and scheduled caste beneficiaries and primary producer stakeholders in NEH region.

The choice limitations in plant protection, slow pace of varietal replacement, lack of effective dissemination of GAP and organic management strategies and absence of MRL values for spice crops were identified as some of the key research-policy gaps in the spices sector.

A study on the asafoetida sector in the country was undertaken with focus on the processing sector, crop introduction, policy

environment and trade related issues to identify the constraints in asafoetida economy and to develop effective policy inputs.


ICAR - IISR

RESEARCH ACHIEVEMENTS

BLACK PEPPER

Genetic resources

Germplasm accessions are being maintained at ICAR-IISR Experimental Farm, Peruvannamuzhi, Kerala (3511 accessions) and at alternate germplasm site at CHES, Chettalli, Karnataka (542 accessions), respectively. A field gene bank containing 222 accessions and 80 core accessions are being maintained and characterized at ICAR-IISR, Kozhikode. Twenty one *Piper* accessions were collected during 2024 from different parts of India and added to the *Piper* germplasm repository. Specifically, a leaf tip mutant accession from Goa was added to the repository (Fig.1).

Analysis of genetic diversity among *Piper* species

The genetic diversity and taxonomic relationships among 22 *Piper* genotypes, which include 20 wild species and two *P. nigrum* land races, were investigated utilizing 47 novel gene-based SSR markers. The markers had a medium polymorphism information content (0.10 too.38; average- 0.23) and gene diversity (0.10 to 0.5; average- 0.27). However, these markers had high cross-species transferability of 87.0% across all *Piper* species, which ranged from 56.1% in *P. magnificum* to 97.6% in *P.argyrophyllum* (Fig. 2).

Fig. 1: Leaf tip mutant black pepper accession established at ICAR-IISR, Kozhikode

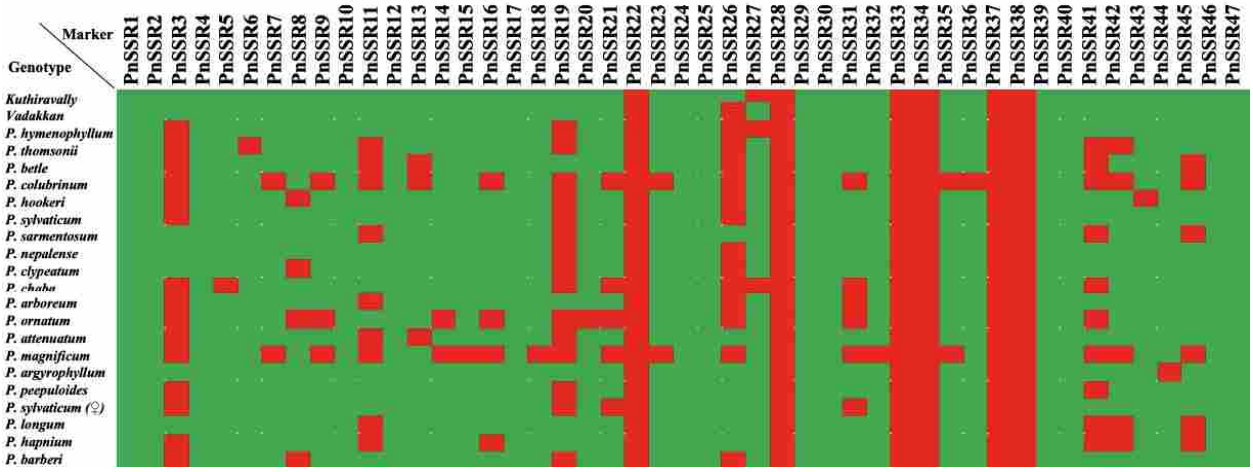


Fig. 2 Pictorial representation of the extent of cross transferability of gene-based SSR markers in different *Piper* species. Green represents transferability and red represents non-transferability.

A total of 295 alleles were found, including 115 unique alleles, with an average of 7.2 alleles per amplified marker locus. The number of alleles varied significantly amongst *Piper* species, ranging from 27 in *P. colubrinum* to 51 in *P. hymenophyllum*. Principal component analysis and UPGMA-based clustering separated the *Piper* genotypes into discrete groups based on geographical origin, growth habit and spike orientation. The three South American *Piper* species, *P. colubrinum*, *P. arboreum*, and *P. magnificum*, which share a common morphological trait of erect, bushy growth habits with erect spikes, were clustered together in both analyses, indicating shared genomic regions and evolutionary relationships. Pairwise comparison of relationships between *Piper* species revealed closest genetic relationship between *P. longum* and *P. hapnium*, *P. colubrinum* and *P. magnificum* and *P. attenuatum* and *P. argyrophyllum*.

Analysis of genetic variability in elite black pepper genotypes for morpho-physiological and yield-related traits

The morphological, physiological and yield-contributing traits of various genotypes was investigated to identify potential drought-tolerant candidates. A significant range of variability were observed among the traits, indicating the presence of substantial diversity within the genotypes. Principal Component Analysis (PCA) was employed to determine the proportional contribution of various traits to drought tolerance, while UPGMA clustering analysis grouped the genotypes based on shared characteristics. Among the genotypes, Accession 7211 (Cluster 2) and Accessions 1495, 1343 and 4132 (Cluster 3) displayed traits like low stomata number and high wax content indicative of strong drought tolerance. These genotypes exhibited favourable morphological features like spike length and setting percentage, efficient physiological adaptations, and stable yield traits under water-limited conditions, making them promising candidates for breeding programs aimed at enhancing drought resilience.

Root anatomy and architecture of different *Piper* species

A study on the root anatomy of four *Piper* species, *P. colubrinum, P. nigrum, P. betle and P. longum* revealed the presence of aerenchyma in *P. colubrinum*, collenchymatous hypodermis in *P. longum*,

starch-filled parenchyma in the cortex of *P. betle* and bundles of conjoint, collateral xylem vessels in *P. nigrum* (Fig.3). Number of vessels per cross section and steel width was more in *P. nigrum* compared to *P. colubrinum* and *P. betle*. The root architecture studies revealed the presence of sturdy roots in *P. colubrinum* as compared to *P. nigrum* and *P. chaba*.

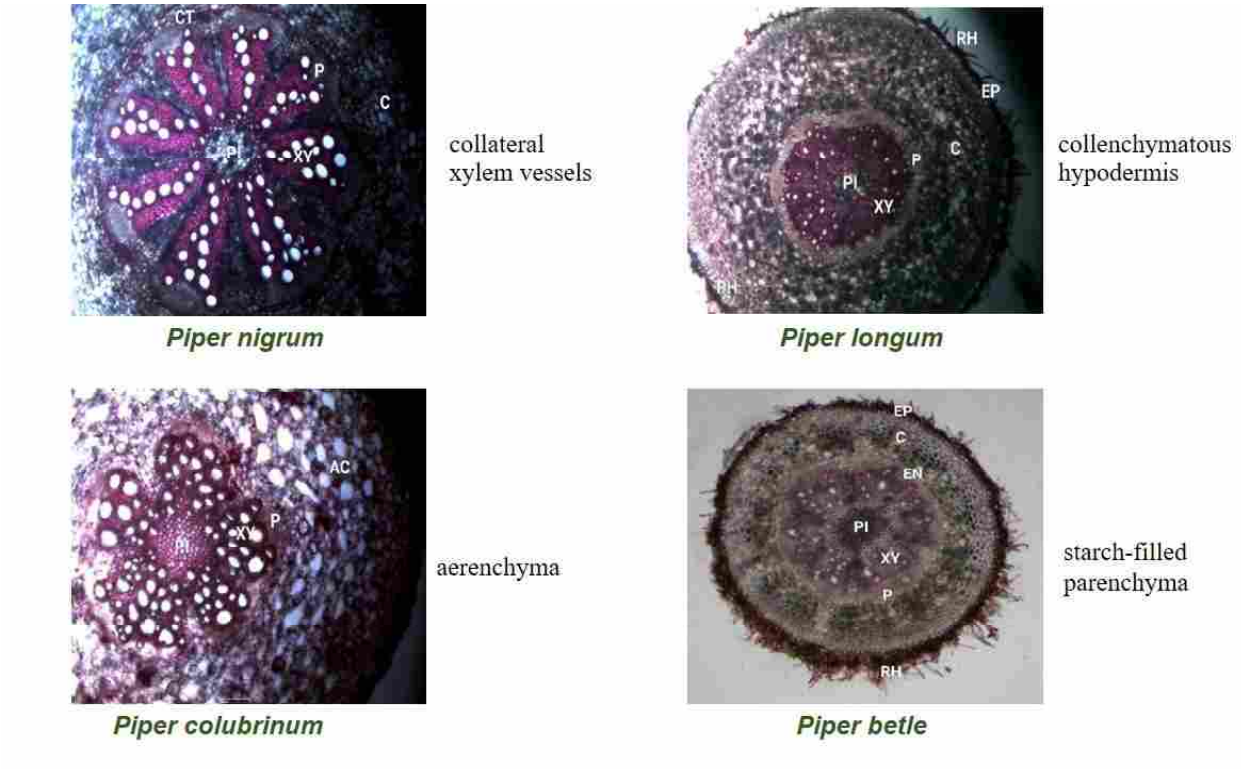


Fig. 3 Root anatomy and architecture of different *Piper* species

Root morphological and anatomical features of black pepper varieties

Root morpho anatomy of 13 varieties was analyzed at the nursery stage and found that Panniyur5 and Vijay had the highest root weight (6.70g&6.00g, respectively). The longest root was observed in IISR Malabar Excel and Pournami (33.10 cm&32.55 cm). The highest primary root length was observed in IISR Thevam, Pournami and PLD-2 (28.87 cm; 24.97 cm&23.5 cm) and the highest number of secondary roots was observed in IISR Thevam (74.67). The varieties Pournami, IISR Shakthi and IISR Thevam had the highest number of xylem vessels (95.33; 92.33 & 88.33). IISR Shakthi and Vijay had the largest number of root hairs per cross-section (71.33&57.66). Widest steel was observed in IISR Shakthi (58.73 µm). These root morpho anatomical advantages might be the reason for the tolerance to abiotic and biotic stresses in IISR Shakthi, IISR Thevam and Pournami varieties.

Differential expression analysis of DHN and SOD (Cu/Zn) genes in nutrient-deficient plants

To study the differential expression of DHN and SOD (Cu/Zn) genes, the variety, Panniyur-1 was grown with the recommended dose of nutrients (1g urea+2 g SSP+ 4g MOP/ 10kg soil; applied after two

months of crop growth) and without fertilizer application. After one month of nutrient application, root length was 4.5 times and the root spread was 1.73 times higher in nutrient-treated plants compared to untreated plants. Differential expression of genes indicated that untreated plants had significantly higher expression levels for both the DHN (0.182167) and SOD (Cu/Zn)1(0.276114) genes compared to nutrient-treated plants.

Meghalaya's cultivated long pepper identified as *Piper peepuloides*

A comprehensive study of long pepper cultivated in Meghalaya, revealed the species to be *P. peepuloides*, distinct from the commercially cultivated *P. longum* through integrated morphological, biochemical, and DNA fingerprinting analyses (Fig. 4). *P. peepuloides* exhibied distinctive characteristics, including a climbing growth habit and unique leaf and inflorescence morphology. The species presents a distinct chemical profile lacking several compounds typical of *P. longum*, while containing significant levels of bioactive constituents such as beta-caryophyllene and beta-bisabolene. These properties, combined with its economic viability and suitability for intercropping systems, establish *P. peepuloides* as a promising alternative crop for the region.

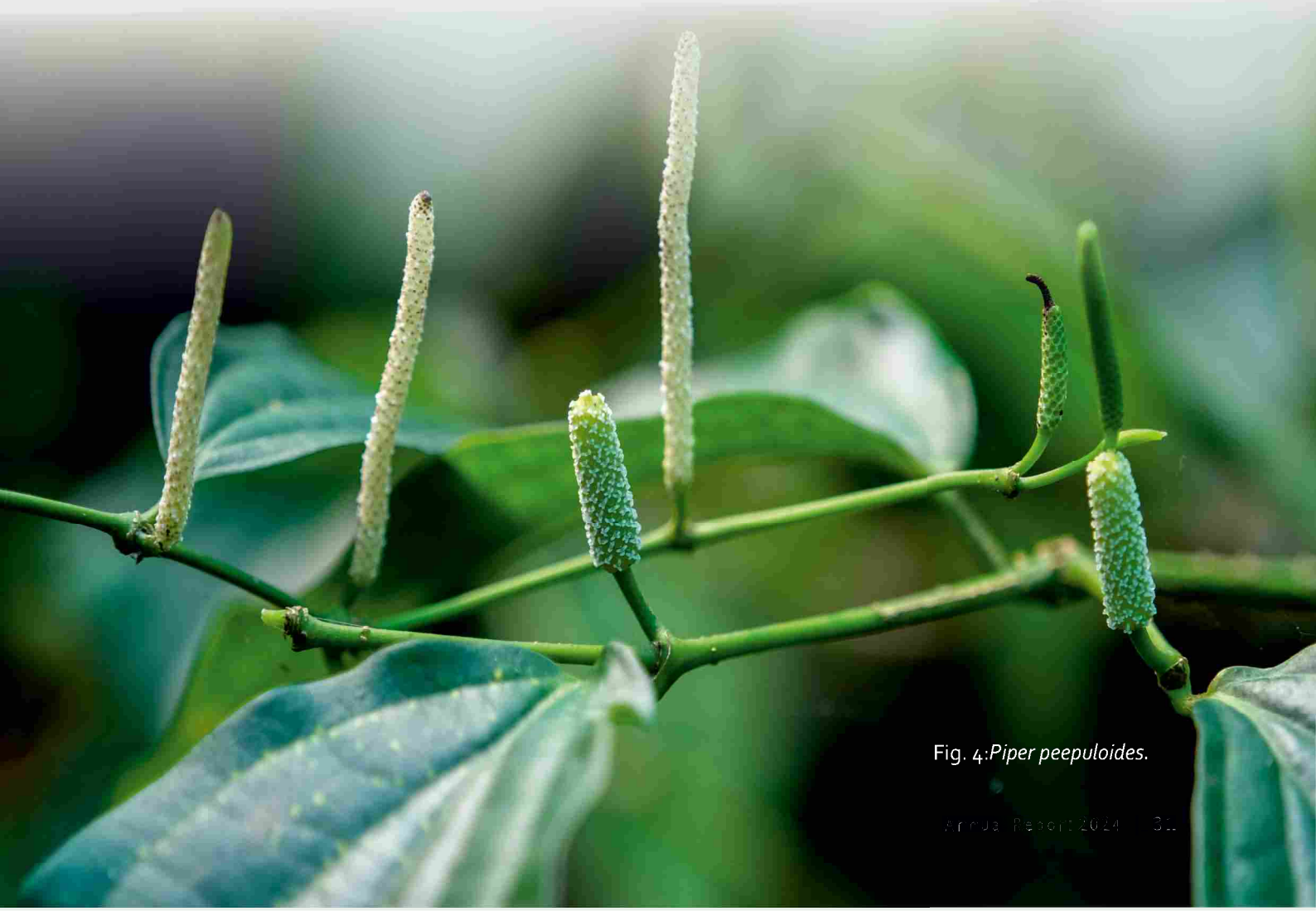


Fig. 4:*Piper peepuloides.*

Fig. 5 :Licensing of IISR Chandra to a farmer from Karnataka by RAC committee

Commercialization of hybrid "IISR Chandra"

'IISR Chandra', an early-maturing hybrid, is characterized by high fruit set and long spikes. The variety has been made available for commercial cultivation through non-exclusive licensing agreements (Fig.5). During the year, 23 licenses were issued to growers across four states: Kerala, Karnataka, Tamil Nadu, and Meghalaya.

Impact of rainfall on yield parameters

Yield characters such as spikes per 0.5m^2, spike length, number of berries per spike and fruit set percentage were recorded from 25 black pepper plantations in Karnataka (Kodagu, Hassan, Chikmagalur districts) and Kulashekaram in Tamil Nadu under coffee + black pepper and arecanut + black pepper cropping systems. In the coffee + black pepper system, the average spike intensity was 17.8 spikes per 0.5 m^2, and the yield per vine ranged from 0.5 to 1 kg. In contrast, the arecanut + black pepper system showed a significantly higher spike intensity of 33.9 spikes per 0.5 m^2 and a yield per vine ranging from 2.4 to 2.5 kg.

Field evaluation of elite genotypes for drought tolerance

Eleven genotypes identified as drought tolerant were evaluated in the field for their tolerance to water stress. Antioxidant enzyme activity was measured at weekly intervals in both control and moisture-stressed plants. The activities of polyphenol oxidase (PPO) and glutathione reductase (GR) enzymes were highest in all accessions, except for Acc 807. Under water stress, reductions were observed in the number of spikes (36%), berry size (8.2%), and berry set percentage (15%). Based on physiological and yield parameters, the genotypes Acc 4226, 1277, and 1495 showed the best performance under drought conditions.

Chemo-diversity analysis

A total of 95 samples were analyzed for key quality parameters, including essential oil, oleoresin, piperine, and total phenolic content. Essential oil content of the accessions ranged from 1.6% (Acc. 1462) to 5.6% (Acc. 1249), while oleoresin content varied between 5.5% (Acc. 984) and 10.0% (Acc. 1266). The piperine content ranged from 2.9% (Acc. 1199) to 6.8% (Acc. 1000). Total phenolic content ranged from 2.17 mg GAE/g (Acc. 4116) to 8.17 mg GAE/g (Acc. 984).

Analyzing the virulence pattern of *Phytophthora* isolates

Virulence analysis through detached leaf assay was carried out with *P. capsici* (05-06 and 18-02) and *P. tropicalis* (98-02 and 98-177) on nine varieties: PLD 2, Sreekara, IISR Malabar Excel, IISR Thevam, IISR Shakthi, Panchami, Panniyur 6, Panniyur 8, and Panniyur 9. Results indicated that all isolates were virulent on tested varieties.

Cross-infectivity of *Phytophthora* isolates

Cross-infectivity studies using detached leaf assay with multiple isolates of *P. capsici* and *P. tropicalis* on arecanut, coconut, and nutmeg revealed that *P. capsici* isolate 09-03 and *P. tropicalis* isolate 98-177 were highly pathogenic on nutmeg, resulting in development of 457.66 mm^2 and 526.66 mm^2 lesion areas, respectively (Fig. 6).

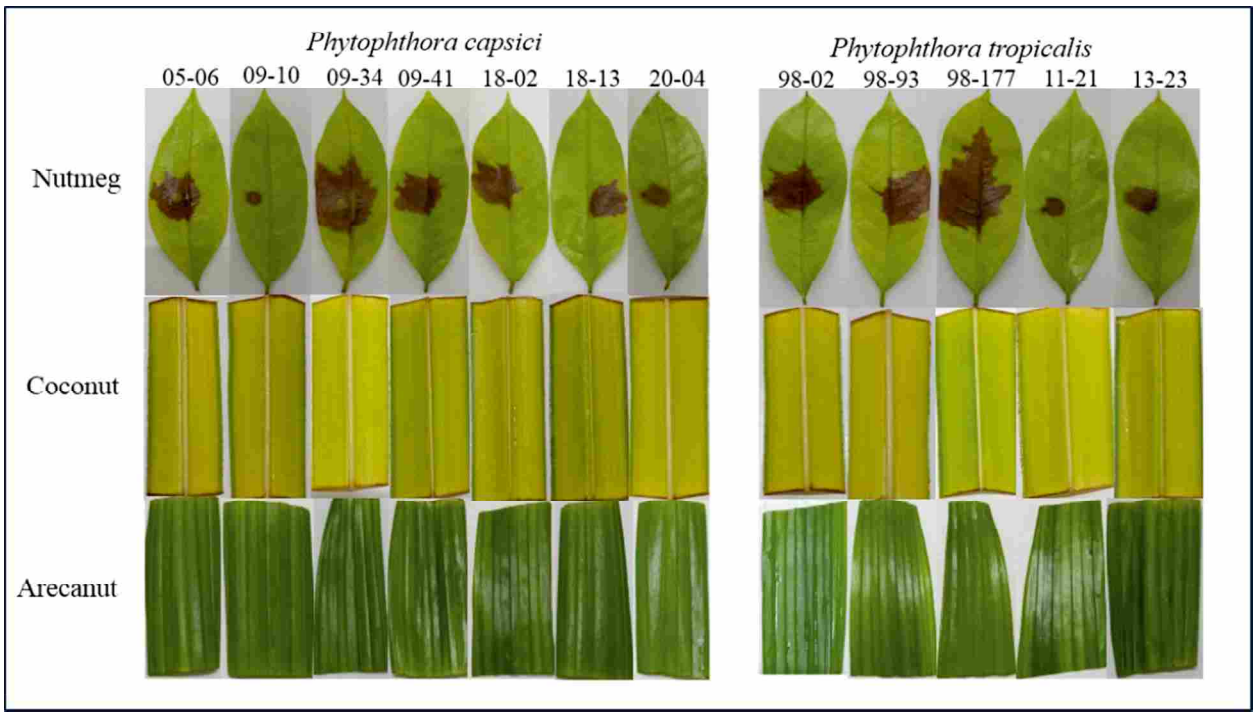


Fig. 6: Cross infectivity assay of *P. capsici* and *P. tropicalis* isolates on nutmeg, coconut and arecanut

Genome content estimation and analysis of genome size of *P. capsici* and *P. tropicalis*

Genome content analysis using *Arabidopsis thaliana* ecotype Columbia (Col-0) as reference revealed that most *P. capsici* isolates had genome content greater than 150 Mbp/2C, except isolates 01-04 and 05-06. *P. tropicalis* isolates showed genome content around 100 Mbp/2C, with isolate 03-07 being an exception

Analysis of haplotypes in *P. capsici* and *P. tropicalis*

Haplotype analysis identified a total of 30 haplotypes from the mitochondrial and nuclear genes. The *EF1-α* gene showed five haplotypes, while *Cox1*, *Cox2*, *Nad5*, β-*tubulin*, *enolase*, *HSP90*, and *TigA* genes each showed three haplotypes, and Nad1 and Ura3 showed two haplotypes each. Haplotype network was also plotted with

the *P. capsici* isolates of diverse host and *P. capsici* and *P. tropicalis* isolates of India which were isolated from black pepper. It was observed that the nuclear genes such as *EF1-α*, *enolase*, *HSP90*, *TigA* and *Ura3* and mitochondrial genes such as *Cox2* and *Nad5* incorporates unique haplotypes with EF1-α showing the greatest diversity (Fig. 7).

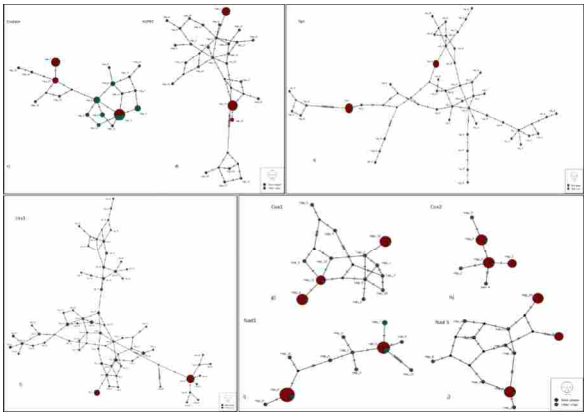


Fig. 7: Gene genealogy analysis of *Phytophthora* isolates of Hawaii and some of the contiguous United States and black pepper isolates from India

Analysis of effector RxLR29 and RXLR132 in *P. capsici* and *P. tropicalis* isolates

The highly upregulated RxLR genes following the infection with *Phytophthora* spp. was selected for the protein-protein interaction studies. The DRB4 protein structure displayed four alpha helices and three anti-parallel beta sheets and the structure of RxLR29 protein of all the isolates has 12 alpha helices and that of PT09-01, PT06-17 and PT11-29 had 13 alpha helices. In RxLR132 protein of the isolates had 5 alpha helices and 1 incipient helix and the structure of CMPG1 had 21 alpha helices, 1 incipient helix and 2 anti-parallel beta sheets.

The interaction between RxLR29 and DRB4 was resolved using HADDOCK 2.4. In the diagram, the effector protein RxLR29 is represented in slate blue and DRB4 protein in a palecyan tint. In RxLR29, the isolates PC05-06, PC18-02, PC23-01, PT03-07, PT06-17, PT09-01, PT11-29, PT13-23 and for all the isolates of RxLR132 the HADDOCK scores were within the favoured range, which indicates that the docking model is reliable and energetically favourable (Fig. 8)

Analysis of Effector RxLR29 and RxLR132 in *P. capsici* and *P. tropicalis* Isolates

The highly upregulated RxLR genes following infection with *Phytophthora* spp.

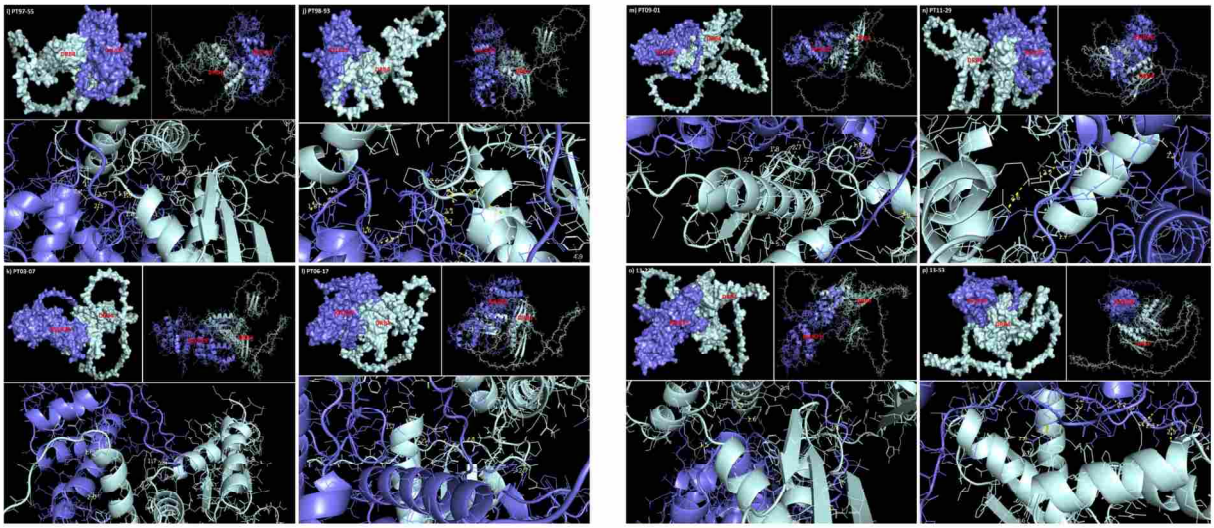


Fig. 8: Protein-protein interaction between RxLR29 and DRB4 among the isolates of *P. capsici* (PC) and *P. tropicalis* (PT). Top left shows the 3D surface image, top right displays the cartoon model and the bottom image is the closer view showing hydrogen bonds between RxLR29 and DRB4 proteins represented by yellow dotted lines

were selected for protein-protein interaction studies. The DRB4 protein structure consists of four alpha-helices and three anti-parallel beta sheets. The RxLR29 protein structure across all isolates contains 12 alpha-helices, while isolates PT09-01, PT06-17, and PT11-29 have 13. In contrast, the RxLR132 protein in the isolates has five alpha-helices and one incipient helix, whereas CMPG1 comprises 21 alpha-helices, one incipient helix, and two anti parallel beta sheets.

The interaction between RxLR29 and DRB4 was resolved using HADDOCK 2.4. In the diagram, the effector protein RxLR29 is represented in slate blue and DRB4 protein in a palecyan. In RxLR29, the isolates PC05-06, PC18-02, PC23-01, PT03-07, PT06-17, PT09-01, PT11-29, PT13-23 and for all the isolates of RxLR132 the HADDOCK scores were within the favoured range, which indicates that the docking model is reliable and energetically favourable (Fig. 8).

Sensitivity of *P. capsici* and *P. tropicalis* isolates towards fungicides

Fungicide sensitivity studies with *P. capsici* and *P. tropicalis* isolates showed sensitivity to dithiocarbamates (iprovalicarb-propineb 0.2%, propineb 0.25%, cymoxanil-mancozeb 0.2%, metalaxyl-mancozeb 0.125%), benzamides (fluopicolide-propamocarb 0.125%), copper oxychloride (0.25%), and Bordeaux mixture (1%). The isolates were insensitive to strobilurin (penflufen-trifloxystrobino.04%) and azoxystrobin 0.3%) and dinitrile groups (chlorothalonil 0.2%).

Duplex recombinase polymerase amplification–lateral flow assay (RPA-LFA)

The optimized duplex RPA-LFA was validated using DNA from various *Phytophthora* species, including *P. capsici, P. tropicalis, P. meadii, P. palmivora,* and *P. nicotianae***.** Also, ten isolates each of *P. capsici* and *P. tropicalis*, along with seven *Pythium* spp. isolates obtained from black pepper plants were also included in validation. Additionally, crude extracts from black pepper leaves inoculated with different *Phytophthora* and *Pythium* isolates, as well as root and soil samples collected from black pepper plantations, were tested. The developed duplex RPA-LFA assay demonstrated high specificity, with no cross-reactions observed with other pathogens, confirming its robustness.

Screening of germplasm accessions against virulent *P. capsici* and *P. tropicalis* isolates

A new collection of accessions was screened for resistance against *P. capsici* (28 accessions) and *P. tropicalis* (13 accessions) using the soil inoculation method. Among the accessions tested against *P. capsici*, seven (7492, 7445, 7457, 7467, 7439, 7657, 7482) survived the infection. Against *P. tropicalis*, 11 accessions (7548, 7585, 7492, 7445, 7503, 7563, 7401, 7478, 7577, 8043, 7457) exhibited survival.

Development of black pepper resistant to *Phytophthora* through CRISPR/Cas

The *NPR3* gene from the variety *Sreekara* was amplified, cloned, and sequenced. Sequence analysis against the black pepper genome database revealed four distinct isoforms. Specific primers were designed and optimized for each isoform. The NPR3 gene sequence was then used to design guide RNA (gRNA) for genome editing via CRISPR/Cas.

Occurrence, complete genome sequencing, and diagnostic development for black pepper virus F

The occurrence of black pepper virus F (BPVF) was identified in India for the first time, and its complete genome was sequenced. The RNA 1 and RNA 2 segments of the Indian BPVF isolate (BPVF-IND) contain 6,376 and 3,340 nucleotides, potentially encoding proteins of 230.7 kDa and 114 kDa, respectively. Sequence comparison of BPVF-IND RNA 1 with BPVF isolates from Brazil (BPVF-BR-PA) and China (BPVF-ZYP-1) showed 95% and 90% identity, respectively, while RNA 2 exhibited 96% and 90% identity. Phylogenetic analysis of the Pro-Pol region of RNA 1 and the coat protein region of RNA 2 revealed that all three BPVF isolates clustered closely together, distinct from other species in the Fabavirus genus. Diagnostic assays based on RT-PCR and RT-recombinase polymerase amplification (RT-RPA) were developed for the sensitive detection of BPVF.

Development of a lateral flow immunoassay (lfia) for piper yellow mottle virus (pymov)

A lateral flow immunoassay (LFIA) was developed using polyclonal antiserum against the PYMoV coat protein. Colloidal gold nanoparticle (GNP)-Immunoglobulin G (GNP-IgG) conjugates were prepared with 30 nm GNPs, optimized at pH 9 with an IgG concentration of 30 µg/ml.LFIA strips were assembled using a PT-R5 conjugate release matrix coated with GNP-IgG, a GFB-R04 sample pad, an AP045 absorbent pad, and a 10 µm nitrocellulose membrane laminate printed with PYMoV IgG (test line) and anti-rabbit IgG (control line). The strips produced colored lines at both test and control positions when tested with homologous antigen and PYMoV-infected plant extracts, while only the control line appeared for negative samples (Fig. 9).Results were obtained within 5–10 minutes. The LFIA was validated using 39 field samples (22 symptomatic and 17 asymptomatic) from black pepper, betelvine, and Indian long pepper plants.

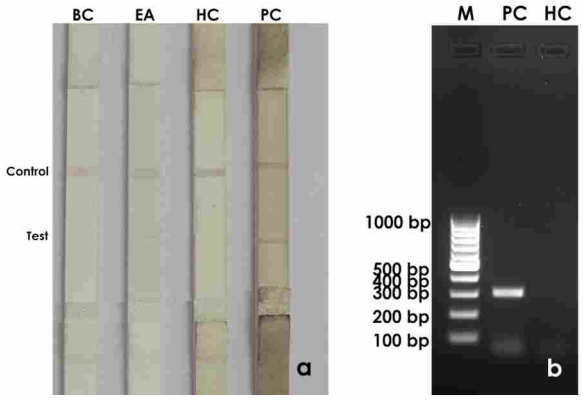


Fig. 9(a) Standardization of LFIA for the detection of piper yellow mottle virus (PYMoV). Lane BC: buffer control; Lane EA: *in vitro* expressed protein; Lane HC: healthy control; Lane PC: positive control. b) Confirmation of the presence of PYMoV in positive control and its absence in healthy control. Lane M: 100 bp DNA ladder

Screening germplasm for nematode resistance

A total of 112 germplasm accessions were screened for resistance to burrowing nematode (*Radopholus similis*) and root-knot nematode (*Meloidogyne incognita*) under natural conditions. Thirty-five accessions exhibited immune response to *M. incognita*, while none of the accessions showed immunity to *R. similis*.

In vitro screening of the nematicide fluozaindolizine

The efficacy of the nematicide Fluozaindolizine was tested against *R. similis*, *M. incognita*, and *Pratylenchus* spp. under *in vitro* conditions at various concentrations and exposure durations. At 2,000 ppm, 24-hour exposure resulted in 100%, 55%, and 26% mortality for *M. incognita*, *R. similis*, and *Pratylenchus* spp.,

respectively. After 48 h, mortality increased to 94% for *R. similis* and 50% for *Pratylenchus* spp. The highest exposure period (72 h) led to 88% mortality of *Pratylenchus* spp.

Evaluation of low-risk insecticides against root mealybug (*Planococcus lilacinus*)

Field trials were conducted for two years to assess the effectiveness of soil drenching of insecticides for managing black pepper root mealybug using eight treatments, including five low-risk insecticides (Clothianidin, Flonicamid, Spirotetramat, Spiromesifen, Triflumezopyrim) and two standard checks (Chlorpyriphos, Thiamethoxam). Clothianidin 50 WDG (1 g) consistently reduced adult female populations, followed by Spirotetramat 15.31 OD (1 ml). Both insecticides were effective in controlling root mealybug.

CARDAMOM

Fig.10 : Moisture stress tolerant line 584058-3 a. Panicles; b. Fresh capsules

Genetic resources

The National Active Germplasm Site at ICAR-IISR Regional Station, Appangala, continues to maintain 625 germplasm accessions. During the year, 21 accessions were characterized for morphological traits, yield, and quality parameters. Among them, genotype IC 349627 exhibited superior performance in plant height (322.5 cm), bearing tillers (35.2), and capsules per plant (248.6). It also recorded the highest fresh yield (1,502.7 g/plant) and dry yield (313.8 g/plant) based on three-year pooled data. Essential oil content ranged from 6.5% to 8.3 %, while oleoresin content varied from 1.7% to 3.0% across genotypes.

Evaluation of moisture stress-tolerant lines

Yield observations were recorded from 14 moisture stress-tolerant lines developed through artificial screening with PEG. Among them, line 584058-3 recorded the highest yield, producing 860 g of fresh yield and 149 g of dry yield /plant (Fig.10).

Evaluation of hybrids

In a coordinated varietal trial with nine hybrids and a check variety, the hybrid Bold × IC 547219 recorded the highest yield, producing 2784.1 kg/ha fresh yield and 517.7 kg/ha dry yield. It was followed by (GG × Bold) × Appangala 1 (1310.0 kg/ha fresh,

285.1 kg/ha dry yield) and MHC-2 (1304.7 kg/ha fresh, 248.2 kg/ha dry yield).

Multi location trial on leaf blight tolerant lines

A multi-location trial was conducted on five leaf blight-tolerant genotypes, along with resistant and susceptible checks. Fresh yield ranged from 109 to 344 kg/ha, while disease incidence varied between 10.6% and 22.8% PDI. The highest was recorded in IISR Vijetha, while IC 547222 had the lowest incidence of disease.

Notification of varieties

Two open-pollinated small cardamom varieties, IISR Manushree (recommended for Karnataka and Kerala) and IISR Kaveri (recommended for Karnataka), were notified during the year. The notification was issued by the Government of India, Ministry of Agriculture and Farmers' Welfare (Department of Agriculture and Farmers' Welfare) under F. No. 3-76/2024 SD-IV, dated 23 September 2024.

Field evaluation of fungicides

Pre- and post-monsoon spraying and drenching with Tebuconazole @ 1 ml/L or Metalaxyl + Mancozeb @ 1.25 g/L significantly reduced the rhizome rot incidence. Application of two rounds of foliar spray with Hexaconazole 5% SC, one pre-monsoon (June) and one post-monsoon (September), was effectively managing leaf blight disease.

Integrated management schedule for diseases

A field trial conducted at ICAR-IISR, Regional Station, Appangala demonstrated that a pre-monsoon spray and drench with Tebuconazole (1 ml/L) followed by a post-monsoon spray and drench with *Bacillus atrophaeus* and *B. amyloliquefaciens* (0.5%), resulted in the lowest disease incidence, with a percent disease index (PDI) of 10%. Spraying Bordeaux mixture (1%) during both pre- and post-monsoon periods and drenching with *B. atrophaeus* and *B. amyloliquefaciens* (0.5%), showed a PDI of 12.5%. Both treatments effectively reduced

IISR Manushree

IISR Kaveri

rhizome rot incidence indicating that the combined application of fungicides and biological agents can significantly reduce rhizome rot incidence.

Spray schedule optimization of low-risk insecticides

Three low risk insecticides (spinosad, flubendiamide, chlorantraniliprole @ 1.0 ml/L) and a neem based botanical insecticide (3.0 ml/L) with a standard check (quinalphos @ 2.0 ml/L) were evaluated under field conditions for optimizing spray schedules against the shoot and capsule borer (*Conogethes sahyadriensis*). Two spray schedules were tested: (i) January–February, March–April, and September–October, and (ii) February–March and September–October.. Results indicated that for the second consecutive year, both the spray schedules were effective in reducing the shoot and capsule damage.

LARGE CARDAMOM

Foorkey disease

Rapid detection of cardamom bushy dwarf virus causing *foorkey* disease

A recombinase polymerase amplification (RPA) assay was developed for the rapid detection of cardamom bushy dwarf virus (CBDV) in large cardamom using crude leaf extract. The concentration of magnesium acetate, time, and temperature for the optimum detection of CBDV was determined. The RPA assay was 1000 times more sensitive and significantly faster than conventional PCR, indicating its suitability for large-scale indexing.

GINGER

Genetic Resources

A total of 668 ginger accessions are being maintained at the field gene bank of ICAR-IISR Experimental Farm, Peruvannamuzhi.

Evaluation of lines for disease tolerance

Ten ginger entries (five from IISR, three

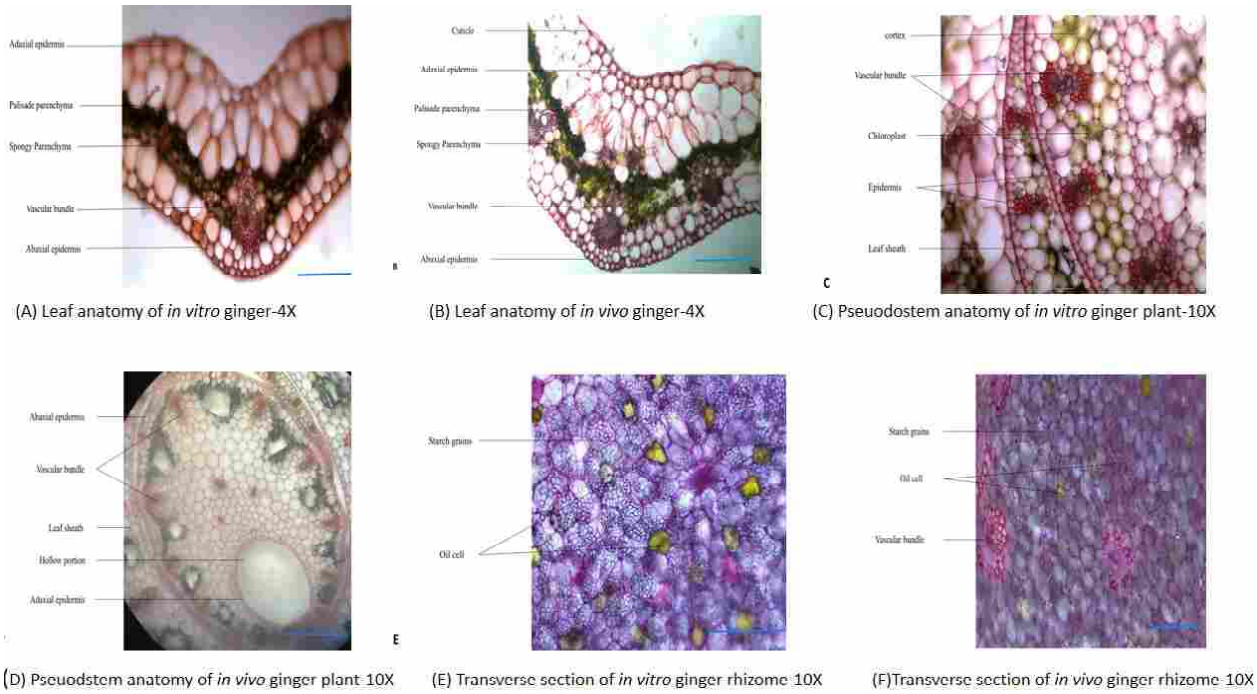
from Pottangi, one from Raigarh, and one control) were evaluated under field conditions for three years. Based on pooled CVT data, R 1.25/4 recorded the highest yield (15.6 t/ha), which was on par with the control variety, Varada. The mutants R 1.25/4 and HP 0.5/2 were tested under artificial inoculation for *Pythium* and *Ralstonia*. HP 0.5/2 showed mild susceptibility to *Ralstonia*, while R 1.25/4 exhibited lower *Pythium* infection.

Chemical mutagenesis in ginger

A study on chemical mutagenesis was carried out using the variety IISR-Varada. Twelve treatments, including controls, were designed with varying doses of ethyl methane sulphonate (EMS), a mutagen at 0.0%, 0.5%, 0.75%, 1.0%, 1.25%, and 1.5%, each tested at 2-hour and 4-hour incubation periods. Fifty single buds were used per treatment, and 179 plants survived post-germination, which are currently under evaluation. 50% mortality was observed at 1.0% EMS (4 hours) and 1.25% EMS (2 hours).

Anatomical variations of *in vitro* and *in vivo* grown ginger

Anatomical studies were conducted on 50-day-old plants of the variety IISR-Varada to compare *in vitro* plants (tissue culture-derived) with *in vivo* plants (pro-tray grown). Transverse sections of leaves, pseudostems, and rhizomes were examined under light microscopy. It was observed that both *in vitro* and *in vivo* plants had a similar leaf structure but differed in spongy parenchyma thickness, stomatal density, oil cells, air canals, and vascular bundle distribution. The pseudostems of *in vitro* plants had tightly bound leaf sheaths and epidermis, unlike their in vivo counterparts. Anatomical analysis of rhizomes revealed larger vascular bundles in *in vivo* ginger (farm-grown rhizomes) and higher starch and sugar content in *in vitro* rhizomes (Fig.11).



(A) Leaf anatomy of *in vitro* ginger-4X

(B) Leaf anatomy of *in vivo* ginger-4X

(C) Pseudostem anatomy of *in vitro* ginger plant-10X

(D) Pseudostem anatomy of *in vivo* ginger plant 10X

(E) Transverse section of *in vitro* ginger rhizome 10X

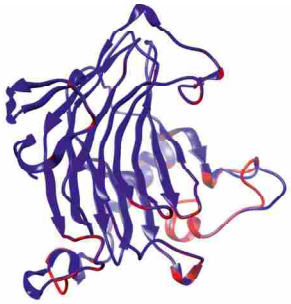
(F)Transverse section of *in vivo* ginger rhizome 10X

Fig. 11: Anatomical variations of *in vitro* and *in vivo* grown ginger

Amplification, sequencing and structural modelling of the XET 23 gene

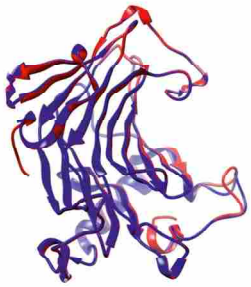
Bacterial wilt caused by *R. psuedosolanacearum* is a serious disease resulting in severe reduction in yield. XET genes are known to be involved in plant growth, development, pest and disease resistance and abiotic stress tolerance. Therefore, xet23 was selected for PCR amplification and cloning using gene specific primers. PCR protocols were standardized for xet23 gene and the amplicon sequencing was done to confirm the sequence. The genomic sequence of XET 23 was used to deduce its amino acid sequence. A comparative analysis identified conserved motifs of Xet23 protein family. This, along with comparative structural modelling in XET23 and XET10 revealed mutations that may lead to functional variation in these genes (Fig.12).

a)



RMSD	Alpha Carbons	Back Bones	Heavy Atoms	All Atoms
Xet 10	1.14	1.11	1.85	1.85

b)



RMSD	Alpha Carbons	Back Bones	Heavy Atoms	All Atoms
Xet 23	0.99	0.95	1.82	1.82

Fig.12: Superposed structural models of ginger a) XET10 and ginger b) XET23 with the XET template from *Populus tremula*

Evaluation of various farming systems

The effect of various management systems on soil nutrient availability at 120 days after planting revealed significant differences in nutrient status due to different crop management practices. The highest levels of OC and Ca were observed in the Integrated Nutrient Management (INM) treatment, while P, Cu, Mn and Fe were most abundant in the organic treatments.

Spray dried ginger-lime juice powder

A spray dried ginger lime juice powder was prepared using IISR Varada. The juice powder was studied for various physical properties *viz.*, moisture content, encapsulation yield, bulk density, true density, porosity, tapped density and lightness, which were determined as 6%, 74.9 %, 378.8 kg/m^3, 663.4 kg/m^3, 42.9%, 410.2 kg/m^3 and 83.4, respectively. Functional properties of the spray dried ginger-lime juice powder namely hygroscopicity, wettability, water solubility, water absorption index, flowability and cohesiveness were determined as 54.6%, 67 s, 84.6%, 0.7, 14.5 and 1.7, respectively.

Efficacy of vacuum infiltration for elimination of *R. pseudosolanacearum*

The rhizomes inoculated with *R. pseudosolanacearum* were subjected to heat treatment at 30°C, 40°C, 50°C, and 60°C for

5, 10, 20, and 30 minutes using a sett treatment device. Bacterial biofilm persisted in treatments below 60°C for 30 minutes. Although exposure to 60°C for 30 minutes eliminated the pathogen, it severely impacted germination (<5%).Chemical treatments with calcium chloride, copper oxychloride, and copper hydroxide were also tested for 10 and 30 minutes. Among them, copper oxychloride (0.4%) for 10 minutes was the most effective, yielding 60% disease-free plants.

Influence of date of planting on soft rot incidence

Influence of date of planting on soft rot incidence was studied under field conditions. Early (March) and normal (June) planting was compared, with observations recorded on soil *Pythium* population, germination, growth parameters, and percent disease index (PDI).Results showed that early planting in March significantly reduced disease incidence and *Pythium* soil population compared to late planting.

Influence of crop rotation with non-host crops on soft rot incidence

Field trials on the influence of crop rotation with non-host crops of *Pythium* like mustard, amaranthus, French bean, cowpea and sorghum indicated that planting with cowpea and mustard enhanced seed germination, and reduced soft rot incidence.

Evaluation of new generation molecules against *Pythium* spp

Six new generation fungicides, Kresoxim methyl (18%) +mancozeb (54%), Kresoxim methyl (15%) +chlorothalonil (56%), copper sulphate pentahydrate, propineb (70%) Fluopicolide (4.44%) + Fosetyl-Al (66.67%), Fluopicolide (5.56%) + Propamocarb Hydrochloride (55.6%) were evaluated for their efficacy against *Pythium* under *in vitro* and greenhouse conditions. The fungicides were tested at doses 0.5x, 1x, (x25%), (x+25%) and higher dose (2x).Four fungicides *viz.*, Kresoxim methyl +mancozeb, Kresoxim methyl + chlorothalonil, Fluopicolide + Fosetyl-Al and Propineb were found effective against *Pythium* under *in vitro.* Under greenhouse conditions ,all the four fungicides were found effective against *Pythium*.

Field evaluation of integrated disease management schedule for soft rot disease

An Integrated Disease Management (IDM) strategy for soft rot was evaluated under field conditions. The study tested solarization, crop rotation with non-host crops (cowpea and mustard), and bioagents (*B. safensis, B. amyloliquefaciens, B. licheniformis,* and *Trichoderma asperellum*).Results showed that crop rotation with cowpea and mustard, combined with bioagent application (*B. safensis, B. amyloliquefaciens,* and *T. asperellum*) at 30-day intervals, significantly reduced *Pythium* soil population, enhanced germination, and lowered soft rot incidence.

Effect of arbuscular mycorrhizal fungi on growth, disease and nematode tolerance

Ginger roots inoculated with AMF enhanced ginger growth, tillering, and nutrient uptake, increasing N (27.8 g/plant) and P (3.9 g/plant) absorption along with K, Ca, Mg, Fe, Mn, Zn, and Cu. AMF also improved disease resistance, reduced *P.myriotylum*-induced soft rot incidence to 40% compared to 80% in non-AMF plants. Additionally, AMF significantly inhibited *M.incognita* (J2) penetration into roots, demonstrating its potential against nematodes.

Effects of endophytic bacterial extracts on *Pythium* spp. and bioactive metabolite profiling

Scanning electron microscopy (SEM) analysis of *P. myriotylum* and *P. deliense* treated with endophytic bacterial extracts revealed significant morphological alterations in their hyphae (Fig. 14). Treated mycelia exhibited rough, wrinkled surfaces, hyphal rupture, fragmentation, peeling of the outer layer, and abnormal structural formations, whereas untreated control hyphae remained smooth. *P. myriotylum* showed more severe damage compared to *P. deliense*, highlighting its susceptibility to bacterial extracts.

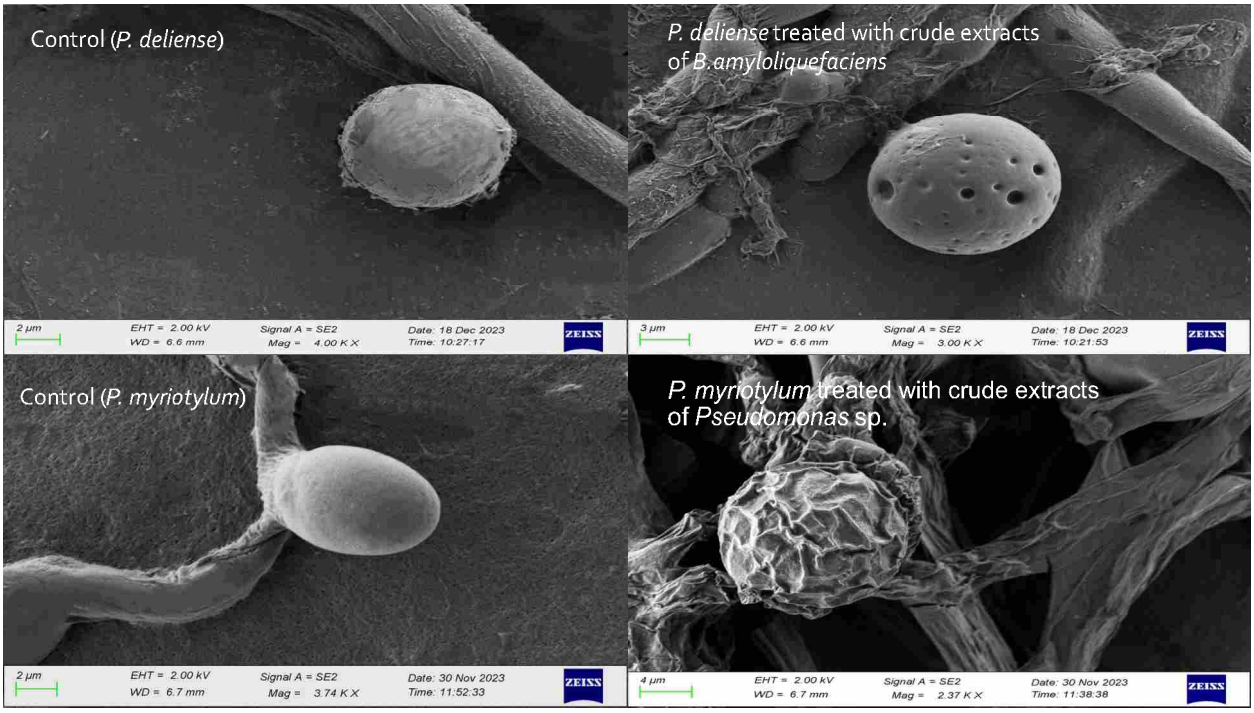


Fig 14. SEM analysis of the mycelia and spore on treatment with methanolic extract of selected bacterial isolates

GC-MS analysis of methanolic extracts from *Pseudacidovorax intermedius* (NCC15), *Rhizobium* sp. (NCC17), *Bacillus amyloliquefaciens* (CC11), and *B. pumilus* (KG6) identified distinct metabolite profiles. Extracts from *P. intermedius* and *Rhizobium* sp. were rich in diketopiperazines (DKPs), followed by esters and heterocyclic compounds. In contrast, *B. amyloliquefaciens* and *B. pumilus* extracts contained higher levels of amines and amino acids, along with hydrocarbons and heterocyclic compounds.

Screening of microbes for nematicidal property

Several bacterial strains were isolated from soil and tested for nematicidal activity against *M.incognita*. Among them, *B.megaterium*, *B.aryabhattai*, and *B. cereus* were found effective and *B. aryabhattai* was the most effective in inhibiting nematode host penetration.

Management of root-knot nematode

Application of Fluopyram (1250 ml/ha) was found to be the best among all treatments as it showed up to 8-fold reduction in *M. incognita*. It also showed up to 5-fold reduction in *Pratylenchus* sp. population. The application resulted in 87% higher yield compared to untreated control, 20% higher compared to the application of carbofuran,

and 59% higher than the application of Fluensulfone.

Field evaluation of an IPM package against shoot borer infesting ginger and turmeric

An Integrated Pest Management (IPM) package for the management of *C. punctiferalis* infesting ginger and turmeric was evaluated under field conditions for the second consecutive year. Three insecticides (chlorantraniliprole and Spinosad @ 0.5 ml/L and lambda cyhalothrin @ 2.0 ml/L) and a neem product (5.0 mL/L) in combination with a liquid formulation of *M. pingshaense* (1×10^7 conidia/ml) were evaluated at a spray interval of 21 days. The results indicated that all the treatments were effective in controlling the pest compared to the control.

TURMERIC

Genetic resources

A total of 1404 germplasm are being maintained of which 1132 have been characterized for morphological and rhizome characters and 600 for quality characters.

Evaluation of black turmeric genotypes

Seven black turmeric genotypes were evaluated in Coordinated Varietal Trial. In the first year of evaluation, Acc. 751 recorded highest yield producing 11 kg per bed.

Evaluation of light yellow colour turmeric for specialty market

Based on three-year coordinated trials, Acc. 849 was identified as a superior variety, recording a 10% higher yield than the national check (*IISR Prathibha*) and a 30% increase over the local cultivar (*Mydukur*). This variety was recommended for release in Kerala, Telangana, Arunachal Pradesh, and Odisha during the XXXV Annual Group Meeting of AICRP on Spices. The variety was named *IISR Surya*, highlighting its key feature, a light yellow rhizome with a curcumin content of 2–3% (Fig.15). It is well-suited for the powdering industry due to its unique flavor and significantly high levels of minor volatile compounds, including zingiberene (21.07%), β-sesquiphellandrene (14.13%), 1,8-cineole (3.42%), and α-humulene (6.30%).*IISR Surya* is a high-yielding variety, with an average fresh yield of 29 t/ha and a potential yield of 41 t/ha, producing a dry yield of 5.8 t/ha.

Fig. 15
IISR SURYA

Evaluation of extra-long and bold lines

Sixty-one genotypes shortlisted from the germplasm evaluation trial were multiplied and assessed in field conditions. Among them, eight genotypes (Acc. 636, Acc. 761, Acc. 979, Acc. 1035, Acc. 1037, Acc. 596, Acc. 599, and Acc. 612) were selected for further evaluation based on a yield increase of at least 10% over the check variety. The yield of these shortlisted genotypes ranged from 30 to 40 kg per bed (3 × 1 m).

Seedling progeny evaluation

Out of 86 seedling progenies evaluated for two years (2022-2023 & 2023-2024) 23 (SC-25, SC-26, SC 27, SC 30, SC-32, SC-34 SC-73, SC-74, SC-75, 69/10/4, 138/23/5, 138/23/12, 138/23/20, 138/23/21, SC-60, SC-61, SC-62, SC-51, 138/74/13, 138/74/17, 138/74/4, 138/74/35, 138/23/13) genotypes were shortlisted based on the yield and rhizome colour variation.

Analysis of land suitability under future climate scenarios

The current and future suitability for turmeric cultivation in India was assessed by analyzing climatic variables for future scenarios using advanced geospatial techniques. The analysis revealed that certain districts in Madhya Pradesh, Maharashtra, and Chhattisgarh are projected to shift from moderately suitable to highly suitable category by 2050. In contrast, some districts in Himachal

Pradesh and Punjab are expected to move from highly suitable to moderately suitablecategory. The study also indicated a significant reduction in highly suitable areas by 2100 under all scenarios, particularly under SSP 3-7.0 and SSP 5-8.5, where the highly suitable areas nearly disappear (Fig.16). This decline in suitable land will likely affect crop productivity due to changing temperature and rainfall patterns, highlighting the need for adaptation and management strategies.

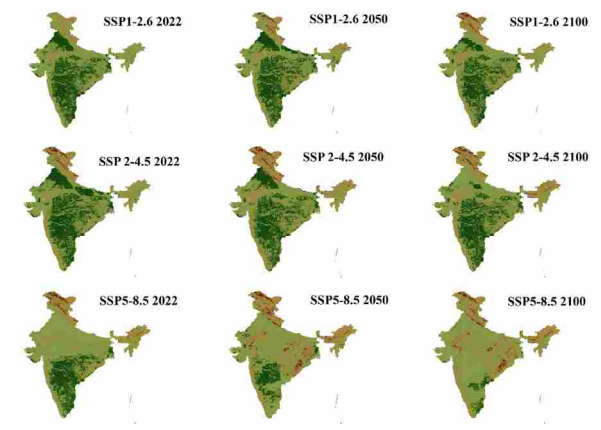


Fig. 16 Land suitability map for current and future climate scenarios (SSPs)
(Dark green indicates highly suitable and light green indicates moderately suitable areas)

Drying characteristics of turmeric slices under hot-air assisted infrared drying

The optimized conditions for drying turmeric slices using hot-air assisted infrared drying were an infrared power of 750 W and a hot air temperature of 55±1.24 °C. Under these conditions, the drying time was reduced by approximately 40% compared to traditional sun drying. The moisture content of the turmeric slices decreased from 76.5±0.51% (wet basis) to 7.2±0.84% (wet basis) within 6 hours using the developed drying system.

Modified protocol for curcumin estimation

A modified protocol for curcumin estimation was developed, which involves the extraction of curcumin using probe sonication, followed by spectroscopic determination. The traditional ASTA method requires approximately 420 mL of solvent per sample, whereas the modified protocol uses only 26 mL of solvent per sample, resulting in a 93.8% reduction in solvent consumption. Additionally, the modified protocol reduces the estimation time by 97.8%. Energy consumption per sample was 0.5 kW for the ASTA protocol and 0.2 kW for the modified protocol, leading to a 60% reduction in energy usage.

Turmeric oleoresin impregnated biodegradable packaging film

Turmeric oleoresin-impregnated arrowroot starch films were developed and evaluated. The optimal combination of 0.89% arrowroot starch and 0.25% turmeric oleoresin resulted in films with minimal water vapor permeability (WVP) of 5.22 gmm/m² day kPa and maximum solubility of 61.53%, with a desirability index of 0.991. The films were analyzed for various characteristics, including weight, thickness, moisture content, swelling index, solubility, water vapor permeability, color value, free fatty acid content, peroxide value, heat sealability, and total plate count.

Evaluation of organic farming systems

The highest soil pH, organic carbon (OC), N, P, Ca, Mg, Fe, Mn, Zn and Cu levels, along with increased activity of acid phosphatase and alkaline phosphatase, were observed under 100% organic management. However, the highest dehydrogenase activity was recorded in the Integrated Nutrient Management (INM) treatment (75% organic + 25% inorganic). The maximum fresh rhizome yield was achieved

under 100% organic management, with the variety Sudarsana yielding the highest at 54.7 t/ha.

Integrated organic farming system model

An integrated organic farming system was implemented at Chelavoor farm, combining spices, fodder, and vegetables. The crops planted included pepper, turmeric, fodder grasses (CO-3, CO-4), tapioca, banana, cowpea, and coconut. The system produced 500 kg of turmeric, 65 kg of banana, 60 kg of tapioca, 60 kg of cowpea, and 1500 kg of coconut. Fodder grass was used to feed the cows maintained at the IISR farm. The system generated a profit of Rs 1.96 lakhs per acre and created 322 man-days of employment per year.

Natural farming

An experiment was conducted with the treatments that included, Complete Natural Farming (CNF), AI-NPOF package, Integrated Crop Management (ICM) with 50% nutrient application from organic manures and 50% from inorganic sources using a prophylactic/preventive method, ICM with 50% nutrient application from organic manures and 50% from inorganic sources, with the application of need-based pesticides for pest management, and a control group (no inputs except labour for operations, including weeding). Maximum fresh rhizome yield (18.6 t/ha) and oil content (4.9%) were observed in the AI-NPOF package. Among the treatments, ICM (50% organic + 50% inorganic) with Neem Astra resulted in the highest oleoresin content (11.1%), while the CNF treatment recorded the highest curcumin content (5.64%).

A pot study was conducted to evaluate the effectiveness of Neemashtra (100% and 50%) and panel leaf extracts (100% and 50%) for managing *M. incognita*. The results showed that the Neemashtra treatment (100%) reduced the nematode population by 55% and increased the yield by 15% compared to the untreated control.

Hot water treatment for lesion nematode management

Hot water treatment with vacuum infiltration effectively controlled lesion nematodes rhizomes. Exposure to 50°C, 52°C, and 54°C for 10 minutes resulted in 67%, 78%, and 89% mortality, respectively, without affecting germination.

Influence of plant phenology and varietal duration on the incidence of shoot borer

The seasonal incidence of *Conogethes punctiferalis* was studied for the third year by monitoring pest occurrence at fortnightly intervals. The study included two short-duration varieties (IISR-Pragati and Rajendra Sonya), two long-duration varieties (IISR-Prathibha and Alleppey Supreme), and an extra-long-duration variety (ACC. 849).

Pest incidence was first observed in early August in Prathibha, Pragati, and ACC. 849, while in Rajendra Sonia and Alleppey Supreme, it appeared in mid-August. The highest incidence occurred in early October for Alleppey Supreme and ACC. 849, while Pragati peaked in late September. Rajendra Sonia and Prathibha recorded peak infestations in November. Among the varieties, ACC. 849 had the highest pest incidence, while Rajendra Sonia had the least.

VANILLA

Fig. 17: *V. planifolia* x *V. andamanica*
V. andamanica x *V. planifolia*

Genetic resources

A total of 77 accessions, including 65 *Vanilla planifolia* and 12 *Vanilla* sp., were established in the polyhouse and field conservatory. Collections from the Andaman and Nicobar Islands were also added to the germplasm. Interspecific hybridization was carried out between *V. planifolia* × *V. andamanica* and *vice versa* (Fig.17).

In vitro seed germination

In vitro rooting was attempted in multiple shoots developed from *in vitro* germinated seeds. Observations at 60 days after inoculation indicated that the media combination of half strength MS + 0.5 mg L^{-1} NAA developed more number of roots (4) and leaves (3). Root length (5 cm) and thickness (1.2 cm) were also more in this treatment combination.

Quality profiling

A standardized method for quantifying key flavor compounds in vanilla, including vanillin, p-hydroxybenzoic acid, p-hydroxybenzaldehyde, and vanillic acid, has been developed. Among the populations studied, G7 and G9 recorded a vanillin content of 2%.

TREE SPICES

NUTMEG

The field gene bank of nutmeg is being maintained with 163 accessions.A wild species of *Myristica*, *M. beddomei* was collected from the Bhagamandala region of Kodagu district, Karnataka (Fig.18 & 20). A new accession of *M. malabarica* was collected from Myladumpara, Idukki, Kerala. Three promising accessions of nutmeg including two monoecious lines (Acc 562, Acc 590) and a female type (Acc 530) were proposed for Coordinated Varietal Trial for nutmeg under the AICRP on spices (Fig.19). Chloroplast genome-based polymorphic markers were developed to distinguish four *Myristica* species *viz.*,*M. fragrans*, *M. andamanica*, *M. malabarica* and *M. magnifica*.

Fig.18: *M. beddomei*

Fig. 19: Acc. 530 - A high yielding nutmeg accession with bold nut and thick mace

Fig. 20: M. beddomei

Hot-air assisted infrared drying of nutmeg mace

Hot-air assisted infrared drying was applied to nutmeg mace, with drying time reduced to 7 h and decreasing the moisture content from 55.6±0.7% to 8.3±0.2%. This method resulted in 33.0 % reduction in drying time compared to sun drying. The drying rate and effective moisture diffusivity of mace were found to be 2.5 g water/g.dm.h and 1.9 $\times 10^{-7}$ m^2/s, respectively. Additionally, the essential oil and oleoresin contents of mace under this drying system 7.1% and 12.8%, respectively.

Optimization of parameters for drying of nutmeg rind juice powder

The process parameters for spray drying nutmeg rind juice powder were optimized using response surface methodology. The three factors considered for optimization were inlet air temperature (130°C, 150°C, and 170°C), maltodextrin level (20%, 25%, and 30%), and blower speed (2100, 2200, and 2300 rpm). The responses studied were moisture content and encapsulation yield. Under the optimized conditions, the encapsulation yield was 41.8%, and the moisture content of the spray-dried powder was 3.6%.

Vacuum drying of nutmeg mace

The performance of a vacuum tray dryer (capacity: 20–30 kg) was evaluated by drying nutmeg mace at drying air temperatures of 45°C, 50°C, 55°C, and 60°C. The moisture content of mace decreased from an initial value of 55–60% to 7–8% within 4 hours under vacuum and hot-air drying. The drying process followed the falling rate period. During the initial stage of drying, the drying rate for mace reached a maximum of 1.06 g/g dry mass.h under vacuum drying and 0.35 g/g dry mass.h under hot-air drying. The essential oil and oleoresin content of vacuum-dried mace were found to be 14.53% and 19.9%, respectively.

In vitro effect of *Pimenta racemosa* EO against a virulent strain of *R. pseudosolanacearum*

The minimum inhibitory concentration (MIC) of *P. racemosa* extracts against *R. pseudosolanacearum* was determined using the broth dilution method. Among the treatments, the essential oil exhibited the highest inhibitory activity, followed by chloroform and hexane extracts. Minimum bactericidal concentration (MBC) analysis revealed that chloroform and hexane extract completely inhibited bacterial growth at 0.8 mg/mL, whereas methanol and ethyl acetate extracts achieved complete inhibition at 2.5 mg/mL. In the swarming assay, chloroform and hexane extracts at 0.8 mg/mL completely inhibited bacterial growth, while lower concentrations (0.3 mg/mL and 0.5 mg/mL) restricted bacterial mobility. The superior antibacterial activity of the essential oil, hexane, and chloroform extracts is likely due to the presence of volatile constituents such as eugenol and chavicol, which were found in higher concentrations in these extracts based on GC-MS analysis.

CINNAMON

The field gene bank for cinnamon is being maintained with 172 accessions. Chloroplast genome-based molecular markers were developed to differentiate *C. verum* and *C. malabatrum*.

CLOVE

Natural crossing was observed between Zanzibar clove and Normal clove, resulting in progenies that exhibited hybrid vigor. These hybrids outperformed their parental genotypes in terms of early flowering and larger flower bud size. To confirm hybridity, five SSR markers were selected for each chromosome from the 'Clove SSRDB' database. Genotyping analysis using these markers unequivocally established the hybrid nature of the early-flowering, vigorous seedlings, which also displayed increased bud weight. These findings confirm that the seedlings are a cross between Zanzibar clove and Normal clove (Fig. 21 a-c).

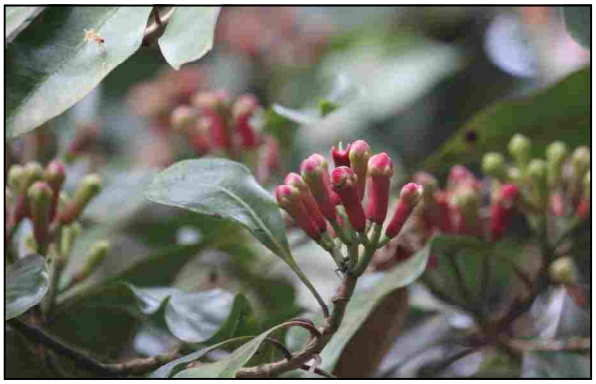


Fig. 21 a: Zanzibar clove

Fig. 21 c:Common clove

Fig. 21 c: Zanzibar clove X Common clove

GENERAL

Evaluation of novel lime-based formulations under greenhouse and field conditions

Granular lime-based formulations were developed to ameliorate soil pH and facilitate microbial delivery. Following successful evaluation trials in greenhouse and field conditions, the product development process was filed for patent approval. The following granular formulations Tricholime, Bactolime, Bactogypsum and Trichogypsum were released:

TRICHOLIME: This formulation combines lime and *Trichoderma* in a single product. It neutralizes soil acidity, enhances plant growth, and protects crops from soil-borne pathogens in a single application.

BACTOLIME: A granular lime-based bacterial formulation integrating beneficial bacteria with lime. It improves low-pH soils while ensuring the simultaneous delivery of plant-beneficial bacteria.

BACTOGYPSUM: Designed for ameliorating high pH soils and also ensures simultaneous delivery of plant beneficial bacteria.

TRICHOGYPSUM: A gypsum-based *Trichoderma* formulation that helps manage high-pH soils and supports trichoderma colonization for plant health.

Evaluation of selected bacteria for potassium (K) mobilization under greenhouse conditions.

Seven bacterial isolates were shortlisted and evaluated for their ability to mobilize potassium (K) and promote plant growth in rice under greenhouse conditions. Various treatments with different K fertilizer levels (0%, 50%, 75%, 100%) were applied individually and in combination with these bacterial isolates. The isolates KSB 1 (*Pantoea cypripedii*) and KSB 6 (*Bacillus cereus*) showed promising results for K mobilization, under greenhouse conditions.

Evaluation of bacterial consortia under field conditions

A consortia of *Raoultella terrigena*, *Bacillus safensis*, *Acinetobacter* sp., and *B. amyloliquefaciens* was evaluated on ginger. There was a significant increase in yield in treatments with consortia and 100, 75, and 50% NPK compared to individual

applications. It was observed that the rhizome rot incidence was less than 5% in ginger treated with the consortia combined with varying fertilizer doses (100, 75, and 50% NPKZn), compared to the fertilizer-only treatments and the absolute control. Among all treatments, the consortia plus 100% NPKZn and consortia with 75% and 50% NPKZn registered significantly higher rhizome yield than the absolute control and consortia alone. Additionally, higher

microbial activity in consortia treatments was confirmed through elevated dehydrogenase activity.

Greenhouse evaluation of temperature tolerant *Trichoderma* isolates

Temperature-tolerant *Trichoderma* isolates were evaluated in a greenhouse under varying moisture levels. *Trichoderma* application significantly ($P < 0.05$) promoted black pepper growth, as indicated by increased shoot and root length, leaf number, and fresh and dry weights at 60 days after planting (DAP). Among the six isolates tested, *T. asperellum* (NAIMCC0049) and *T. harzianum* (APT2) inoculated plants showed significantly higher ($P < 0.05$) shoot length, leaf number, and root length across all moisture levels (100%, 75%, 50%, and 25% FC). Plants inoculated with *Trichoderma* isolates also had significantly higher relative water content (RWC), while uninoculated plants under low moisture conditions experienced a sharp decrease in RWC from 91.3% at 0 days after inoculation (DAI) to 81.9% at 60 DAI. Proline and total soluble protein levels were elevated in plants inoculated with *T. harzianum* (APT2) and *T. asperellum* (NAIMCC0049) under moisture stress.

Infectivity of *Metarhizium pingshaense* to *Chilo* spp.

Laboratory studies were conducted to determine the median lethal concentration (LC_{50}) and median survival time (MST) of major sugarcane pests, *Chilo infuscatellus*, *C. sacchariphagus indicus* and *C. partellus* infected by *M. pingshaense*. The LC_{50} of *M. pingshaense* against late-instar larvae of *C. infuscatellus, C. sacchariphagus indicus* and *C. partellus* were 4.6×10^5, 1.7×10^5 and 9.5×10^5 conidia/ml, respectively. The MST for *C. infuscatellus* ranged from 5.3 to 6.9 days, for *C. sacchariphagus indicus* from 5.4 to 7.9 days, and 6.9 to 8.3 days, at the tested doses of 1×10^8 and 1×10^7 conidia/ml.

Production of cuticle degrading enzymes by *M.pingshaense*

The qualitative and quantitative assessment of cuticle-degrading enzymes (CDEs) production by the fungus, which are considered as the key virulence indicators revealed the fungus's ability to produce essential infection-related enzymes, including chitinases, proteases (subtilisin-like Pr1 and trypsin-like Pr2), and lipases. Enzyme production was also significantly enhanced in media supplemented with insect cuticle, indicating substrate-dependent upregulation. Genes encoding two major CDEs, chitinase and protease, were cloned and sequenced. Phylogenetic analysis revealed these genes to be closely related to those of *M.anisopliae*, suggesting a strong evolutionary relationship within the *Metarhizium* lineage.

Phytotoxicity testing of effective low risk insecticides in ginger, turmeric and black pepper

Two low risk insecticides, chlorantraniliprole and spinosad, were tested for phytotoxicity to ginger and turmeric crops at their 2× recommended dose (1.0 ml/L) and the phytotoxicity of chlorantraniliprole at 2× recommended dose (1.0 ml/L) was tested in black pepper, under field conditions. None of the tested chemicals expressed phytotoxicity symptoms such as, leaf injury on tips/surface, stunting, necrosis, chlorosis, vein clearing, epinasty and hyponasty in the tested plants.

Zinc solubilization and plant growth promotion by an entomopathogenic fungus, *M. pingshaense*

The entomopathogenic fungus *M. pingshaense* IISR-EPF-14, isolated from *C.punctiferalis*, is reported for the first time to enhance zinc (Zn) solubilization and

promote plant growth (Fig. 22). Zn solubilization efficiency varied with different Zn sources [ZnO or $Zn_3(PO_4)_2$] and was linked to production of organic acids including gluconic, keto-gluconic, oxalic, tartaric, malonic, succinic and formic acids. The fungus improved plant growth parameters such as leaf size, shoot/root length, dry weight, and chlorophyll content in rice and cardamom, and increased Zn uptake in rice plants. Additionally, it exhibited plant growth-promoting traits like IAA production, ammonia, siderophores, phosphate solubilization, and hydrolytic

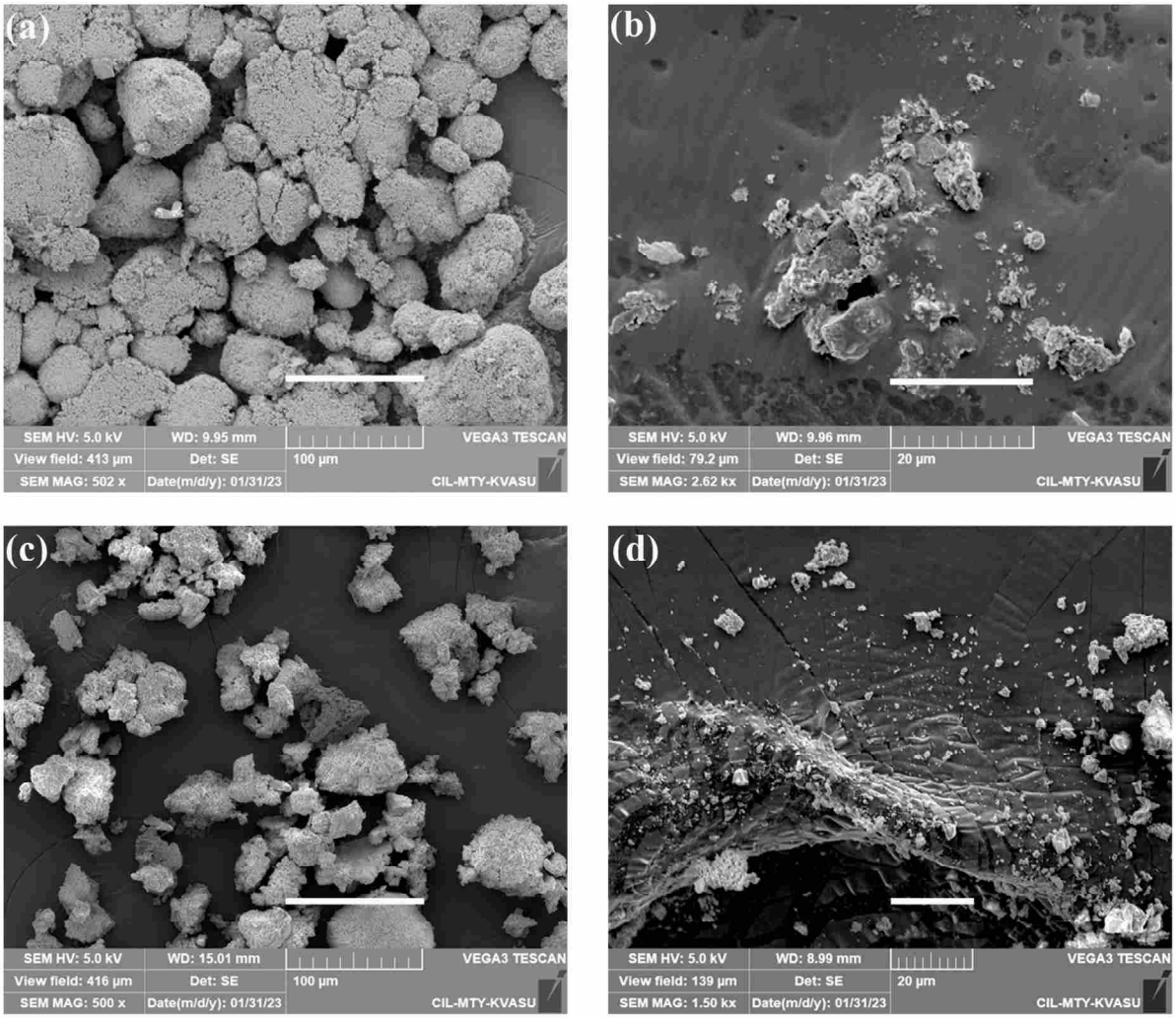


Fig. 22 Scanning electron microscope (SEM) micrograph showing solubilization of zinc compounds by *M.pingshaense* in mineral salts broth (MSB) media amended with 0.1% ZnO or $Zn_3(PO_4)_2$. Figures a & c correspond to un-solublilizedZnO and $Zn_3(PO_4)_2$ in control media un-inoculated with the fungus. Figures b & d indicates solubilization of Zn by the fungus in the MSB media 10 days after inoculation (DAI). Scale bar: a & c = 100 m; b & d = 20 m.

DUS testing facility

New candidate varieties of ginger and turmeric are under evaluation. On site DUS test evaluation was conducted for the black pepper varieties, MDBP 16 (Chhattisgarh), VJ1, VJ2, VJ3 and VJ4 at Karnataka. The candidate varieties like Zion Mundi (black pepper), Pachaikkai (cardamom), Aadi-Lo, Sitaram Adrak, Vaijnath adrakh, Devangarh Aadi, Kaldev Aadi, Nasari Desi, Pankaj Adrakh 1 (ginger) and Manoj T, Srikant Safed, Ragini T, Chitrasen Haldi, SK 4,

Crop	No. of example varieties	Location
Black pepper	21	IISR, Chelavoor and CHES, Chettalli
Cardamom	15	IISR, RS, Appangala
Ginger	23	IISR, Chelavoor and IISR, Experimental Farm, Peruvannamuzhi
Turmeric	35	IISR, Chelavoor and IISR, Experimental Farm, Peruvannamuzhi

Pahalu Haldi-1 (turmeric) were registered under PPV&FRA.

DNA fingerprinting and barcoding in spices

During 2024, the facility successfully generated DNA fingerprints for Mango Ginger variety (IISR Amrit), Small Cardamom varieties (IISR Kaveri and IISR Manushree), and Ginger variety (IISR Surasa), aiding their notification by the CVRC/SVRC. Additionally, the uniqueness of several spices varieties including turmeric (IISR Surya), cumin (Jodhpur Jeera), fennel (Gujarat Fennel-13) , Coriander (Karan Dhaya-1), and fenugreek (Karan Methi-1)were established, contributing to their identification and presentation at the AICRPS Annual Group Meeting. The facility also demonstrated the uniqueness of pipeline varieties, such as turmeric variety Rajendra Haldi and Acc. 1545, fennel variety Karan Sauf-1 (UF 231), nutmeg varieties MF4 and MF6, and ginger varieties R1.25/4 and HP 0.5/2.

Data analysis and visualization toolkit for NGS

The Data Analysis and Visualization Toolkit for NGS is equipped with five core modules: Basic Statistics, Visualization, Normalization, Differential Expression Analysis, and Correlation Profiling. Each module is tailored to address specific needs in the downstream analysis pipeline of NGS data, providing researchers with the tools necessary to design hypotheses and answer research questions efficiently. The tool will be available in Github along with the tutorial.

Technology copy rights

Hot air assisted infrared dryer for spices – design no - 420100-001, 2024 under class 15-03

Development of a vacuum Impregnation unit-Design No - 420101-001

A lab-scale, stand-alone vacuum impregnation unit was developed for the impregnation of spice extracts and natural colours into fruits and vegetables for the development of novel food products. The unit consists of a vacuum chamber, vacuum pump, heating coil, thermocouple, condenser unit, water supply system for the

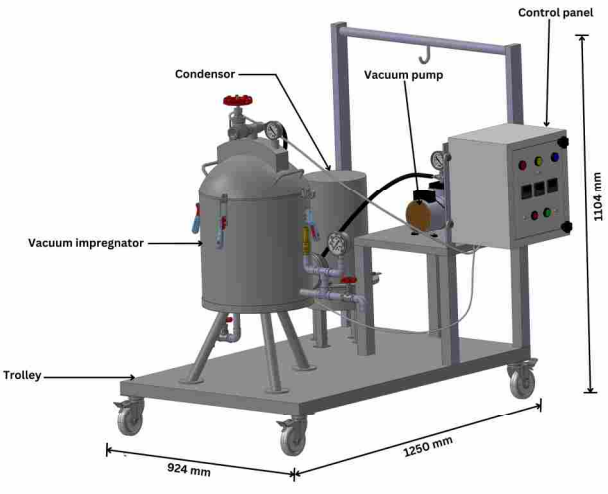


Fig.23: Vacuum impregnation unit

condenser, control panel, and other necessary accessories. The vacuum chamber, made of stainless steel (304), is a double-jacketed vessel with an inner wall thickness of 6 mm and an outer wall thickness of 3 mm. It features top and bottom compartments, with the top compartment having a capacity of 15 L. The system is designed to withstand a maximum pressure of 2–2.5 kg/cm² (Fig.23).

SPICE FeRT – Site specific fertilizer management system for spices (SW-19375/2024)

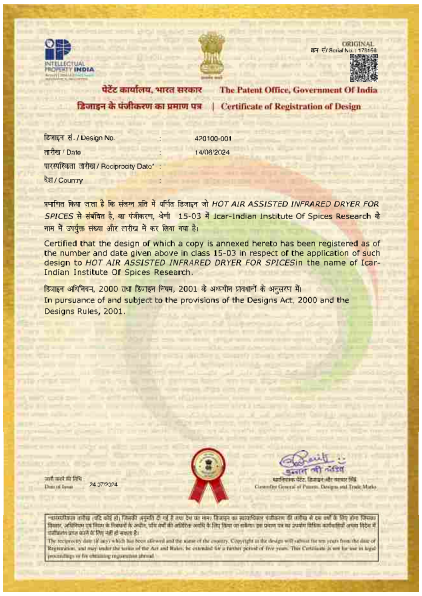


Fig.24:

NABL accreditation for ICAR-IISR laboratories

The ICAR-Indian Institute of Spices Research has been assessed and accredited by the National Accreditation Board for Testing and Calibration Laboratories (NABL) in accordance with the standard ISO/IEC 17025:2017 for its Spices quality and Organic Manure testing laboratories with effect from 14.11.2024. This recognition under ISO/IEC 17025: 2017 is a significant milestone for quality testing of Spices and Organic Manures. In the present-day sustainable farming systems, the quality parameters such as moisture, pH, EC, total OC content, N,P and K contents essentially decide the quality of the organic manures. With respect to the quality parameters of spices piperine, curcumin, moisture content, volatile oil, total ash, acid insoluble ash, light berries and bulk density (black pepper) are covered under the certification.


National Accreditation Board for Testing and Calibration Laboratories

NABL

CERTIFICATE OF ACCREDITATION

ICAR-INDIAN INSTITUTE OF SPICES RESEARCH

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

MARIKUNNU POST, KOZHIKODE, KERALA, INDIA

in the field of

TESTING

Certificate Number: TC-14890

Issue Date: 14/11/2024 Valid Until: 13/11/2028

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued satisfactory compliance to the above standard & the relevant requirements of NABL.
(To see the scope of accreditation of thislaboratory, you may also visit NABL website www.nabl-india.org)

Name of Legal Entity: ICAR-INDIAN INSTITUTE OF SPICES RESEARCH

Signed for and on behalf of NABL

N. Venkateswaran
Chief Executive Officer

Production of quality planting materials

A total of 150,000 black pepper rooted cuttings from improved varieties were produced at the Main Campus, Experimental Farm, and Regional Station, and distributed to farmers and developmental agencies. Additionally, 15,000 suckers and seedlings of small cardamom, along with 20 kg of seed capsules, were produced at the Regional Station. Seven tonnes of improved ginger varieties were produced through both IISR and participatory mode with farmers. Ten tonnes of improved turmeric rhizomes were produced and distributed to farmers. At the Experimental Farm and Regional Station, 700 beds of IISR turmeric varieties, Pragati, Prathibha, Prabha, Aleppey Supreme, and Kedaram were planted for seed production. Similarly, 300 beds of IISR ginger varieties, Varada, Mahima, and Rejatha were also planted for participatory ginger seed production with three farmers. Further, 250 budded nutmeg plants (Keralashree), 50 nutmeg grafts (Keralashree), 750 nutmeg seedlings, 2000 cinnamon seedlings, 500 rooted cinnamon cuttings (Nithyashree and Navashree), and 200 clove seedlings were also produced.

Farmers training & district level seminars

A training on Good Agricultural Practices (GAP) in black pepper and cardamom was organized at the Indian Cardamom Research Institute (ICRI), Myladumapara, in collaboration with the Spices Board on 24th January 2024. There were 130 participants, including farmers, scientists, and developmental officials. Experts from ICAR-IISR, ICRI, and KAU conducted lectures on GAP, and a panel discussion was held to address farmers' queries.

On 15th February 2024, a one-day training on "Good Agricultural Practices in Ginger and Turmeric"was conducted at ICAR-CTRI Research Station, Hunsur, sponsored by the Directorate of Arecanut and Spices Development, Kozhikode. The training focused on improved varieties, their production, and plant protection technologies for ginger and turmeric. Over 120 farmers participated in the event.

A three-day MIDH-sponsored seminar on 'Spice Processing and Entrepreneurship Development' was held at ICAR-IISR from 05 – 07 March 2024, whichwas attended by 124 participants. The seminar covered topics like agro-processing schemes, value addition in spices, and technologies for farmers and entrepreneurs. Additionally, hands-on training for preparing value-added products and demonstrations on budding and grafting techniques were also conducted.

ECONOMICS AND POLICY STUDIES

SWOT analysis of large cardamom

A SWOT analysis of the large cardamom sector was conducted to identify critical challenges and opportunities, enabling the formulation of effective intervention strategies. The study utilized data from an ICAR-IISR field study report and discussions with stakeholders, including scientists and personnel from development agencies. The key weaknesses identified include the lack of a strong planting material supply chain, the continued use of traditional 'Bhattis' for post-harvest processing, and the widespread incidence of viral diseases. Additionally, the absence of water harvesting structures and the limited diversification of export destinations pose significant constraints to the sector's growth. Strengthening farmer collectivization, investing in infrastructure development, and exploring nutraceutical applications can significantly enhance the sector's prospects. Leveraging large cardamom's organic production profile to secure market premiums and deploying virus detection kits in production zones were also identified as potential strategies for strengthening the industry.

Impact of IISR ginger varieties

A field study conducted across six districts in Karnataka (Mysuru, Chamrajanagar, Hassan, Haveri, Shivamogga, and Dharwad) and two districts in Kerala (Kozhikode and Wayanad) assessed the impact of IISR ginger varieties on the country's ginger economy. India's estimated dry ginger production for 2023-24 stands at 89,049 tonnes, with IISR varieties Mahima and Varada emerging as the preferred choices due to their high dry recovery and superior visual quality of the final produce. These varieties have largely replaced the traditional "Maran" variety in key dry ginger-producing regions. In Karnataka alone, over 70% of dry ginger production now comes from IISR Mahima and Varada. The estimated dry ginger output from these varieties in 2023-24 is 40,072 tonnes, accounting for 45% of the total national production. The economic contribution of IISR varieties is significant, with an estimated market value of Rs. 1,102 crores for the dry ginger produced in 2023-24. In a hypothetical scenario without these varieties, the projected economic impact would be Rs. 244.9 crores per year, underscoring the pivotal role of IISR varieties in enhancing ginger production and profitability.

Benefits of micronutrient application during the 2022-23 crop season

The impact of micronutrient application was assessed for black pepper, ginger, turmeric, and cardamom using data from primary and secondary sources. Information on micronutrient sales was gathered from technology licensees, while its effects on ginger and turmeric yields were evaluated through small-scale field surveys and focus group discussions with primary producers. A mathematical model was employed to estimate the national-level yield impact of micronutrient application. To ensure practical relevance, the study relied on field estimates rather than research-based projections for yield improvements. The net benefits of micronutrient adoption were determined by deducting the cost of technology adoption from the gross benefit, which amounted to Rs 25,415 lakhs in black pepper, ginger, turmeric and cardamom during the cropping season. At the national level, the yield impact of micronutrient application was estimated to be 3.2, 84.2, 24.6 and 2.88 kg/ha for black pepper, ginger, turmeric and cardamom, respectively.

CSR PROJECT

Action research project on the improvement of spice value chains

The project funded by Tata Trusts aims to enhance agricultural productivity and sustainability in 12 economically disadvantaged districts across 10 states (Tamil Nadu, Odisha, Andhra Pradesh, Gujarat, Rajasthan, Uttar Pradesh, Uttarakhand, Nagaland, Mizoram and Assam) by introducing advanced cultivation technologies in ginger and turmeric to mitigate key barriers to agricultural production. The key activities included onsite training programs, master training programme at ICAR-IISR with a focus on modern farming practices, pest and disease management, and sustainable production methods. Under the project 126 Front Line Demonstrations (FLDs) are being implemented across the country, demonstrating the superiority of improved farming technologies especially integration of advanced bio-inputs and the refinement of agronomic practices. This includes

Summary of activities: Spice value chain project funded by Tata Trust

Key activities	Number
Training programmes conducted at project locations (Nos)	16
Number of Frontline Demonstrations across 10 states (Nos)	128
Master training programmes at ICAR-IISR (Nos)	2
Biocapsules supplied (Nos)	9,100
Inputs: Ginger Micronutrient formulation (kg)	190
Inputs: Turmeric Micronutrient formulation (kg)	185
Seed material supplied- Ginger (kg)	4,750
Seed material supplied- Turmeric (kg)	4,000

Training programme on Improvement of spice value Chain sponsored by TATA trust

intensive technology dissemination focusing on use of beneficial micro-organisms and micronutrient application. Site specific soil health management strategies are also envisaged to enhance productivity and crop resistance to pests and diseases.Regular field visits and real time monitoring methods were adopted to track the implementation and impact of these interventions. This data-driven approach has ensured timely adjustments to strategies and design of interventions.

TSP PROGRAMMES

Vegetable seed kit distribution

ICAR-IISR distributed 1,000 vegetable seed kits in Kerala and Karnataka to enhance tribal nutritional security, with support of Community Agro Biodiversity Centre, MSSRF, and Department of Agriculture, Kerala state from various partners. On November 21, 2024, a Farmer-Scientist Interaction in Cheeyambam included disease diagnosis, vegetable cultivation training, and bio-input distribution.

Supply of agricultural tarpaulins

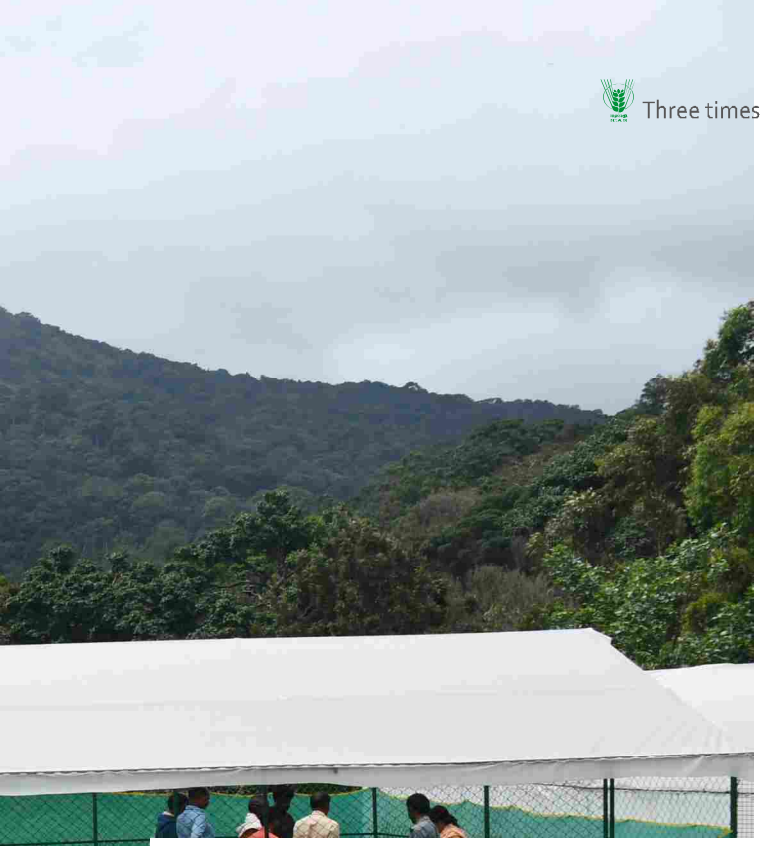
As part of its initiative to improve clean and safe post-harvest processing of spices and other crops, ICAR-IISR supplied agricultural tarpaulin sheets to 20 tribal farmer clusters during May 2024, across Wayanad district.

Pepper nursery at KVK, Idukki (Kerala)

A nursery was set up at KVK, Idukki, for supporting enhanced availability of planting material to the tribal population and to provide planting material at an affordable cost to tribal farmers, ensuring the rapid adoption of improved varieties.

Support to tribal collective farming initiative

ICAR-IISR supported collective tribal farming at Cheengeri Extension Scheme,



Wayanad, by providing diverse crop planting materials. Benefiting over 100 rehabilitated tribal families, the initiative included a training session on November 21, 2024, on scientific spice cultivation for better productivity.

Black pepper improvement programme at Yercaud (TN)

On September 12, 2024, a one-day training on integrated crop management for pepper cultivation was held at Horticultural Research Station (TNAU), Yercaud. The program trained tribal farmers in use of bio-fertilizers and bio-control agents. Farmers received 5,000 black pepper cuttings, 10,000 coffee plants, 2,500 silver oak plants, and 500 Trichoderma biocapsules.

Farmers training on ginger cultivation, Thalamalai, Erode (TN)

On December 12, 2024, ICAR-IISR held a ginger cultivation training at KVK, Myrada, Erode, with TNAU's Department of Spices and Plantation Crops. Experts covered best practices, pest management, and value addition. Attended by 55 tribal farmers, the program included input distribution, such as fertilizers and bio-fertilizers, in Thalamalai.

Workshop on entrepreneurship development, UAS Bengaluru

A three-day workshop on "Entrepreneurship Development for Tribal Farmers in the Spices Sector" was held from 24-26 October 2024. About 40 Karnataka tribal farmers in spice cultivation, pest management, processing, and marketing were trained. The workshop also included hands-on training in processing and packaging spices. Inaugurated by Dr. S.V. Suresha, Vice-Chancellor of UAS Bengaluru, the event was also graced by Dr. K.C. Narayanaswamy [Registrar and Dean (PGS)], Dr. Siddayya

(Professor and Head, Institute of Agri-Business Management), Dr. V. Srinivasan (Head, Division of Crop Production & Post-Harvest Technology, ICAR-IISR)

Support to tribal farming in Meghalaya

ICAR-IISR, in collaboration with the Meghalaya Farmers Empowerment Commission, supported tribal farmers by supplying elite planting materials, including nutmeg, cinnamon, clove, cardamom, and black pepper. Additionally, 600 biocapsules, micronutrient formulations, and bush pepper plants were provided to set up demonstration units for the benefit of farmers.

NEH PROGRAMMES

Seed supply chain development for ginger in NEH region

NEH zones contribute a significant share of ginger in the country in terms of area and production. The total area under ginger is 30.84 thousand hectares with a total production of 209.15 thousand tons with an average yield of 6.78 t/ha which is higher than the reported national average yield 3.56t/ha. As a part of NEH mode project, a programme for development of improved seed variety IISR Varada was initiated in three states, Meghalaya, Tripura and Mizoram.

Technology adoption profile

Farming technologies followed the LEISA approach across all locations. In Meghalaya's East Khasi and Jaintia Hills, raised beds were used on slopes, while ridges and furrows were adopted in Dhalai and North Tripura. In Mizoram, ginger was grown on steep slopes using shifting cultivation. Zero tillage, slash weeding, green leaf mulching, and organic manuring were practiced universally.

Early impact pathways

Farmers relied on traditional cultivars like Nadia, leading to mixed varieties and disease spread, especially soft rot. The new scheme promotes phased varietal replacement with improved varieties like IISR Varada, which shows healthier crops, higher tillering, and reduced disease losses. In Khasi Hills, Varada yielded 17.3 t/ha versus 9 t/ha for local varieties, increasing net returns from ₹1.45 lakh to ₹4.3 lakh per hectare, with a BC ratio of 2.4 compared to 1.6 for locals. Estimated organic farming losses were 30% in Lawngtlai, 25% in East Khasi and Jaintia Hills, and 28% in Tripura.

SCSP PROGRAMMES

Under the SCSP program, the institute conducted multiple skill development training sessions, empowering approximately 1,000 individuals. A holistic approach was adopted to ensure livelihood enhancement. To enhance agricultural productivity, beneficiaries received training in advanced spice production technologies. Recognizing the importance of self-reliance, several SCSP youth were trained in entrepreneurship skills. The program also supported diversified livelihoods by distributing equipment like bee hives and FRP tanks for ornamental fish farming, along with essential inputs such as seed material, micronutrient mixtures, and bio-capsules. A significant achievement was facilitating a SCSP-based Krishi group in obtaining a license for the multiplication and sale of two black pepper varieties. Furthermore, beneficiaries were sensitized to post-harvest processing techniques for spice crops, enabling them to add value to their produce. These diverse initiatives contributed to the economic and social upliftment of the target group.

Summary of initiatives under SCSP

1	Capacity building of SCSP beneficiaries through various trainings and skill development programmes (Locations: Kerala, Karnataka and Tamil Nadu)
2	Creating awareness on cultivation technologies of spice crops (Locations: Kerala, Karnataka and Tamil Nadu)
3	Empowering SCSP farming community (Jeevani Krishikottam) by sponsoring the license fee for two black pepper varieties
4	Creating awareness on Pepper cultivation and expanding pepper area for the upliftment of SC community group (Locations: Kerala and Tamil Nadu)
5	Popularization of improved varieties of spice crops among the Scheduled Caste farmers through KVK, Kannur
6	Youth empowerment through entrepreneurship development training programme on processing, packaging and marketing of spices (Locations: Kerala and Tamil Nadu)
7	Empowering, a group of SC women through providing inputs for turmeric cultivation and acquiring licence for turmeric seed production
8	Distribution of fibre reinforced plastic tanks for promoting ornamental fishing to enhance the livelihood of SC beneficiaries
9	Outscaling technological innovations through participatory action programme at Pannikkottur village, Chakkittapara Gram Panchayat

10	Hands on training on Field management and processing in turmeric to farmers from Moodadi village
11	Hands on training on Field management and processing in turmeric to farmers from Pannikkottur village
12	Empowering the SC farmers with innovative technologies in Horticulture through ICAR-IISR KVK, Peruvannamuzhi
13	Empowering SCSP farmers in Karnataka with the innovative technologies in Bee Keeping
14	Empowering the SC farmers with innovative technologies in Horticulture through Regional Horticultural Research and Extension Centre, UHS,Bengaluru
15	Entrepreneurship Development Training Programme on Processing of Spices in collaboration with University of Horticultural Sciences, Bagalkote

Training on turmeric processing to farmers from Pannikkottur village

Agricultural Technology Information Centre (ATIC)

The Agricultural Technology Information Centre (ATIC) of the Indian Institute of Spices Research (IISR) serves as a vital bridge between scientific research and farming communities, offering comprehensive support services to spice farmers and agricultural stakeholders. At its core, ATIC functions as a single-window delivery system, providing farmers with access to the institute's technologies, services, and products. The centre actively supports technology transfer and advisory services through expert consultations on spice cultivation, disease management, and post-harvest technologies. Farmers can access diagnostic services for pest and disease issues, while regular training programs and field demonstrations promote practical knowledge. Information dissemination is a key focus, with publications, technical bulletins, and research highlights available in local languages for broader accessibility.

ATIC also facilitates the distribution of high-quality planting materials for farmers sourced from improved varieties developed by IISR. The centre also serves as a marketplace for technology products created by IISR, including bio-control agents and micronutrient mixtures. Farmers can access a range of value-added products and processing technologies, as well as testing facilities for soil and plant samples. This comprehensive support system enables farmers to implement scientific cultivation practices effectively. Additionally, the centre promotes direct interaction between scientists and farmers through regular meetings and awareness programs, providing an effective platform for knowledge exchange.

A total of 48 general training programs focused on technology transfer were

organized by ATIC, both independently and with partner agencies. These included various project-based, online, customized, and off-campus programs. Topics covered ranged from modern cultivation practices and integrated pest management to organic farming and post-harvest processing techniques. The programs offered both short-term and long-term courses, ranging from single-day workshops to week-long sessions. Additionally, the institute facilitated educational training for 1,650 students across graduate, postgraduate, and professional courses.

Training program on ginger production for Meghalaya

A five-day training program on 'Ginger Production and Processing' was held from 11-15 November 2024 for 26 farmers from the Khasi-Jaintia Farmers Association (KJFA), five Horticulture officers from the Meghalaya State Agriculture Department,

and one entrepreneur. Sponsored by the Meghalaya Farmers' Empowerment Commission (MFEC), the training covered production technology, improved varieties, pest management, commercialization, and post-harvest processing. Participants also visited the IISR experimental farm, Wayanad's ginger fields, and the MSSRF in Kalpetta for practical insights into modern farming and biodiversity conservation.

Capacity building program for tribal spice farmers of Kerala

ICAR-Indian Institute of Spices Research hosted a three-day capacity-building program for tribal spice farmers in Kerala from 26-28 November 2024 on 'Sustainable Production Practices and Post-Harvest Processing of Black Pepper.' Sponsored by the Spices Board, Kochi, the training was attended by 20 farmers from Vanchivayal, a tribal village in the Periyar Tiger Reserve, Idukki. The program focused on introducing diverse crop varieties, disease-resistant practices, and improved farming techniques to boost productivity. The farmers, who currently sell 20 tons of pepper annually through the Kerala Forest Department, also received practical training on post-harvest and value addition methods.

Table: Sale Profile of ATIC:2024

Particulars	**Revenue**
Planting Materials-NHM	4,65,400
Planting Materials-General Farm	75,440
Farm Produce	1,58,043
Diagnostic Services	8,46,896
Oil Estimation	9,500
Trichoderma Talc Formulation	66,200
Bacillich Talc Formulation	1,700
Pochonia Talc Formulation	16,270
Micro nutrient Formulation	9,93,440
TRICHOLIME	55,118
BACTOLIME	18,672
Biocapsules	18,86,550
Publications	15,864
Others(including GST+Postal Charges)	4,16,130
Total	**50,25,224**

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

XXXV Annual Group Meeting of the ICAR-All India Coordinated Research Project on Spices was held from October 15th to 17th, 2024, at Choudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. Dr. V.R. Kamboj, the esteemed Vice-Chancellor of CCS HAU, Hisar, inaugurated the workshop, with Dr. S.K. Singh, Deputy Director General, Horticulture Science, ICAR, gracing the occasion as the chief guest. The event also witnessed the felicitation of Dr. Sudhakar Pandey, Assistant Director General (ADG), Horticultural Sciences, ICAR, Dr. Vinay Bhardwaj, Director, National Research Centre on Seed Spices (NRCSS), Ajmer, Dr. R. Dinesh, Director, ICAR-IISR, Kozhikode, Dr. N. Krishna Kumar, Former DDG, ICAR, and Dr. V.A. Parthasarathy, Former Director, ICAR-IISR, Kozhikode.

The AICRP Best Center Award was bestowed on NM College of Agriculture, Navsari, Gujarat in recognition of their outstanding contributions to spice research and development. The meeting also witnessed the launch of eleven new publications, showcasing the latest research findings and advancements in spices.

New spice varieties

During the XXXV group meeting of spices, seven new spice varieties were identified for release:

Karan Dhaya-1: A high-yielding coriander cultivar demonstrating resistance to stem gall and moderate resistance to powdery mildew. It exhibits an average seed yield of 1482 kg/ha and a mean volatile yield of 5.73 l/ha, maturing in 110-120 days. This variety is recommended for irrigated regions of Rajasthan, Gujarat, and other major coriander-growing areas.

Jodhpur Jeera 1: A high-yielding cumin cultivar with an average seed yield of 566 kg/ha, characterized by increased branching, a high number of umbels, and a significant essential oil content (4.34%). It exhibits moderate resistance to wilt, blight, and aphids. This cultivar is recommended for release in Rajasthan.

CAZRI Cumin 1: High-yielding cumin cultivar with an average seed yield of 522 kg/ha, characterized by high seed number per umbel and tolerance to fusarium wilt. It is also recommended for release in Rajasthan.

Gujarat Fennel 13: A high-yielding fennel cultivar with average seed yield of 1814 kg/ha, characterized by compact umbels, bold seeds, and a substantial volatile oil content (2.87%). It exhibits moderate resistance to *Ramularia* blight and is recommended for release in Gujarat, Rajasthan, Haryana, Bihar, and Uttar Pradesh.

Karan Methi-1: A high-yielding with average seed yields of 1742 kg/ha, short-duration (121 days) fenugreek cultivar with moderate resistance to powdery mildew and downy mildew. It is recommended for release in all major fenugreek-growing regions of India.

SAS-KEVU: Unique bold ginger variety, suitable for vegetable use, exhibits a high yield potential of 17.21 t/ha. It is characterized by moderate oil content, low fiber content, high dry recovery, and a soft texture. This variety is recommended for release in the North-Eastern states and hilly areas of Andhra Pradesh.

IISR Surya: Unique turmeric variety with light yellow rhizomes , curcumin content of 2-3%, and unique flavour with high levels of minor volatile compounds, an average fresh yield of 29 t/ha, potential yield 41 t/ha, and dry yield 5.8 t/ha, light yellow coloured powder making it highly suitable for the powdering industry. Recommended for release in Kerala, Telangana, Odisha,

Madhya Pradesh, and Arunachal Pradesh.

New Spice technologies for adoption
During the workshop five spice-based technologies were identified for release.

Leaf mould mulching for sustainable productivity and soil health in large cardamom: Application of leaf mould mulch @ 10 t ha^{-1} enhances dry capsule yield by 41.5%, increases soil moisture content by ~38%, and boosts soil quality. This technology is recommended for Sikkim, Arunachal Pradesh, Nagaland, Meghalaya, and parts of Manipur and Mizoram.

Management of leaf blight in small cardamom : Two rounds of foliar spray during pre-monsoon (June) and post-monsoon (September) using hexaconazole (2 ml L^{-1}) or tebuconazole (1 ml L^{-1}) significantly reduced leaf blight incidence by up to 35%, enhanced dry yield by up to 18% (339 g $clump^{-1}$), and improved the benefit-cost ratio (2.35). This technology is recommended for Karnataka, and Kerala

Management of rhizome rot in small cardamom : Pre- and post-monsoon spraying and drenching of tebuconazole (1 mL L^{-1}) or metalaxyl + mancozeb (1.25 g L^{-1}) significantly reduced rhizome rot incidence by up to 30%, enhanced yield by 51% (up to 569 kg/ha), and improvd the benefit-cost ratio (3.34). This technology is recommended for Karnataka.

Pre and post monsoon spraying and drenching of fenamidone + mancozeb@2g L^{-1} reduced the disease incidence in Kerala and increased yield by 45.1%. This technology is recommended for Kerala.

Priming of ginger seed rhizomes with Trichoprime

Priming of ginger seed rhizomes with Trichoprime @ 5% prior to storage enhanced bud vigour, improved sprouting, and protects rhizomes from fungal pathogens, ensured uniform tiller emergence and enhances yield. The technology is recommended for the states of Kerala, Meghalaya, Andhra Pradesh, Telangana, Jharkhand, Nagaland, Arunachal Pradesh, Odisha, West Bengal, and Chhattisgarh.

Priming of turmeric seed rhizomes with Trichoprime

Priming of turmeric seed rhizomes with Trichoprime @ 5% prior to storage enhanced bud vigour, improved sprouting, and protects rhizomes from fungal pathogens, ensured uniform tiller emergence and enhanced yield. The technology is recommended for the states of Kerala, Tamil Nadu, Telangana, Mizoram, Arunachal Pradesh, Odisha, West Bengal, Himachal Pradesh, and Uttar Pradesh.

Central Varietal Release Committee approves spice varieties for cultivation

The 31stmeeting of the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops was held on 13thNovember, 2024. Ten AICRPS varieties of spice crops were recommended for release and notification by the committee. These included two Fennel varieties (Karan Saunf-I and RF-296), one Ajwain variety (Gujarat Ajwain 3), one small cardamom variety (IISR Manushree), two nutmeg varieties (Konkan Sanyukta and Kerala shree), one cassia cinnamon variety (IISR Cassia) and three black pepper varieties (IISR Thevam, IISR Malabar Excel and IISR Girimunda). Besides, ten varieties OUAT Kalinga Ginger 1,2 & 3, CO-5, Gujarat Methi-4, Chhattisgarh haldi-2, Narendra haldi-4, OUAT Kalinga Turmeric-1 & 2 and IISR Kaveri were also released.

Institute Technology Management - Agribusiness Incubation Unit (ITM-ABI Unit)

During the period, thirty-eight (38) licenses were issued for various technologies developed by ICAR-IISR and a revenue of 58.83 Lakhs was generated.

Two patent applications were filed:
1. Appl.No.202411070878, dated; 19-09-2024, A jaggery-based product and a process for preparing the same
2. Appl. No 202411105091, dated; 31-12-2024,Spice concoction and the process for preparing the same thereof

Three trademark registrations, three copyrights, three designs, three PPV& FRA applications were filed for registration of IISR varieties.

MoA was signed on 12th April 2024. with ICAR-Central Tuber Crops Research Institute making biocapsules for tuber crops using the patented technology 'A novel method of storing and delivering PGPR/ Microbe'.

MoA was signed with Spices Board, Idukki for marketing of agri inputs developed at ICAR-IISR on 13th September 2024 and a sales outlet was opened at Idukki by Spices Board.

Collaborations were initiated with Meghalaya Farmers (Empowerment) Commission for increasing farm income, livelihood promotion, and rural development in Meghalaya, through transfer of innovations and technologies, capacity building and skill development activities. MoA was signed on 12th August 2024.

The unit facilitated three consultancy visits to black pepper plantations of Karnataka and Tamil Nadu. A contract entitled Effect of Nano Urea (liquid) in reducing the application of conventional Urea with IFFCO Cochin, Kerala generated a revenue of 16.72 Lakhs.

Conducted virtual interactive session as part of World Intellectual Property Day on 30th April 2024 under the theme IP and the SDGs: Building our common future with innovation and creativity. Dr. Geetika Suyal (Registered Patent Agent, ZTM-BPD Unit, ICAR Indian Agricultural Research Institute, New Delhi) delivered the lead talk on the topic "Intellectual Property Rights-Promoting Innovation and Creativity for a

Sustainable Future". A total of 40 participants including scientists, research scholars and staffs joined the session.

In collaboration with IP&TM cell, ICAR-IISR organized Intellectual Property awareness week for five days in virtual mode during 16th August, 2024 followed by sessions during 20-23 August 2024. The sessions were focussed to create awareness about all IP aspects among scientists, technical staff and students. Final session on technology commercialization was handled by Dr. Neeru Bhooshan, ADG, IP&TM Unit.

Conducted three Techno Commercial Assessment Committee (TCAC) meeting with Agrinnovate for evaluation and development standard terms for commercialization of technologies.

Organized an entrepreneurship awareness program for women entrepreneurs at the institute on 25-01-2024. Fourteen prospective entrepreneurs participated in the program and visited various ABI facilities.

Organized a two-day bootcamp cum orientation program for selected incubatees (14nos) at Kerala Startup Mission, Kochi, from 6-7 March 2024.

Hosted UDAYAM 1.0 – Women's Entrepreneurship Meet and Agricultural Expo from 22 -25 March 2024. The event featured 60 exhibition stalls by women entrepreneurs showcasing their innovations and products.

Organized an online program where Mr. Baiju Nedumkery (Chairman, Agropark, Piravom) delivered a session on agro-processing, agribusiness ventures, and opportunities in transforming agricultural inputs into high-value products.

Organized an Entrepreneurship Development Program on value addition in mushrooms from 29-30 May 2024. The live demonstrative program developed 10 value-added products from mushrooms.

Organized six webinars during the period in association with Kerala Startup Mission for promoting agro based entrepreneurship in the country.

Organized a 5-day collaborative online training program with the National Institute of Agricultural Extension Management (MANAGE), Hyderabad, on innovations in the production, value addition, and marketing of spices in India, from 10- 14 June 2024.

Organized Entrepreneurship Development Programme on Value Addition in Fruits and Vegetables, held on 29-30 October 2024. 21 prospective entrepreneurs participated in the programme.

Organized a webinar on business prospects in spice extraction on 27th November 2024. 85 prospective entrepreneurs attended the programme.

Organized an Entrepreneurship Awareness Programme in collaboration with MSME-DFO, Thrissur on 12.12.2024. 60 prospective entrepreneurs participated in the programme.

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 responsible for maintaining web servers, computers, and peripherals, as well as overseeing network security. They also handle the upkeep and regular updates of the institute's website, AICRP websites, ABI website, Bioinformatics website, library portal, and the IISR Intranet portal. Additionally, AKMU manages the uploading of institute activities and the development and publication of videos on the YouTube channel. They are also involved in developing three databases and one laboratory reporting software. AKMU provide seamless technical support for online meetings, webinars, online workshops and trainings (online 412 and offline 48 numbers). Apart from this AKMU assists in statistical analysis of scientific data using R software.

IISR LIBRARY

The IISR Library continues to prioritize excellence in academic support through its comprehensive online and offline services. Its extensive collection includes:

- 5111 books
- 6010 bound journals
- 2308 reprints
- 1037 technical reports
- 420 MSc project reports
- 206 PhD theses
- 300+ ebooks

During the year, the library added 44 new books to its stock including hindi books

CeRA

As a member of the Consortium for e-Resources in Agriculture (CeRA), the IISR Library provides access to over 3,500 full-text journals and more than 1,000 e-books. These resources cover a wide range of agricultural and allied subjects, supporting the research and academic needs of its users.

DSpice

The institutional digital repository software, **DSpice**, was updated with Institute publications. Out of 206 Ph.D. theses, 196 have been digitized and made available online. 29 M.Sc. project reports were added to Dspice in this year. A total of 375 M.Sc. project reports have been digitized for user access.

Koha

The library updated its collections, including the newly added resources, into the KOHA library automation software. Users can search the Online Public Access Catalog (OPAC) by title, author, subject, year of publication, and other parameters for easy access to the library's holdings.

ICAR – Krishi portal

The IISR Library actively contributes to the *Krishi Portal* by regularly updating it with Institutional publications like research articles (147), annual report (15), research highlights (18), extension pamphlets (30), newsletters (42), training manual (6) and other publications (8)

Calibre

The library integrated over 300 e-books into **Calibre,** a powerful and user-friendly e-book management system, making it easier for users to access digital content.

Plagiarism detection

The library extended its support to academic integrity by providing plagiarism detection services for research theses. During the year, 86 documents were processed for plagiarism checks.

INDIA STAT AGRI

To enhance access to agricultural data, the library enabled the use of IndiastatAgri, a platform offering extensive statistical data on agricultural areas, further aiding research and analysis.

Other services

A total of 1,037 students/researchers utilized the library facilities, and 386 users accessed the computer facility available in the library. Additionally, the digital classroom facility within the library was utilized for various online meetings and training sessions.

KRISHI VIGYAN KENDRA (KVK)

Trainings

A total of 72 On-campus, 32 Off-campus capacity building trainings were organized by KVK for the benefit of benefitted more than 3135 farmers and 1483 youth participants.

Special capacity building programmes

The special capacity building programmes included banana fibre extraction, rubber mushroom cultivation and, organic vegetable production and bee keeping, Also, RAWE attachment trainings to B.Sc. (Agriculture) final year students of Lovely Professional University, Punjab and Guru Kashi University, Punjab were conducted.

Front-Line Demonstrations and On-Farm Trials

Besides the approved 17 FLDs, three OFTs on (i) assessment of marigold hybrids suited to Kozhikode district (ii) Assessment of organic management practices against collar rot disease in elephant foot yam and (iii) assessment of mussel farming techniques to enhance production were conducted.

ATARI – KVKs zonal workshop held at IISR

The workshop was attended by Dr. V. Venkatasubramanian, Director, ICAR-ATARI-Zone XI, Dr. Rajarshi Roy Burman, ADG (Agricultural Extension), ICAR, Dr. S.N.Sushil, Director, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Dr. R. Dinesh, Director, ICAR- Indian Institute of Spices Research, Kozhikode and Dr. P Ratha Krishnan, Head, Krishi Vigyan Kendra. Heads of KVKs and experts. During the event, the prestigious Kisan Samriddhi Award- 2024 was conferred to Dr. Pushpalatha, Former DE, KAU and Kisan Samriddhi best women entrepreneur award to Smt. Vasundhara Hegde, Uttara Karnataka

SCSP programmes during 2024- 25

Distribution of literature / newspapers and cycles to SC beneficiaries as requested by Schools and BRC, Perambra, Kozhikode

Training and distribution of inputs for scientific management of Coconut at Pannikkottur SC colony, Kozhikode.

Fruit plants distribution at Koothali and Perambra grama panchayats, Kozhikode

Establishment of SCSP Custom Hiring Centre at KVK

Other important activities and Income generation activities

KVK also documented two success stories viz., jack fruit processing unit by SmtShylamma, Kurachundu and millet cultivation and processing by Kudumbasree unit, Kayana.

Participated in district level exhibitions and facilitated farmers participation in Agricultural Science Congress, Cochin and Women Conclave, Thrissur.

The nursery and polyhouse units of KVK produced seedlings of vegetables, pepper rooted cuttings, bush pepper, nutmeg grafts, arecanut (Mohitnagar) seedlings, etc and sold to 2723 farmers.

About 2.8 quintals of turmeric (IISR Pragathi, Prabha turmeric)and ginger (IISR –Varada and Vajra) seeds were produced and made available to farmers.

About 26 quintals of bioinputs (vermicompost, Trichoderma, goat manure, etc) were produced and sold.

The layer bird's maintenance unit at KVK sold about 1759 layer chicks and 1200 ornamental fishes.

Projects on Ornamental fishes sponsored by NABARD; Natural farming sponsored by ICAR and NICRA project sponsored by CRIDA were also implemented successfully.

हिंदी अनुभाग

राजभाषा कार्यान्वयन समिति की बैठक

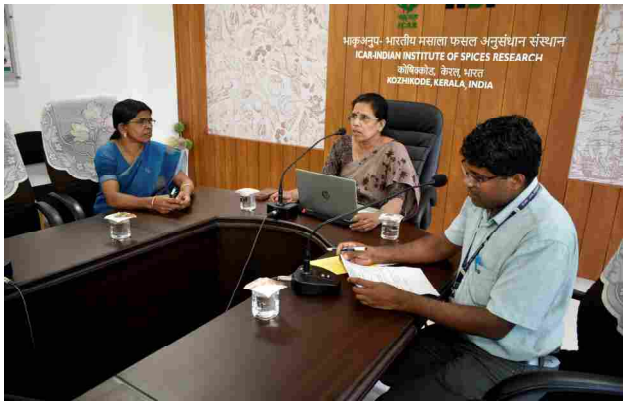
वर्ष 2024 में राजभाषा कार्यान्वयन समिति की चारबैठकें आयोजित की गयी। बैठकें दिनांक 11 मार्च 2024,24 मई 2024, 29 जुलाई 2024 तथा २९नवंबर २०२४को निदेशक डॉ. आर. दिनेश की अध्यक्षता में संपन्न हुई। समिति ने राजभाषा कार्यान्वयन की गतिविधियों की समीक्षा करके सुधारने के लिए सुझाव दिया।

हिंदी कार्यशाला

वर्ष 2024 की अवधि में भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान के अधिकारियों तथा कर्मचारियों के हिंदी ज्ञान को बढ़ाने के लिए चार कार्यशालाएं आयोजित की गयीं। इन कार्यशालाओं में, श्रीमती एन. प्रसन्नकुमारी,भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान कोषिक्कोड, डॉ. रजिला ओ. पी., असिस्टन्ट प्रोफेसर, हिंदी विभाग, सरकारी कला एवं विज्ञान महाविद्यालय, कोंटोट्टी, मलप्पुरम, डॉ. आर. सुरेंद्रन (डॉ. आरसु), सेवानिवृत्त विभागाध्यक्ष, हिंदी विभाग, कालिकट विश्वविद्यालय, डॉ. पी. प्रिया, असिस्टन्ट प्रोफेसर, हिंदी विभाग, सरकारी कला एवं विज्ञान महाविद्यालय, कोषिक्कोड ने क्रमशः दिनांक 16.02.2024, 11.06.2024, 18.09.2024 तथा 11.12.2024 को "राजभाषा नीति एवं कार्यान्वयन - आगे बढ़े", "संप्रेषणीय हिंदी", "राजभाषा का सरल और शुद्ध प्रयोग एवं हिंदी टिप्पणी"आदि विषयों पर व्याख्यान दिया।

दिनांक १६ फरवरी २०२४ को आयोजित हिंदी कार्यशाला

दिनांक ११.०६.२०२४को आयोजित हिंदी कार्यशाला



दिनांक 11.12.2024 को आयोजित हिंदी कार्यशाला

हिंदी बैठक/सम्मेलन/कार्यशाला में सहभागिता

- डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं हिंदी अधिकारी तथा श्रीमती एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने 19 जनवरी 2024 को राजभाषा विभाग द्वारा प्रबंधन अकादमी, हिंदुस्तान एरनॉटिक्स लिमिटड, बंगलूरू में आयोजित क्षेत्रीय राजभाषा सम्मेलन एवं पुरस्कार वितरण समारोह में भाग लिया।
- श्री. अब्दुल रशीद, सहायक प्रशासनिक अधिकारी, आई.आई.एस.आर. क्षेत्रीय केंद्र, अप्पंगला, कर्नाटक ने राजभाषा विभाग, गृह मंत्रालय, भारत सरकार द्वारा 14-15 सितंबर 2024 को भारत मंडपम, नई दिल्ली में आयोजित हिंदी दिवस एवं चतुर्थ अखिल भारतीय राजभाषा सम्मेलन में भाग लिया।

नगर राजभाषा कार्यान्वयन समिति

नगर राजभाषा कार्यान्वयन समिति की 72वीं अर्धवार्षिक बैठक 12दिसंबर 2024 को होटल ईस्ट एवन्यु, नटक्काव में संपन्न हुई। प्रस्तुत बैठक में संस्थान से डॉ. के. अनीस, वरिष्ठ वैज्ञानिक एवं प्रभारी हिंदी अधिकारी तथा सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने भाग ली।

हिंदी प्रकाशन

- अनुसंधान के मुख्य अंश 2022
- मसाला समाचार जनवरी-जून 2023
- मसालों की महक 2024
- एआईसीआरपीएस वार्षिक प्रतिवेदन का कार्यकारी सारांश 2023
- आईसीएआर-आईआईएसआर के वार्षिक प्रतिवेदन का कार्यकारी सारांश 2023
- हल्दी (पुस्तिका)

राजभाषारिपोर्ट

संस्थान के राजभाषा कार्यान्वयन की जनवरी-मार्च 2024, अप्रैल-जून 2024, जुलाई-सितंबर 2024 तथा अक्तूबर-दिसंबर 2024 की तिमाहियों की रिपोर्ट तैयार करके भारतीय कृषि अनुसंधान परिषद, नई दिल्ली को भेज दिया। यह रिपोर्ट राजभाषा विभाग, नई दिल्ली को ऑनलाइन भर दिया। राजभाषा कार्यान्वयन का अर्धवार्षिक रिपोर्ट तैयार करके नगर राजभाषा कार्यान्वयन समिति को प्रस्तुत किया।

हिंदी सप्ताह2024

राजभाषा हिंदी की प्रोन्नति के लिए भा.कृ.अनु.प.-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में 18 सितंबर से 25 सितंबर तक हिंदी सप्ताह मनाया गया। उद्घाटन समारोह दिनांक 18.9.2024 को संपन्न हुआ। डॉ. आर. सुरेंद्रन (डॉ. आरसु) सेवानिवृत्त विभागाध्यक्ष, हिंदी विभाग, कालिकट विश्वविद्यालय ने समारोह का उद्घाटन किया। उद्घाटन भाषण में उन्होंने **भाषा के विभिन्न स्वरूप** पर विस्तृत रूप से व्याख्यान दिया। उद्घाटन के बाद हिंदी स्मरण शक्ति परीक्षा आयोजित की। उसमें सभा में उपस्थित सभी अधिकारियों ने भाग लिया। उसी दिन दूसरे सत्र में हिंदी कार्यशाला आयोजित की। इसमें डॉ. आरसु ने **राजभाषा हिंदी के स्वरूप** पर व्याख्यान दिया।

हिंदी सप्ताह के अवसर पर हिंदी स्मरण परीक्षा, हिंदी कहानी लेखन, हिंदी सार लेखन,हिंदी

टिप्पणी एवं मसौदा लेखन,हिंदी श्रुतलेखन,हिंदी भाषण, हिंदी कमेंट्री, हिंदी गीत, हिंदी प्रश्नोत्तरी आदि प्रतियोगिताएं आयोजित की। इन में संस्थान के सभी सदस्यों ने सक्रिय रूप से भाग लिया।

हिंदी सप्ताह का समापन समारोह दिनांक 25 सितंबर 2024 को पूर्वाह्न 11 बजे संपन्न हुआ। समारोह में प्रोफेसर योगेंद्र मिश्रा, क्षेत्रीय निदेशक, केंद्रीय हिंदी संस्थान, मैसूर मुख्य अतिथि थे। उनके करकमलों से संस्थान की राजभाषा पत्रिका **मसालों की महक** 2024 का विमोचन किया गया। इसके अलावा वर्ष के दौरान हिंदी में सर्वाधिक कार्य किये अधिकारियों को पुरस्कृत किया गया। हिंदी सप्ताह के अवसर पर आयोजित विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार वितरण किया गया। मुख्य अतिथि ने सभा को संबोधित करके **हिंदी भाषा और दैनिक जीवन की संपूरकता** पर व्याख्यान दिया।

दिनांक १८.०९.२०२४ को डॉ. आर. सुरेंद्रन (डॉ. आरसु) हिंदी सप्ताह का उद्घाटन करते हुए।

दिनांक २५सितंबर 2024 हिंदी सप्ताह के समापन समारोह में मुख्य अतिथि प्रोफेसर योगेंद्र मिश्रा, क्षेत्रीय निदेशक, केंद्रीय हिंदी संस्थान, मैसूर द्वारा संस्थान की राजभाषा पत्रिका **मसालों की महक२०२४** का विमोचन करते हुए।

हिंदी सप्ताह २०२४ की झलकियां

हिंदी पुरस्कार

भा.कृ.अनु.प.-भारतीय मसाला फसल अनुसंधान संस्थान क्षेत्रीय केंद्र अप्पंगला को श्रेष्ठ राजभाषा कार्यान्वयन के लिए नगर राजभाषा कार्यान्वयन समिति, मडिकेरी का राजभाषा शील्ड (प्रथम) पुरस्कार प्राप्त हुआ।

Human Resources Development (HRD) & Institute Deputation Committee (IDC)

Memorandum of Understanding (MoU)

Sl. No.	Colleges/Universities
1.	Mahatma Gandhi Udyanikee and Vanikee Vishwavidyalaya, Sankra, Durg, Chhattisgarh
2.	National Institute of Food Technology, Entrepreneurship and Management, Thanjavur, Tamil Nadu
3.	Dr. YSR Horticultural University, Andhra Pradesh
4.	IQRAA International Hospital and Research Centre, Kozhikode, Kerala
5.	Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Government of Puducherry

Training attended

Sl. No	Name	Name of the pregame	Organizer	Date
Scientist				
1.	Dr. Sharon Aravind	AgrIP: A Specialized Online Short Course on Patents in Agriculture	ICAR-IP&TM and ICAR-CIFT, Kochi	15 January to 05 February
2.	Dr. M Shamsudheen			
3.	Dr. K Anees	NABL assessors training	NABL authority	19 January
4.	Dr. S Mukesh Sankar	Genome utilization and editing of plant for useful traits	ICAR- NIPB, New Delhi	07 February to 27 February
5.	Dr. M Shamsudheen	ISO/IEC 17025:2017-General Requirement for the Competence of Testing & Calibration	Ministry of Commerce & Industry , New Delhi	13 February
6.	Dr. Sona Charles	Metagenomics Data Analysis	ICAR-IASRI, New Delhi	26-28 June
7.	Dr. C M Senthil Kumar	Generative AI Tools for Agriculture	ICAR-NAARM, Hyderabad	22-24 July
8.	Dr. R Sivaranjani	Multivariate analysis using R	ICAR-NAARM, Hyderabad	26 -30 August

9.	Dr. S R Maneesha	Phenomics and High Throughput Phenotyping: Dissecting Traits for Abiotic Stress Tolerance	ICAR-IASRI, New Delhi	27 August to 02 September
10.	Dr. S Mukesh Shankar			
11.	Dr. M Shamsudheen	Remotely piloted aircraft system (RAPS)	Drone Destination Limited, Gurugram, Haryana	30 September
12.	Dr. K S Krishnamurthy	Vigilance Perspectives for ICAR Officers	ICAR-NAARM	06-08 November
Technical				
1.	Ms. N Karthika	Uncertainty of Measurement and Decision Rule as per ISO/IEC"	Quality Council of India	13-14 November
2.	Ms. O Shajina			
Administrative				
1.	Ms. N Archana	Pre-Examination Training for UDC post	ICAR-NIASM, Baramati	21August -6 September
2.	Mr. R K Babu	Coordination of Official language in administration	ICAR-NBPGR,New Delhi	27-29 November

Seminars/Symposium/Conferences attended

Sl. No	Name	Conferences	Date
1	Dr. C Sarathambal Dr. H J Akshitha Dr. Honnappa Asangi Dr. S Aarthi	3rd Indian Horticulture Summit-cum-International Conference-2024, organized by Society for Horticultural Research and Development at Rajasthan Agricultural Research Institute, Jaipur	1-3 February
2	Dr. A Ishwara Bhat Dr. C N Biju Dr. R Praveena	National Conference on Plant Health for Food Security: Threats and Promises ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh	1-3 February
3	Dr. Sona Charles	Bioclues (Bioinformatics Society) and Telangana Mahila Vishwavidyalayam,	15-16 March

4	Dr R Dinesh Dr D Prasath Dr V Srinivasan Dr T E Sheeja Dr. A Ishawara Bhat Dr. C M Senthil Kumar Dr. Lijo Thomas Dr Praveena R Dr. VKSajesh	International seminar on "Spices: Innovative and green technologies for sustainability, organized by College of Agriculture, Vellayani, Thiruvananthapuram	5-7 June
5	Dr. C M Senthil Kumar	International Congress on Invertebrate Pathology & Microbial Control, Vienna, Austria	28 July -1 August
6	Dr. SR Maneesha	International Conference on Precision Horticulture, HC& RI, Periyakulam	22-24 August
7	Dr. V Vinu	International conference on Current Innovation and Technological Advances Agriculture and Allied Science, Organized by Faculty of Agriculture, Guru Krishi University,	29-31 August
8	Dr. MS Shivakumar	1S ASIA-Pacific Congress on alternate Crops: Alternate crops for health and nutritional Security, the Assam Royal Global University, Guwahati, Assam	9-12 September
9	Mr. Abdul Rasheed	Department of Official Language	14-15 September
10	Dr. Balaji Rajkumar	10th International Conference on "Recent Advances in Agriculture, Engineering, Applied & Life Sciences for Environmental Sustainability,Uttaranchal University, Dehradun, Uttarakhand	23-25 October
11	Mr. Muhammed Nissar	National Conference on Managing Agro Biodiversity in North Eastern India (NCMAN-2024)	23-25 October
12	Dr. P V Alfiya	Indian Society of Agricultural Engineers	12 -14 November

Ph. D Awarded

Sl. No	Name	Guide	Subject
1.	Ms. Neenu Maria George	Dr. D Prasath	Botany
2.	Ms. Aswathi AP		

Ph.D. new registrations

Sl. No	Name	Guide	Subject	University
1.	Ms. M Anusree	Dr. TE Sheeja	Biotechnology	Kerala University of Fisheries &Ocean Studies
2.	Ms. A Neeraja	Dr. D Prasath	Horticulture	Dr.Y.S.R. Horticultural University

On going Programmes

Program	No: of students
Post Doctoral research	1
Ph.D	27
M.Sc	35
Post MSc	4
B.Sc	2
Internship	14
Honorary Research	8

Training program on From Bench to Bytes: An Interactive workshop in Bioinformatics, 15-21 May 2024

Seven day training program was organised by the Bioinformatics and Integrative Genomics (BIG) Facility, ICAR- IISR for Research Scholars, Project Fellows, MSc Students and JRFs. 12 participants were selected from various Institutes for the workshop. Training manuals including theory notes and practicals were shared with the participants.

Online workshop on R for Bioinformatics from 4-8 November, 2024

Bioinformatics and Integrative Genomics (BIG) Facility has organized an Online workshop on R for Bioinformatics . This five-day virtual workshop has delivered both theoretical as well as practical exposure to the Scientists/ Asst. Professors/ Research Scholars/ MSc Students in using R for statistical and biological data analysis and visualization. Total of 59 participants including 49 students and 10 faculty attended the workshop.

Internship programme on spice processing and product diversification

Internship programme on "Spice Processing and Product Diversification" for the first-year Food and Nutrition students of Dr. N.G.P. Arts and Science College, Coimbatore was organized from 29 May- 28 June 2024, at ICAR-Indian Institute of Spices Research, Kozhikode.

AWARDS AND RECOGNITIONS

1. Best thesis: Dr. Alfiya P V received Ph.D best thesis award during the 58th ISAE Annual Convention and International Symposium organized at Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani.

2. Best research paper: Dr. Alfiya PV received the award during the 58th ISAE Annual Convention and International Symposium organized at Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani.

3. Best Technology certificate: Best Technology in Horticultural Sciences

of ICAR for the technology 'Process for Instant soluble turmeric enriched spice flavoured dairy milk powder' for the team comprising of Dr. E Jayashree, Dr. Anees K, Dr. Rajeev P, Dr. Radha E and Dr. Thankamani CK during the ICAR- Foundation Day celebration held at NASC complex, New Delhi on 16 July 2024

4. Best oral presentation award: Dr. Akshitha HJ, Dr. Shivakumar MS and Dr. Ankegowda SJ. 2024. 'Identification and description of phenological growth stages of cardamom using extended BBCH scale during 3rd Indian Horticulture Summit cum International conference- 2024.

5. Best oral presentation: Dr. Honnappa A, Dr. Balaji Rajkumar M, Dr. Mohammed Faisal P, Dr. Akshitha HJ, Dr. Ankegowda SJ, Dr. Shivakumar MS and Dr. Sivaranjani R 2024. 'Characterization of cardamom (*Elettaria cardamomum* Maton) field gene bank accessions for morphological, yield, quality traits and disease resistance during 3rd Indian Horticulture Summit cum International conference- 2024.

6. Best oral presentation: Dr. Raghuveer, Dr. Prasath D, Dr. Yuvaraj KM, Dr. Aarthi S, Dr. Srinivasan V and Dr. Krishnamurthy KS. 'Suitability of turmeric genotype for controlled environment production in terms of yield and quality'during International conference on Precision Horticulture- 2024.

7. International Travel support award Dr. C M Senthilkumar to attend the International congress on Invertebrat Pathology and Microbial control held during 28 July to 1 August 2024 at Vienna, Austria

MAJOR EVENTS 2024

QRT Visit

The Quinquennial Review Team (QRT) QRT constituted by ICAR reviewed the research programme of ICAR IndianIn stitute of Spices Research and AICRP on Spices. The QRT, chaired by Dr. Parvinder Kaushal, Vice Chancellor, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture & Forestry, Uttarakhand visited ICAR-IISR during 17-19 January. The other members of the team were Dr. SK Pandey, Former Director, ICAR-CPRI Shimla; Prof. V. Palanimuthu, Director, NIFTEM Thanjavur; Dr. Yaduraju NT, Former Director ICAR-Directorate of Weed Research Jabalpur; and Dr. SK Sharma, Former Director, ICAR-CIAH Bikaner. The QRT reviewed the progress on research and development activities pertaining to both ICAR-IISR and AICRPS for the period 2018-2023.

EDP on Processing and Value Addition of Spices

An Entrepreneurship Development Programme (EDP) on Processing and value addition of spices was held at ICAR – IISR for 14 entrepreneurs from Assam during 12 – 16 February, 2024. The five-day EDP was sponsored by the Department of Industries, Commerce & Public Enterprise, Government of Assam, and the Assam Agribusiness Rural Transformation Project (APART Assam). The program included

hands on training sessions on processing and quality evaluation of spices, preparation of Detailed Project Reports and other aspects related to entrepreneurship in spice processing sector.

National Science Day 2024

National Science Day was celebrated at ICAR – IISR on 28th February 2024. The chief guest of the programme was Shri. MMK Balaji, Project Coordinator, Regional Science Centre and Planetarium, Calicut, who also delivered the science day lecture on the theme 'Indigenous Technologies for Viksit Bharat'. A science quiz competition was also organized for the students and staff members.

International Women's Day Celebration

The International Women's Day 2024 was celebrated by the institute on the theme 'Invest in Women: Accelerate Progress'. Dr. Lakshmi V M, Group Director, Solid Propellant Combustion Research Group, Vikram Sarabhai Space Centre, Thiruvananthapuram was the chief guest of the program. She delivered a talk on 'Challenges for a Women leader in Science'. A panel discussion on 'Inspiring an Inclusive Society: The Path Ahead' was also organized as part of the celebration. The

panelists included Dr. Lakshmi V. M., Dr. R. Dinesh, Dr. Shakkeela V., Director, Community Agro Biodiversity Centre, MSSRF, Wayanad, Dr. Manoj P. Samuel, Executive Director, KSCTEC-CWRDM, Ms. Archana Raj, Administrator, SAKI-One Stop Centre, Kozhikode, and Ms. Nishida Saibuni, Kudumbasree Mission.

UDAYAM2024

The Institute of Technology Management – Agri Business Incubation Unit (ITM-ABI) of ICAR-IISR organized "UDAYAM 2024" – a Women's Entrepreneurship Meet and Agricultural Expo from March 22 to 25, 2024. The event featured an exhibition highlighting women-owned small-scale enterprises in agriculture and allied sectors. Dr. Neeru Bhushan, Assistant Director General, IP&TM, ICAR New Delhi, inaugurated the program, while Ms. Sindhu

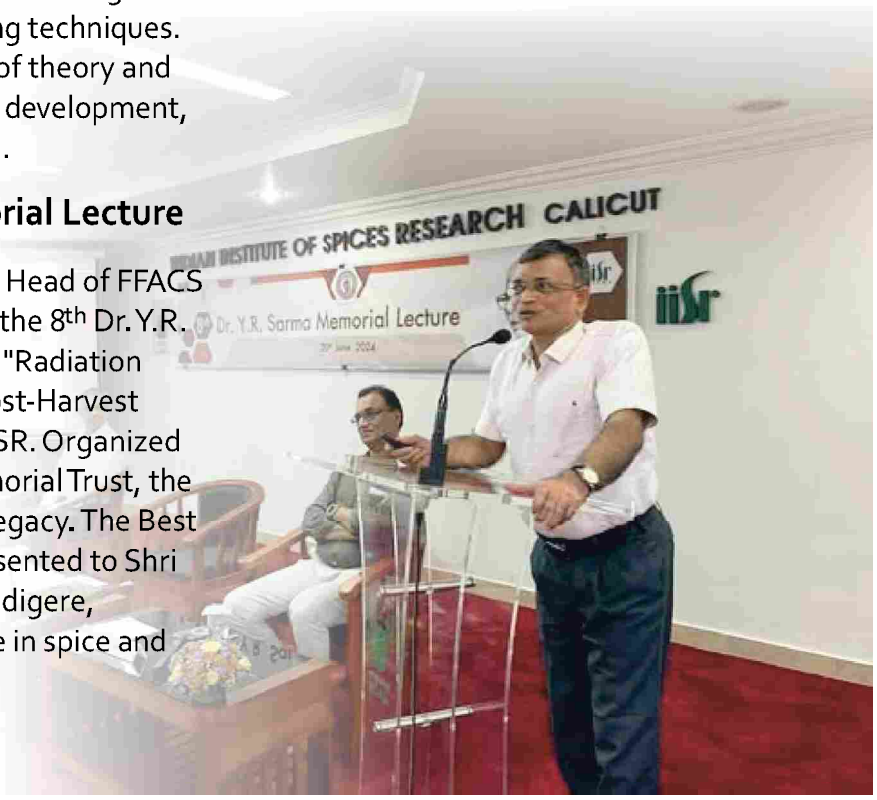
R, District Project Coordinator, Kudumbashree Mission, Kozhikode, served as the Chief Guest. The expo showcased over 60 exhibition stalls by women entrepreneurs, displaying innovative products and solutions, which garnered significant public interest. As part of the event, several handholding sessions were conducted to support entrepreneurs by introducing new products and technologies and offering practical guidance on managing commercial business enterprises

Training on Spice processing and Product diversification

A one-month Summer Internship Programme was conducted at ICAR-IISR on 'Spice processing and Product diversification' from 29th May to 28h June 2024. Seven students participated in the programme to gain hands-on training in cutting-edge spice processing techniques. The programme comprised of theory and practical sessions in product development, analysis and standardization.

8th Dr. Y R Sarma Memorial Lecture

Dr. Prasad S. Variyar, former Head of FFACS at BARC Mumbai, delivered the 8th Dr. Y.R. Sarma Memorial Lecture on "Radiation Processing for Enhancing Post-Harvest Quality of Spices" at ICAR-IISR. Organized with the Dr. Y.R. Sarma Memorial Trust, the event honored Dr. Sarma's legacy. The Best Farmer 2024 Award was presented to Shri Laxmana Gowda G.M. of Mudigere, Karnataka, for his excellence in spice and plantation crop cultivation.



Institute Foundation Day

ICAR-IISR celebrated its Foundation Day on July 1, 2024, marking its entry into the 50th year of existence. Prof. Prasad Krishna, Director, NIT Calicut, was the Chief Guest and commended the institute's contributions to spices research. Dr. Sanjay Kumar Singh, Deputy Director General, ICAR, New Delhi, presided over the function, highlighting IISR's role in transforming the spices sector through multidisciplinary and collaborative research. Distinguished guests, including Dr. Prathap Kumar S., Dr. Sudhakar Pandey, Dr. Vinay Bharadwaj, Dr. G Byju, Dr. B Augustine Jerard, and Dr. V A Parthasarathy, delivered felicitations. A special logo for the Golden Jubilee celebrations was also released.

The Spice Awards 2024, instituted by ICAR-IISR, were presented by Prof. Prasad Krishna, Director of NIT Calicut, to Mrs. Sopna Kallingal from Thrissur and M/s. Diya Foundation, Kamrup, Assam. Mrs. Kallingal was honored for her work in enterprise diversification and spice-based cropping, while Diya Foundation was recognized for supporting small and marginal spice farmers in the Northeast.

KVK Zonal Workshop

The Zonal Workshop of KVKs was held at ICAR-IISR from September 2-4, 2024, with participants from Kerala, Karnataka, and Lakshadweep. Jointly organized by ICAR-IISR and ICAR–ATARI, Bengaluru.Dr. Rajarshi Roy Burman, Assistant Director General, ICAR, New Delhi, was the Chief Guest. Eminent speakers, including Dr. V Venkitasubramanian, Director, ICAR-ATARI, Dr. S N Susheel, Director, ICAR-NBAIR, Dr. Manoj P Samuel, Director, CWRDM and Dr. Jacob John, KAU addressed the gathering. A novel biocapsule with a *Pseudomonas* strain, developed by ICAR-NBAIR and commercialized by KVK Kozhikode with ICAR-IISR's support, was launched.

Vigilance Awareness Week

ICAR-IISR observed Vigilance Awareness Week 2024 from October 28 to November 3 on the theme "Culture of Integrity for Nation's Prosperity." Activities included essays, slogan, and poster competitions, along with a Vigilance Awareness Rally to Chelavur. Mr. Ganesh Kumar N., Dy. SP, Vigilance & Anti-Corruption Bureau, Kozhikode was the chief guest for valedictory function held on 3rd November.

Inauguration of CTGC Facility and Compost Unit

Dr. Suresh Kumar Chaudhari, DDG (NRM), inaugurated the Carbon Dioxide and Temperature Gradient Chamber (CTGC) facility, along with the newly established enriched compost unit on 30th November.

Swachhta Hi Seva

Swachhta Pakhwada was inaugurated by Dr. R. Dinesh, Director, ICAR-IISR, followed by a cleanliness drive and Swachhta Pledge led by Dr. D. Prasath. Activities spanned multiple locations, including tree planting under the "Ek Ped Maa Ke Naam" campaign, a Swachhta Rally, and a Waste-to-Art Competition. The second phase (Dec 16-31) featured a Swachhta Pledge, discussions, school competitions, and clean-up drives at Madikeri tourist spots and other IISR centers

RESEARCH PUBLICATIONS

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2. Akshitha, H. J., Shivakumar, M. S. and Ankegowda, S. J. (2024). Phenological growth stages of cardamom (*Elettaria cardamomum* Maton): Detailed identification and description using the extended BBCH scale. Annals of Applied Biology, 184(3), 391-399.

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ON GOING PROJECTS

DIVISION OF CROP IMPROVEMENT AND BIOTECHNOLOGY

Mega Project I: Characterizing genetic resources to identify core collections and their long-term conservation[Project Leader: Dr. M.S. Shivakumar]

1. Gen. XXVIII (813): Conservation and characterization of *Piper* germplasm (2008-2025) [Dr. Muhammed Azharudheen T.P, Dr. M.S. Shivakumar, Dr. Honnappa Asangi, & Dr. Maneesha S.R.]
2. Gen. XIX (813): Conservation, characterization, evaluation and improvement of *Zingiber* and *Curcuma* sp. (2007-2026) [Dr. S. Aarthi, Dr Vinu V., Dr. H. J. Akshitha, Dr. D. Prasath & Dr. K.Anees] (External support: Dr. C. N. Biju)
3. Gen. XXXIII (813): Identification of core collection, characterization, and maintenance of cardamom germplasm (2012- 2025) [Dr. Honnappa Asangi, Dr. S. J. Ankegowda, Dr.H. J. Akshitha, Dr. Mohammed Faisal Peeran, Dr. M. Balaji Rajkumar & Dr. Sivaranjani R]
4. Gen. XXXVI (813): Genetic resources management in tree spices (2018-2028) [Mr. V. A. Muhammed Nissar,Dr. Sharon Aravind, Dr. Honnappa Asangi, Dr. Muhammed Azharudheen T.P & Dr. Maneesha S.R] [External support: Dr. Shivakumar M.S., & Dr. Anees K]
5. Gen. XXXVII (813): Conservation of *Vanilla* spp. and their utilization in crop improvement (2018-2025) (Dr. S. Aarthi, Dr. Sharon Aravind Mr. V. A. Muhammed Nissar & Ms. R. Sivaranjani)

Mega Project II: Genomics assisted breeding for trait specific varieties in spices [Project Leader: Dr. T. E. Sheeja]

1. Gen. XXXI (813): Breeding black pepper for high yield, quality, and resistance to stresses (2012-2025) [Dr. M.S. Shiva Kumar, Dr. K.S. Krishnamurthy, Dr. Muhammed AzharudheenT. P & Mr. Mukesh Sankar S.] [External support: Dr. S. J. Ankegowda]
2. Gen. XXXVI (813): Evolving high yielding, biotic and abiotic stress resistant cardamom lines through selection and hybridization (2018 - 2029) [Dr. H. J. Akshitha, Dr. S. J. Ankegowda, Dr. M. Balaji Rajkumar, Dr. M. S. Shivakumar, Dr. Mohammed Faisal Peeran & Dr. HonappaAsangi]

3. Gen. XXXVIII (813): Screening and evaluation of black pepper (*Piper nigrum* L.) genotypes for nutrient use efficiency (2023-2028) (Dr. Maneesha S.R., Dr. M. S. Shivakumar, Dr. Shamsudheen M., Dr. T. E. Sheeja & Dr. K. S. Krishnamurthy)

4. Gen. XXXIX (813): Rootstock breeding in nutmeg and black pepper for enhanced yield, tolerance to biotic and abiotic stresses (2023- 2028) [Dr. Sharon Aravind, Dr. Maneesha S. R., Dr. K. S. Krishnamurthy & Dr. C N. Biju]

5. Biotech. XIV (813): DNA fingerprinting and barcoding in spices (2018 - 2026) (Dr. T.E. Sheeja & Mr. Mukesh Sankar S)

6. Biotech. XV (813): Identification and characterization of gene editing targets for disease resistance in ginger (2021-2026) (Dr. P. S. Divya, & Dr. C.N. Biju) (External support: Dr. T.E. Sheeja & Dr. D. Prasath)

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

8. 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. K.S. Krishnamurthy, Dr. M.S. Shivakumar, Dr. Sona Charles, Dr. Muhammed Azharudheen T.P, Dr. U.B.Angadi & Dr. Sunil Kumar)

9. DUS project (2010-2025) [Dr. Sharon Aravind, Dr. Vinu V., Dr. S. Aarthi, Dr.H. J. Akshitha, Dr. Maneesha S.R. & Dr. Muhammed Azharudheen T.P] (External support: Dr. M. S. Shivakumar & Dr. Honnappa Asangi)

10. ICAR-CIB IV: Enabling Climate Resilience and ensuring food and Nutritional security through Genome Editing in Horticultural Crops (2024-2026)

    Sub project: Application of genome editing to develop trait-specific varieties/hybrids in ginger crops [Dr. Divya P. S., Dr. T.E. Sheeja, Dr. Biju C. N., Dr. Praveena R.]

    Sub project:- Application of genome editing to develop trait-specific varieties/hybrids in black pepper [Dr. Mohammed Faisal Peeran & Dr. Sharon Aravind]

11. NASF-CIB I: Integrating whole genome resequencing transcriptome sequencing and genome wide association analysis for allele mining of yield and quality traits in black pepper and cardamom (2024-2027) [Dr. T.E. Sheeja, Dr. M.S. Shivakumar, Dr.S. Mukesh Sankar, Dr. Muhammed Azharudheen T.P., Dr. Sona Charles, Dr. Akshitha H.J., Dr. Honnappa Asangi]

New Projects sanctioned

12. DBT-CIB X: National Network Project on Crop Bioinformatics (2024-2029) [Dr. D. Prasath, Dr. Sona Charles, Dr Anees K]

13. CSIR-CIB I: Establishment of efficient *in vitro* techniques to produce amide alkaloids from *Piper longum* L.(2024-2027) [Dr. Sharon Aravind & Dr. R. Sivaranjani]

DIVISION OF CROP PRODUCTION AND POST HARVEST TECHNOLOGY

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

1. Phy. X (813): Evaluation of black pepper and cardamom elite lines for yield and quality under moisture stress (2010–2025) [Dr. S.J. Ankegowda & Dr. K.S. Krishnamurthy) (External support: Dr.H. J. Akshitha & Dr. M.S. Shivakumar]
2. 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. Honnappa Asangi& Dr. H. J. Akshitha] (External support: Dr. S.J. Ankegowda, Dr. D. Prasath, Dr C K Thankamani ,Dr. R. Praveena, Dr Vinu V, Mr. V. A. Muhammad Nissar & Dr P Ratha Krishnan)
3. Biochem. X (813): Study on spike abscission: Developing chemically induced method for harvesting black pepper (*Piper nigrum* L.) (2018-2025) [Dr. Anees, K.,Dr. K.S. Krishnamurthy & Dr. C. N. Biju]
4. ICAR-CPPHT-1: Network project on organic farming (2014-2025) [Dr. C.K.Thankamani, Dr. V. Srinivasan, Dr. R. Praveena, Dr. C. Sarathambal, Dr. C Sellaperumal, Dr. S. Shanmughavel & Dr. B. Pradeep]
5. 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. Sivaranjani R , Dr. Ankegowda S.J. & Dr. Kandiannan K.]
6. SSC VII (813):Standardization of UAV-assisted precision spraying for enhanced nutrient and pesticide management in ginger and turmeric (2024-2027) [Dr. Shamsudheen. M, Dr. Srinivasan. V, Dr. C.M. Senthil Kumar, Dr. Praveena. R, Dr. Manimaran.B, Dr. B. Honnappa Asangi & Dr. Manjunatha. K]

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

1. Biochem. IX (813): Evaluation of chemo-diversity and microencapsulation of selected spices (2018-2025) [Dr. R. Sivaranjani & Dr. C.N.Biju] (External support: Dr. Anees K.]
2. 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) & Dr. Alfiya P]

3. CPPHT X (813) Non-conventional approaches for spice processing, preservation and packaging (2023- 2026) (Dr. Alfiya P V, Dr. E Jayasree & Dr. Anees K) (External Support: Dr. C Sarathambal)

4. Biochem. XI (813): Novel protocol development for quality evaluation and extracting phytochemicals from spices (2024-2027) [Dr. K Anees., Dr. E Jayashree, Dr. R Sivaranjani, Dr. Alfiya P V, Dr. Sarathjith MC , Scientist B, CWRDM, Kozhikode]

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

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1. CPPHT VIII (813): Pesticide residue monitoring of major spices (2020-2025) [Dr. Anees K., Dr. N. K. Leela, Dr. C. M. Senthil Kumar, Dr.M. Balaji Rajkumar & Dr.R. Sivaranjani]

DIVISION OF CROP PROTECTION

Mega Project VI: Bio-intensive management of pests and diseases in spices [Project Leader: Dr. A. Ishwara Bhat]

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1. ICAR-CP 1. ICAR-Consortium research project on borers in network mode (2014-2025) [Dr. C.M. Senthil Kumar & Dr. M. Balaji Rajkumar]

2. Ent. XV (813):Integrated management of mealy bug (Pseudococcidae: Hemiptera) infesting black pepper (2019 – 2025) [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, *Conogethes punctiferalis* infesting cardamom, ginger and turmeric (2021-2024) [Dr. C. M. Senthil Kumar, Dr. M. Balaji Rajkumar & Dr. R. Praveena]

4. Ent. XVI (813):Development of an integrated deep learning and molecular tool-based automated expert system for early detection and identification of major insect pests and vector-transmitted viruses of spice crops (2024-2027) [Dr. C. M. Senthil Kumar, Dr. A. Ishwara Bhat Dr. M. Balaji Rajkumar; Inter-Institutional Co-PI: Dr. Gopi Krishna Saramekala, NITC]

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

6. Nema. IX (813): Multipronged management approaches for the major

nematode problems in black pepper and turmeric cultivation (2024-28) [Dr. C. Sellaperumal, Dr. B Manimaran & Dr. S. Aarthi] (External support: Dr. T. P. Muhammed Azharudheen)

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

8. Path. XXX (813): Development and formulation of Plant Beneficial Rhizosphere Microorganisms (PBRMs) for disease antagonism, soil nutrient solubilization and plant growth promotion (2020-2025) [Dr. R. Praveena, Dr. R. Dinesh & Dr. C. Sarathambal] (External support: Dr. V. Srinivasan)

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

10. Path XXXII (813): *Bacillus spp.* based formulation for the management of rhizome rot disease in small cardamom (2021-2025) [Dr. Mohammed Faisal Peeran & Dr. C.Sarathambal] (External support: Dr. R. Praveena)

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

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

13. Path XXXIV (813): Development of arbuscular mycorrhizal fungi based bioinoculant formulation for growth promotion and disease tolerance in major spices (2024-28) [Dr.C. Sarathambal, Dr.V Srinivasan, Dr.R. Praveena, Dr.H.J. Akshitha & Dr. B. Manimaran]

14. Path XXXV(813): Developing a weather-based prediction model and exploring new generation anti-oomycete fungicides to manage foot rot of black pepper (2024-28) [Dr.CN Biju, Dr.S. J. Ankegowda, Dr. T. P. Muhammed Azharudheen & Dr. Mohammed Faisal Peeran]

SOCIAL SCIENCES SECTION

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

1. Ext. VI (813). Capacity building and front-line intervention programmes for (spice sector development in NE states and tribal empowerment (2014-25) (Dr. P. Rajeev, Dr.Lijo Thomas & Dr Sajesh V.K.)

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

3. TATA Ext I (813): Pan India action research project on the improvement of spice value chains (2023-2026) (Dr. R. Dinesh, Dr Lijo Thomas, Dr. D. Prasath,

Dr. P. Rajeev, Dr.Sajesh,V.K., Dr. Sharon Aravind, Dr. Maneesha S. R., Mr Muhammed Nissar V. A., Dr. Shivakumar M. S., Dr. Vinu,V., Dr. C. K. Thankamani, Dr. K. Kandiannan, Dr. V. Srinivasan, Dr. Anees K., Dr. Sivaranjani R, Dr. Biju C.N., Dr. C. Sellaperumal, Dr Mohammed Faisal Peeran & Dr. M. Balaji Rajkumar)

4. Ext. VII (813). Entrepreneurship development in agriculture: A multi-dimensional study with special reference to spices (2023-27) (Dr. Sajesh V.K., Dr. P. Rajeev, Dr. Lijo Thomas, Dr. Maneesha S. R. & Dr. Sheeja T. E.)

Other Externally Funded Projects

1. Institute Technology Management – Agri Business Incubation (ABI) Unit
2. RKVY-CP-2: An advanced centre for mass production of beneficial microflora for sustainable agriculture (2021 – 2025) [Dr. R. Praveena, Dr. C. M. Senthil Kumar & Dr. C. Sarathambal]
3. NBB-CPPHT-1: Establishment of Mini Honey Testing Laboratory (2024 – 2025) [Dr. Sivaranjani. R, Dr. Shamsudheen M & Dr. Aiswariya KK]

ICAR-INDIAN INSTITUTE OF SPICES RESEARCH

PERSONNEL

SCIENTIFIC, HEADQUARTERS

1. Dr. R Dinesh	Director
2. Dr. D Prasath	Project Coordinator (Spices)
3. Dr. V Srinivasan	Principal Scientist & Head, Crop Production & PHT
4. Dr. T E Sheeja	Principal Scientist & Head, Crop Improvement & BT
5. Dr. A Ishwara Bhat	Principal Scientist & Head, Crop Protection
6. Dr. P Rajeev	Principal Scientist (Agri. Extension) & HD I/C
7. Dr. CK Thankamani	Principal Scientist (Agronomy)
8. Dr. K Kandiannan	Principal Scientist (Agronomy)
9. Dr. KS Krishnamurthy	Principal Scientist (Plant Physiology)
10. Dr. E Jayashree	Principal Scientist (Agricultural Engineering)
11. Dr. CM Senthil Kumar	Principal Scientist (Agricultural Entomology)
12. Dr. CN Biju	Principal Scientist (Plant Pathology)
13. Dr. Shamsudheen. M	Principal Scientist (Soil Science)
14. Dr. Lijo Thomas	Senior Scientist (Agricultural Economics)
15. Dr. Divya P.S	Senior Scientist (Agricultural Biotechnology)
16. Dr. Anees K	Senior Scientist (Plant Biochemistry)
17. Dr. R Praveena	Senior Scientist (Plant Pathology)
18. Dr. C Sarathambal	Senior Scientist (Agricultural Microbiology)
19. Dr. Sajesh VK	Senior Scientist (Agri. Extension)
20. Dr. C Sellaperumal	Senior Scientist (Nematology)
21. Dr. Mohammed Faisal Peeran	Scientist (Plant Pathology)
22. Mr. Mukesh Sankar S	Scientist (Genetics & Plant Breeding)
23. Dr. V Vinu	Scientist (Genetics & Plant Breeding)
24. Dr. Sharon Aravind	Scientist (Spices Plantation Medicinal & Aromatic Plants)
25. Dr. S Aarthi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
26. Mr. VA Muhammed Nissar	Scientist (Spices Plantation Medicinal & Aromatic Plants)
27. Dr. Maneesha SR	Scientist (Fruit Science)
28. Dr. R Sivaranjani	Scientist (Plant Biochemistry)

29. Dr. Manimaran B	Scientist (Nematology)
30. Dr. Alfiya PV	Scientist (Agriculture Structures & Process Engg.)
31. Dr. Sona Charles	Scientist (Agricultural Bioinformatics)

ADMINISTRATIVE, HEADQUARTERS

1. Sri. T E Janardhanan	Senior Administrative Officer
2. Sri. Babu RK	Senior Finance & Accounts Officer
3. Sri. P Sundaran	Administrative Officer
4. Ms. C K Beena	Private Secretary
5. Sri. V V Sayed Mohammed	Assistant Administrative Officer
6. Sri Ajith K.S	Assistant Administrative Officer
7. Mr. Abdul Rasheed TK	Assistant Administrative Officer
8. Ms. M Seema	Assistant
9. Mr. Amaan Usmani	Assistant
10. Mr. Anuj Kumar	Assistant
11. Ms. Rebeena N	Upper Division Clerk
12. Mr. P K Rahul	Upper Division Clerk
13. Mr. Krishnakumar P C	Lower Division Clerk
14. Ms. Archana N	Lower Division Clerk

TECHNICAL, HEADQUARTERS

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

15. Mr. Debayan Banarjee	Technician
16. Mr. Satya Priya Singh	Technician

MULTI TASKING, HEADQUARTERS

1. Mr. Abhi Balagopal K P	Multi Tasking Staff

IISR EXPERIMENTAL FARM, PERUVANNAMUZHI

SCIENTIFIC

1. Dr. Muhammed Azharudheen T P	Scientist (Genetics & Plant Breeding)

TECHNICAL

1. Dr. Pavan Gowda M	Senior Technical Officer
2. Mr. T R Sadasivan	Technical Officer
3. Ms. Rejina P Govind	Senior Technician
4. Mr. Rasmish A R	Senior Technician
5. Mr. Nikhil C M	Technician

ADMINISTRATIVE

1. Mr. K Faisal	Personal Assistant

MULTI TASKING

1. Mr. Vijesh V	Multi Tasking Staff

KRISHI VIGYAN KENDRA

SCIENTIFIC

1. Dr. P Ratha Krishnan	Principal Scientist & Head KVK

TECHNICAL

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

ADMINISTRATIVE

1. Ms. Lakshmi Arora	Assistant

MULTI TASKING

1. Mr. C Ravindran	Multi Tasking Staff

ICAR IISR REGIONAL STATION, APPANGALA

SCIENTIFIC

1. Dr. S J Anke Gowda	Principal Scientist (Plant Physiology)
2. Dr. M Balaji Rajkumar	Senior Scientist (Agri. Entomology)
3. Dr. H J Akshitha	Scientist (Spices Plantation Medicinal & Aromatic Plants)
4. Dr. Honappa Asangi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
5. Dr. M S Shivakumar	Scientist (Genetics & Plant Breeding)

ADMINISTRATIVE

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

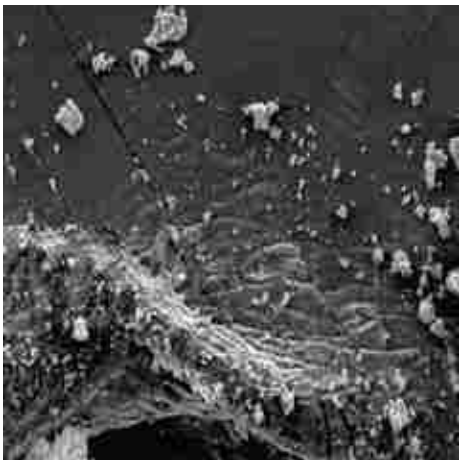
MULTI TASKING

1. Mr. Sachin K.P	Multi Tasking Staff

WEATHER DATA 2024

Month	TEMPERATURE (°C)			
	Experimental Farm, Peruvannamuzhi		Regional Station, Appangala	
	Maximum	Minimum	Maximum	Minimum
January	33.1	21.2	23.5	13.2
February	35.4	20.5	23.5	12.2
March	36.4	22.8	25.3	13.7
April	37.7	23.8	29.6	14.5
May	33	23.9	27.5	12.6
June	30.5	23.2	24.2	12.4
July	28.5	22.8	21.6	12.2
August	30.2	23	21.9	12.1
September	31.1	23	21.8	12.5
October	31.5	22.9	21.6	12.5
November	33.1	22.7	22.3	12.3
December	32.3	21.8	21.5	11.1

Month	RAINFALL					
	Headquarters Kozhikode		Experimental Farm Peruvannamuzhi		Regional Station Appangala	
	Total rain fall (mm)	Rainy days (No)	Total rain fall (mm)	Rainy days (No)	Total rain fall (mm)	Rainy days (No)
January	94.8	03	94.8	5	11.6	2
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	17.5	3	15	2
May	441.4	10	593.1	19	297.8	16
June	524.3	20	946.6	26	444.5	22
July	828.2	24	1800.3	30	1415.7	31
August	263.8	16	662.5	24	394.2	24
September	548.4	15	318.6	21	348.0	21
October	178.15	12	412.2	17	128.6	16
November	64.4	02	118	9	40.4	4
December	38.1	03	157.2	7	54.4	2



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