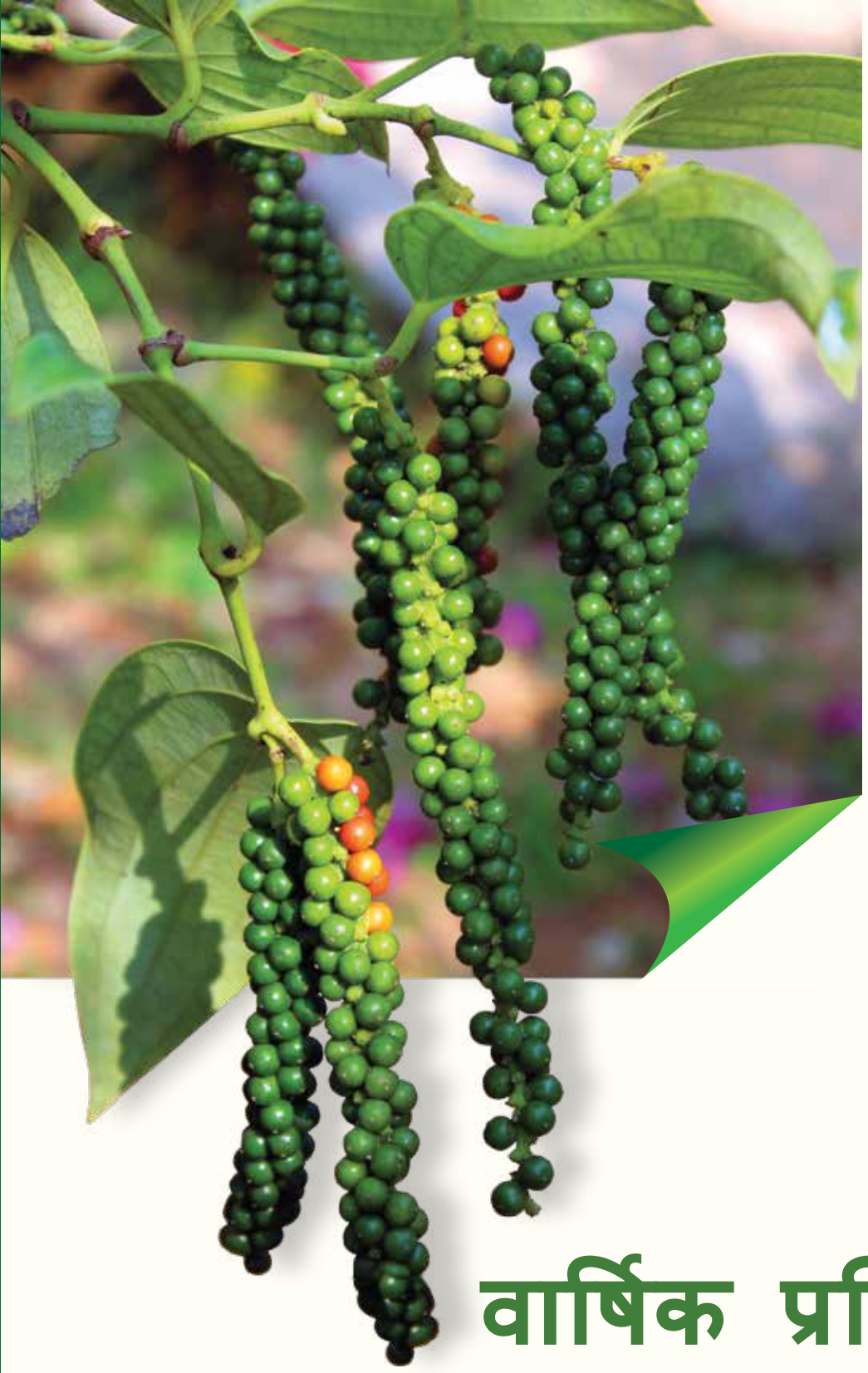
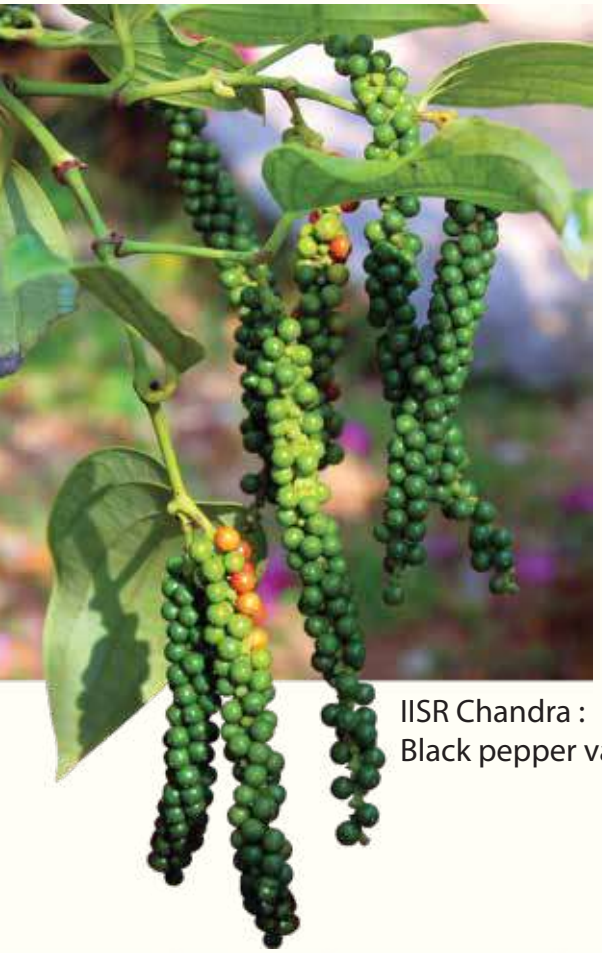


भाकृअनुप
ICAR

2023

वार्षिक प्रतिवेदन
ANNUAL REPORT

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



IISR Chandra :
Black pepper variety

वार्षिक प्रतिवेदन
२०२३

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January 2024

PREFACE

It is my distinct honour to present the Annual Report of the ICAR Indian Institute of Spices Research for the year 2023, marking yet another milestone in our journey of innovation and excellence. This year, amidst a backdrop of global and national challenges, our institute has delivered transformative achievements while continuing to push boundaries and deliver impactful outcomes.

As we reflect on the events of this past year, one cannot overlook the release of our new black pepper variety, *IISR Chandra*. The release of this high yielding variety not only represents a significant advancement in spice cultivation but also coincides with India's successful completion of the Chandrayan mission, symbolizing our nation's prowess in scientific fields. Furthermore, the introduction of 'Tricholime,' an innovative lime-based formulation of *Trichoderma*, underscores our commitment to pioneering sustainable and eco-friendly agricultural solutions. Similarly, the release of 'IISR Amrit,' a mango ginger variety with a distinctive flavor profile, exemplifies our dedication to enhancing crop diversity and quality.

Under the umbrella of the one ICAR policy, our institute has embraced new research initiatives and expanded its horizons, catalyzing innovation across various fronts. The identification and characterization of *Metarhizium indicum*, a new species of entomopathogenic fungus, exemplify our ongoing efforts to harness nature's diversity for pest management solutions.

In alignment with the spirit of progress and inclusivity, we have designed specialized programs to empower women entrepreneurs. The establishment of Incubation facility for Women Entrepreneurship and Development (IMPOWER) is a progressive step in this direction. As a team, we are delighted that these initiatives happened in the year when Indian Parliament passed the historic Women's Reservation Bill-2023, *Nari Shakti Vandan Adhiniyam*.

As we embrace the International Year of Millets, our Institute remains at the forefront of innovation, synthesizing the nutritional benefits of millets with the aromatic richness of spices to develop novel products that cater to evolving consumer preferences. Furthermore, the establishment new facilities like Zebrafish animal facility, Bioinformatics and Integrative Genomics (BIG) unit, Kisan Seva Kendra etc. signifies our commitment to exploring and unlocking new avenues for research, discovery and enterprise.

Moreover, our Institute's dedication to stakeholder engagement is reflected in customized training solutions offered to rural youth, start-ups, and priority sector beneficiaries, including tribal and SC farmers. Our focus on the NEH region persisted, with numerous training programs and input distribution activities across seven NEH states.

In closing, I extend my sincere gratitude to Dr. Himanshu Pathak, Director General of ICAR and Secretary DARE, for his steadfast support and guidance. I also express my appreciation to Dr. A K Singh, former Deputy Director General (Horticultural Sciences), and Dr. S K Singh, Deputy Director General (Horticultural Sciences), for their invaluable contributions. Special thanks are extended to Dr. Vikramaditya Pandey, former Assistant Director General (Hort II) and Dr. Sudhakar Pandey, ADG (Flower/Veg./Spices/Med.Plants)for their valuable guidance.

Special thanks are extended to the editors for their diligence in compiling this report, which serves as a testament to our Institute's commitment to excellence and innovation.

With determination and optimism, we look forward to another year of impactful research and transformative achievements.

R Dinesh
Director

Kozhikode,
31 January 2024

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कार्यकारी सारांश

काली मिर्च

- प्रायोगिक प्रक्षेत्र, पेरुवण्णामुषि, कोषिक्कोड, केरल में तीन हज़ार पांच सौ ग्यारह अक्सेशनों का रखरखाव किया जा रहा है। सीएचईएस, चेट्टाली,कर्नाटक के वैकल्पिक जर्मप्लाज़म साइट में, ५४२ जर्मप्लाज़म अक्सेशनों का रखरखाव किया जा रहा है।
- पाइपर नाइग्रम, पी. हैपनियम, पी. गैलिएटम, पी. बारबेरी (आईयुसीएन-सूचीबद्ध लुप्तप्राय प्रजातियां), पी. मुल्लेसुआ, पी. वेलायुधानी, पी. हुकेरी, पी. हाइमेनोफिलम और पी. अर्गिरोफिलम सहित विभिन्न पाइपरस्पीसीस के सोलह अक्सेशनों को संग्रह में जोड़ा गया।
- पांच प्रकार के संकर संयोजनों अर्थात् तेवम x शक्ति, तेवमx पीएलडी-२, तेवमx श्रीकरा,तेवमx पन्नियूर १ और पन्नियूर १xतेवम के बीच संकरण किया गया और कुल १०७ संकर बीज सफलतापूर्वक अंकुरित हुए।
- संस्थान द्वारा विकसित उच्च फल सेट और लंबी स्पाइक वाली एक प्रारंभिक परिपक्व संकर किस्म को आईआईएसआर चंद्रा नाम से ज़ारी किया गया। वाणिज्यिक उत्पादन के लिए केरल की पांच और कर्नाटक की दो नर्सरियों के साथ गैर-विशिष्ट समझौते पर हस्ताक्षर किए गए।
- औसत उपज सापेक्ष पर्यावरण अधिकतम (YREM) और सर्वश्रेष्ठ रेखिक निष्पक्ष भविष्यवक्ता (BLUP) को कृषक प्रदर्शन के मूल्यांकन के लिए सबसे प्रभावी उपायों के रूप में देखा गया। YREM मान < ०.४१ और BLUP मान < १.५० कि. ग्रा./बेल वाले जीनोटाइप को निम्नतर माना जा सकता है, जबकि YREM मान > ०.६६ औरBLUP मान>२.९९कि. ग्रा./बेल वाले जीनोटाइप को श्रेष्ठ माना जा सकता है।
- पी. नाइग्रमजीनोम में कुल ४१ हीट शॉक ट्रान्स्क्रिप्शन फैक्टर (एचएसएफ) परिवार जीन की पहचान की गई थी और ये जीन १९ क्रोमसोम पर असमान रूप में वितरित थे। HEATSTER डेटाबेस का उपयोग करते हुए विस्तृत एनोटेशन से संकेत मिलता है कि १९ HsfA वर्ग से संबंधित हैं, २१ HsfB वर्ग से संबंधित है, और एक HsfC वर्ग से संबंधित है।
- सात वर्षों (२०१५-२०२३) के फर्टिगेशन परीक्षणों से संकेत मिलता है कि प्रति पौधा ८ लिटर की दर से ड्रिप सिंचाई प्रदान और उर्वरक की अनुशंसित खुराक का ५०% (एन.पी. के १४०:५५:२७० ग्रा./पौधा) को २४ भागों में (मई, जून, सितंबर, अक्तूबर, फरवरी, मार्च) लगाने पर बी:सी अनुपात २.५९ के साथ अधिकतम उपज दर्ज की गई।
- फाइटोफ्थोराआईसोलेट्स के क्रॉस-संक्रामक विश्लेषण से पता चला कि १६ऽफाइटोफ्थोरा

संक्रमित जायफल, टमाटर, मिर्च, कद्दू, ककडी को अलग करता है, और कुछ आईसोलेट्स इलायची को संक्रमित करने के लिए पाए गए। हालांकि, नारियल, सुपारी और वानिला को संक्रमित करने वाले किसी भी आईसोलेट को नहीं पाया गया।

- आठ पी. कैप्सीसी आईसोलेट्स अर्थात् ९८-८१, ०१-०४, ०२-२०, ०५-०६, ०६-१२, ०७-०३, १८-१२, २०-०५ और आठ पी. ट्रॉपिकालिस आईसोलेट्स अर्थात्, ९७-५५, ९८-९३, ०३-०७, ०६-१७, ०९-०१, ११-२९, १३-२३ और १३-५३ को A१(एटीसीसी २३३८) और A २ (एटीसीसी ४०३४) संदर्भ आइसोलेट्स के साथ मेटिंग टाइप विश्लेषण से संकेत मिलता है कि ये आईसोलेट्स A१ मेटिंग टाइप से संबंधित है।
- पी. कैप्सीसी (०५-०६) और पी. ट्रॉपिकालिस(९८-९३) आईसोलेट्स की नए अणु कवकनाशकों के प्रति संवेदनशीलता से पता चला कि फ्लोपिकोलिडे-फोस्टाइल-A१ और कोप्पर सल्फेट पेंटाहाइड्रेट ने क्रमश: ०.३% और ०.५% पर माइलसेलियल वृद्धि को पूरी तरह से रोक दिया।
- फाइटोफ्थोरा स्पीसीस और पिथियमस्पीसीस के पता लगाने के लिए एक रीकॉम्बिनेज़ पोलीमरेज़ एम्प्लिफिकेशन-लेटरल फ्लो परख (आरपीए-एलएफए) प्रोटोकॉल को विकसित किया गया।
- पी. कैप्सीसी संक्रमण के दौरान प्रभावकारी जीनों की विभेदक अभिव्यक्ति से पता चला कि संक्रमण के प्रारंभिक चरण में कुछ R x LRप्रभावकारी जीनों को विनियमित किया गया था।
- दो उच्च-विनियमित R x LRप्रभावकारकों (R x LR२९ औरR x LR१३२) की संरचना की भविष्यवाणी की गई थी और प्रोटीन-प्रोटीन डोकिंग क्रमश: एराबिडोप्सिस के डीआरबी ४ जीन और सोलानम लाइकोपर्सिकमके CMPG1 जीन के साथ किया गया था।
- PYMoVऔर कुकुम्बर मोज़ेक वाइरस (CMV) का पता लगाने के लिए ड्युप्लेक्स रोकॉम्बिनेज़ पोलीमरेज़ एम्प्लिफिकेशन-लेटरल फ्लोपरख (RPA-LFA) विकसित किया गया। RT-RPA-LFAकी पता लगाने की सीमा १०$^{-३}$डिलूशन थी और यह परख विषाणु मुक्त मातृ पौधों की पहचान करने के लिए उपयोगी हो जाएगा।
- ०.५ मि. लि./लि. की दर से फ्लुओपाइरम के मानसून पूर्व और मानसून के बाद उपयोग करने से एकल अनुप्रयोग की अपेक्षा नेमटोड की आबादी में ९५% कमी आई।
- पोल्लु बीटल (लंका रामकृष्णाई) के प्रति नई पीढ़ी के कम जोखिम वाले कीटनाशकों की जांच से पता चला कि क्लोरेंट्रानिलिप्रोल @ ०.३ मि. लि. /लिं. के प्रयोग को कीट के प्रबंधन में प्रभावी पाया गया।
- रूट मीली बग प्लैनोकोकस लिलासिनस के प्रति कम जोखिम वाले कीटनाशकों का मूल्यांकन खेत की परिस्थितियों में करने पर ऐसा संकेत दिया कि क्लोथियानिडिन ५० WDG@ १ ग्राम/लि. के प्रयोग से ड्रेंचिंग

(८३.४%) के बाद २० दिन होने पर और इसके बाद स्पिरोटेरामाट १५.३१ ओ डी @ १ मि. लि. / लि. (७४.८%) के प्रयोग से अधिकतम संख्या में मीली बग की कमी हो गई।

इलायची

- आईआईएसआर, क्षेत्रीय स्टेशन, अप्पंगला के राष्ट्रीय सक्रिय जर्मप्लासम साइट (NAGS) में छह सौ अठाईस अक्सेशनों का रखरखाव किया जा रहा है।
- अप्पंगला-१, आईआईसआर अविनाश, न्जल्लानी ग्रीन गोल्ड और आईसी ५८४०५८, और आईसी ३४९६०६, आईसी ५४७१६७,आईसी ३४९३६४ और आईसी ३४९३५८ के बीच संकरण द्वारा संकर संतानों का विकास किया गया था।
- किसानों की किस्मों जैसे, अर्जुन, वंडर कार्डमोम, पनिकुलंगरा ग्रीन बोल्ड नंबर १, तिरुताली, एलराजन, पचैकायै, पाप्पलु, न्जल्लानी ग्रीन गोल्ड, पीएनएस गोपिनाथ पर तीन साल सीवीटी करने पर पनिकुलंगरा ग्रीन बोल्ड नंबर १ (३०१.६५ कि. ग्रा./हे.) ने सबसे अधिक उपज अंकित की तत्पश्चात् तिरुताली (२७३.८६ कि. ग्रा./हे.) रहा।
- पांच पर्ण ब्लाइट सहनशील जीनोटाइप जैसे IC३४९६५०, IC५४७२२२, आईसी ५४७१५६, IC३४९६४९, IC३४९६४८ के साथ प्रतिरोधी जांच, अप्पंगला-१, न्जल्लानी ग्रीन गोल्ड और अतिसंवेदनशील जांच, आईआईसआर विजेता के बहुस्थानीय परीक्षण से पता चला कि रोग आपतन (%) ११.६६ से २३.३३ के बीच, अधिकतम आपतन आईआईसआर विजेता में दर्ज की गई।
- इलायची जर्मप्लासम लाइन IC ५८४०५८(INGR23102) कॉम्पैक्ट फूल वाले जीनोटाइप, बोल्ड कैप्स्यूल (८०% कैप्स्यूल >७ मि.मी.) के साथ, नमी सहनशीलता आईसीएआर की प्लांट जर्मप्लाज़म पंजीकरण समिति (पीजीआरसी) द्वारा पंजीकृत की गई है।
- १२० दिनों की शेल्फ लाइफ के साथ इलायची और काली मिर्च के स्वाद वाले बाजरा कुकीज़ के लिए मेटालाइज्ड पॉलिएस्टर पैकेज को सबसे अच्छी पैकेजिंग सामग्री पाई गई।
- पार्श्व प्रवाह परख (RT-RPA-LFA) के साथ संयुक्त रिवर्स ट्रांस्क्रिप्शन-रीकॉम्बिनेज़ पोलीमरेज़ एम्प्लिफिकेशन पर आधारित एक परख को पौधों से कच्चे अर्क का उपयोग करके इलाची मोजेक वाइरस (CdMV) की विशिष्ट और संवेदनशील पहचान के लिए अनुकूलित किया गया।
- अर्बुस्कुलार माइकोरिज़ल कवक (एएमएफ) (राइज़ोफैगसइरेगुलारिस) की खुराक- प्रतिक्रिया अध्ययन से पौधों की वृद्धि और पोषक तत्व ग्रहण में वृद्धि देखी गई।

अदरक

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

- इन विट्रोप्रेरित सूक्ष्म प्रकंदों की आनुवंशिक निष्ठा एसएसआर और आईएसएसआर मार्करों का उपयोग करके जांच करने से इन विट्रोके साथ-साथ खेत की स्थितियों में सूक्ष्म प्रकंद व्युत्पन्न पौधों की मोनोमोर्फिक प्रकृति और वास्तविक प्रकार की स्थिति का पता चला। विकसित प्रॉटोकॉल अदरक और संबंधित प्रजातियों में सूक्ष्म प्रसार, जर्मप्लासम संरक्षण और आनुवंशिक परिवर्तन अध्ययन के लिए उपयोगी होगा।
- रालस्टोनिया संक्रमित और असंक्रमित नमूनों का विभेदक प्रतिलेख विश्लेषण किया गया और ४४६ प्रतिलेखों को अलग-अलग व्यक्त किया गया। होमोलॉजी संबंध का उपयोग करते हुए DEजीन के कार्यात्मक एनोटेशन ने २२७ एनोटेटड ट्रांस्क्रिप्ट की पहचान की।
- नैनो यूरिया को पत्ते पर छिड़काव के रूप में ०.४% और आरडीएफ के रूप में ५०% N के साथ मिलाकर लगाने से उपज और अप्लाइड N की उपयोग दक्षता में वृद्धि हुई। मिट्टी में प्रयोग के रूप में ५०% N के साथ पत्ते पर छिड़काव के रूप में नैनो यूरिया के संयोजन से ३३.०% और ताज़ा प्रकंद उपज में नैनो यूरिया उपचार के क्रमश: ०.२% और ०.४% में RDF (१००%N) से अधिक ६६.९% वृद्धि हुई।
- सोडियमहाइपोक्लोराइटकेउपयोगकेसाथ-साथलाख राल-आधारित कोटिंग करके ताज़ाप्रकंदकेशेल्फ लाइफ कोबढ़ायाजासकताहै औरप्रकंदों को बाज़ार में स्वीकार्य गुणों के साथ २० डिग्री सेल्शियस पर चार महीने तक संग्रहित किया जा सकता है।
- अदरक-नींबू रसकेछिड़काव-सूखेपाउडर के उत्पादन के लिए परिचालन स्थितियों को प्रतिक्रिया सतह पद्धति का उपयोग करके अनुकूलित किया गया था।
- रालस्टोनिया स्यूडोसोलानसीरम ने ऊष्मायन के २ घंटे बाद माइक्रोकॉलनी या सह-समुच्चय का गठन किया और राइसोम स्केल पर ऊष्मायन के ३ घंटे के बाद बायोफिल्म का निर्माण देखा गया। जीवाणुक म्लानी संक्रमित प्लॉट में पाए जाने वाले सामान्य खरपतवारों में कृत्रिम टीकाकरण के माध्यम से क्रोमोलाएना ओडोरेटा (यूपेटोरियम ओडोराटम) के साथ आर. प्स्यूडोसोलानसीरम के जुड़ाव की पुष्टि की गई थी।
- अदरक के जंगली संबंधोंसेबैसिलस अमाइलोलिक्विफेसिन्स, बी. वेलेन्जेंसिस, पेन्टोइया हसिंसी, प्रीस्टिया मेगाटेरियम, प्स्यूडासिडोवोरैक्स इंटरमीडियस, पाइथियम मायरियोटिलम और पी. डेलिसेंसके प्रति जीवाणुक एंटोफाइट्स की पहचान और मूल्यांकन किया गया।
- कोडगु के उच्च तुंगता और उच्च वर्षा वाले क्षेत्रोंपरपर्ण चित्ती के लिए रैखिक प्रतिगमन मॉडल का विकास हुआ। सहसंबंध विश्लेषण से पता चला कि पीडीआईकोवर्षाऔरबरसात के दिनों के साथ सकारात्मक सहसंबंध था और तापमान के साथ नकारात्मक सहसंबंध।

- जड़ गांठ सूत्रकृमि,मोलोइडोगाइन इन्कोग्निटा, के प्रति प्रतिरोधकता के लिए १९ किस्मों और जर्मप्लासम अक्सेशनों की जांच की गई और कल्टिवर जमैका और क्वींन्सलान्ड तथा १७, ५७८, ८९१ और ९०७३ अक्सेशनों को प्रतिरोधी पाए गए।
- अदरक और हल्दी को संक्रमित करने वाले सी. पंक्टिफरालिसके प्रबंधन के लिए एकीकृत कीट प्रबंधन (आईपीएम) पैकेज ने संकेत दिया कि कीटनाशकों (क्लोरेंट्रानिलिप्रोल, स्पिनोसाद और लैम्बडा सहलोत्रिन) और मेटारिज़ियम पिंगसेन्स के तरल फॉर्मुलेशन के साथ नीम उत्पाद के उपयोग को नियंत्रण की अपेक्षा कीट को नियंत्रित करने में प्रभावी पाया गया।

आम अदरक

- आम अदरक पर तीन साल के समन्वित किस्म परीक्षण (सीवीटी) के आधार पर, अक्से. ३४७ में ३१ टन/हेक्टर की उच्चतम औसत उपज और ४५.७५ टन/हेक्टर की संभावित
  उपजदर्जकीगईऔरइसे'आईआईसआर
  अमृत' के रूप में ज़ारी की गई। इस जीनोटाइप की विशेषता हल्के पीले रंग का कोर, मिरसिन (५५.५४%) और β पिनेन (१४.५३%) के साथ वांछनीय स्वाद और ०.३२% एसनशयल तेल मात्रा भी है।

हल्दी

- आईसीएआर-आईआईएसआरमें १४०४ कुरकुमा स्पीसीस जर्मप्लासम अक्सेशनों का रखरखाव किया जा रहा है।
- उच्च उपज और उच्च कुरकुमिन पर सीवीटी करने पर सूचित किया कि CL 272 (2 3 ट/हे.) और दो चेक किस्मों (आईआईएसआर प्रगति, आईआईएसआर प्रतिभा) ने उच्च उपज अंकित की।
- हल्के पीले रंग के हल्दी के विशेष रूप से बाज़ार मूल्य पर सीवीटी करने पर अक्सेशन ८४९ ने उधिकतम उपज ३६.१७ ट/हे. अंकित किये तत्पश्चात् अक्से. १५४५ (३१.१७ ट/हे.) है।
- ९२ हल्दी जीनोटाइप के फ्लो साइटोमेट्री प्लोयिडी अध्ययन से सूचित किया कि उनमें से ८३ ट्रिप्लोयिड थे और ९ टेट्राप्लोयिड।
- सेलम लोकल (तमिलनाडु के ईरोड और सेलम जिला) के तेरह अक्सेशनों और मैदुकर (आंध्रप्रदेश) के सात अक्सेशनों को अतिरिक्त लंबे और मोटे हल्दी प्रकार के लिए मूल्यांकन करने पर अक्सेशन SL5तत्पश्चात्SL3ने अधिकतम उपज अंकित की।
- विभिन्न उत्पादन प्रणालियों के तहत उपज और गुणवत्ता के लिए जीनोटाइप की प्रतिक्रिया से पता चला कि ताज़ा उपज और ठीक की गई हल्दी की प्राप्ति के लिए ग्रीनहाउस स्थितियां सर्वोत्तम पाई गई। आईआईएसआर प्रगति >राजेंद्र सोनाली >एनडीएच ८ >सीओ-३ ने ग्रीनहाउस परिस्थितियों में बेहत्तर प्रदर्शन किया।
- पर्ण ब्लॉच (टैफरीना मैकुलन्स) के प्रति प्रतिरोधकता के आधार पर जीनोटाइप के वर्गीकरण से सूचित किया कि ३१ बीज पौधे

रोग के प्रति प्रतिरोधी थे।

- विभिन्न एसएसपी परिदृश्यों के तहत २०५० के लिए केरल में साइट उपयुक्तता विश्लेषण ने दिखाया कि २८% क्षेत्र हल्दी के उत्पादन के लिए उपयुक्त नहीं है। अत्यधिक उपयुक्त के अंतर्गत आता है; ४१% क्षेत्र मध्यम रूप से उपयुक्त और ११% क्षेत्र उपयुक्त नहीं है।
- हल्दी की ग्यारह किस्मों का परीक्षण पांच उपचारों के तहत किया गया, अर्थात् जैविक १००%, जैविक ७५%, आईएनएम (७५% जैविक + २५% रसायन), आईएनएम (५०% जैविक + ५०% रसायन) और १००% रसायन। प्रगति में सबसे अधिक उपज (४० टन/हेक्टर) दर्ज की गई, इसके बाद आईएनएम (५०% जैविक + ५०% रसायन) के तहत सुगुणा और सुदर्शना का स्थान रहा। १००% जैविक प्रबंधन के तहत भी आईआईएसआर प्रगति किस्म में सबसे अधिक ताज़ा प्रकंद (२९.१ टन/हेक्टर) और उसके बाद सुगुणा (२६ टन/हेक्टर) का उत्पादन हुआ।
- जैविक उत्पादन के अंतर्गत खरपतवार प्रबंधन प्रथाएं दिखाया है कि एक जैविक प्रबंधन के तहत ५४०० कि. ग्रा. /हेक्टर की दर से सूखे नारियल के पत्तों के प्रयोग से खरपतवार की वृद्धि को प्रभावी ढ़ंग से नियंत्रित किया गया। खरपतवारप्रबंधन के इस अभ्यास से १.९७ का बी:सी अनुपात और २.८१ लाख रुपए का शुद्ध रिटेर्न प्राप्त हुआ।
- कृषि प्रणाली मॉडल में पशुधन (२ एचएफ गाय और बछडे) के साथ नारियल (६५ सेंट), चारा (१५ सेंट), हल्दी (१० सेंट), टैपिओका, केला, सब्जी, मटर (२.५ सेंट प्रत्येक) जैसी फसलों की जैविक खेती शामिल है। जिससे प्रति वर्ष प्रति एकड़ १.८९ लाख रुपए की शुद्ध आय प्राप्त हुई और इस मॉडल को आर्थिक रूप से व्यवहार्य पाया गया। मॉडल प्लॉट की खेती की लागत २.५७ लाख रुपए प्रति एकड़ है।
- प्राकृतिक खेती पैकेज में बीजामृत के साथ बीज उपचार और रोपण के १२० दिनों तक मासिक अंतराल पर जीवामृत और घनजीवामृत का अनुप्रयोग (मिट्टी को भिगोना), लोबिया के साथ अंतरफसल और अवशेष मल्चिंग शामिल है जिससे कुरकुमिन (५.३%) और एसनश्यल तेल (४.६%) की अधिकतम मात्रा दर्ज की गई।
- कुरकुमा प्रजाति के एसनश्यल तेलों की कीमो प्रोफाइलिंग से पता चला कि सी. अमदाका प्रकंद तेल मुख्य रूप से मायसिन (६३%) और β-पिनीन (८.६%) अंकित किया गया था, जबकि कर्जेरेनोन (१७.५%), जर्मेक्रोन (१३.९%), फ्यूरानोडिएनोन (१३%) और फ्युरानोडीन (७%) पत्ती के तेल में प्रबल है।
- सी. एरोमटिकाप्रकंद तेल में कर्पूर (१८.५%), कर्डियोन (११.४%), फुरानोजर्मेनोन (७.५%), १,८ सिनिओल (८.६%) और आईसोबोर्नियोल (६.७%) का प्रभुत्व था, जबकि इसकी पत्ती का तेल मुख्य रूप से १,८ सिनिओल (१६%), कर्पूर (११.०%), कर्डियोन (११.९%) और

फुरानोजर्मेनोन (६.२%) द्वारा गठित था।

- सी. कैसियाकी ऑक्सिडेंटरोधी क्षमता पर अध्ययन से पता चला कि एसनश्यल तेल का एक छोटा सा घटक यूजिनोल, १४० µg/mL के IC_{50} मान के साथ आशाजनकऑक्सिडेंटरोधी क्षमता रखता है।
- आयनिक जैलेशन का उपयोग करके हल्दी का एनकैप्सुलेशन करने से पता चला कि ऊष्मायन के ५ वें घंटे में ०.५% चिटोसन और ०.१५% हल्दी अर्क के साथ तैयार किए गए नमूने में कुरकुमिन की उच्चतम प्राप्ति अंकित की गई।
- ऑप्टिकल गुणों का उपयोग करके मसालों के एसनश्यल तेल में मिलावट की पहचान करने के लिए एक गैर-रासायमिक पद्धति विकसित की गई।
- सूत्रकृमियों की संख्या की गतिशीलता का अध्ययन करने से पता चला कि सबसे अधिक संख्या प्राटिलेंचस स्पीसीस में नवंबर के दौरान अंकित की गई, जबकि फरवरी से मई के महीनों में कोई संख्या दर्ज नहीं की गई थी।
- प्रॉटिलेंचस स्पीसीस और पिथियम स्पीसीस के बीच एक अंत:क्रिया अध्ययन से पता चला है कि सूत्रकृमि और पिथियम के एकसाथ टीकाकरण के फलस्वरूप प्रकंद गलन (८०%) और पत्तियों का पीलापन (९०%) का प्रतिशत सबसे अधिक था।
- प्ररेह बेधक (कोनोगीथस पंक्टिफरालिस) के प्रभाव पर पौधे की फिनोलोजी और रोपण के समय के प्रभाव से पता चला है कि जल्दी बोई गई फसल (मई) में कीट का प्रकोप पहली बार जुलाई के तीसरे सप्ताह में देखा गया था और सितंबर के अंतिम सप्ताह में अपने चरम सीमा पर पहुंच गया था। सामान्य रोपण (जून) के मामले में, कीट का प्रकोप पहली बार जुलाई के तीसरे सप्ताह में देखा गया था और चरम संक्रमण अक्तूबर के अंतिम सप्ताह में देखा गया था।

वानीला

- कुल ७७ अक्सेशनों (६५ वानिला प्लानिफोलिया और १२ वानिला प्रजाति) का संरक्षण किया जा रहा है।
- वानिला अक्सेशन (११), अंडमान संग्रह (२), वयनाड संग्रह (२) और अन्य वानिला स्पीसीसी (७) के बाईस जीनोटाइप को ११ एसएसआर मार्करों का उपयोग करके चित्रित किया गया था। वी. तहितेंसिस और तीन जीनोटाइप (अक्से. ४७९५, वयनाडु कलक्शन २ और वी. वाइटियाना) के बीच कम समानता देखी गई।
- विभिन्न मीडिया घटकों में १५० दिन पुरानी फलियों के इन विट्रो बीज अंकुरण में बीएम ९ऑर्किड मीडिया + २, ४ -डी (२ मि. ग्रा./लि.) वाले कल्चरों में प्रॉटोकॉर्म जैसे घटक (पीएलबी) दिखाई गई। बीएम ९ऑर्किड मीडिया अंधेरे परिस्थितियों में BAP (1 mg L^{-1}) + NAA (0.5 mg L^{-1}) जैसे विकास नियामकों के साथ पूरक होकर अधिक प्ररोहों में पुनर्जीवित हो गया, जबकि वही मीडिया किसी विकास

नियामकों के बिना प्रकाश में रखने पर अधिक प्ररोहों में पुनर्जीवित हो गया।

वृक्ष मसाले

जायफल

- मिरिस्टिका स्वाम्प्ससेएक जंगली प्रजाती एम. मैग्निफिका को एकत्र किया गया था। इस प्रजाती की विशेषता रूखी जड़ें हैं जो मुख्य तने के आधार से निकलती हैं और पेड़ को सहारा देने के लिए नीचे की ओर झुकती हैं।
- पांच क्रॉस संयोजनों जैसे केरलश्री × कोंकण संयुक्त, केरलश्री ×अक्से. ५९०, केरलश्री × अक्से. ५६२, विश्वश्री ×अक्से. ५९०, विश्वश्री× अक्से. ५६२ मेंएफ1 संकरकाउत्पादन किया गया था।
- जावित्री को सुखाने पर माइक्रोवेव पूर्व-उपचार के प्रभाव पर अध्ययन करने से पता चला कि ३२० वाट की इष्टतम शक्ति पर माइक्रोवेव में एसनश्यल तेल, ओलिओरसिन ओर सूखे जावित्री के रंग को बेहत्तर बनाए रखना पाया गया।
- मिर्च और जायफल की पैकेजिंग के लिए एक यूजीनोल युक्त मेम्ब्रेन विकसित करके मूल्यांकन किया गया।

दालचीनी

- सी. वीरम, सी. रिपेरियम, सी. मैलाबैट्रम और तीन अज्ञात प्रजातियों से युक्त आठ अक्सेशनों को एकत्र करके बनाए रखे गए।

लौंग

- कण्णूर जिले के किसानों के खेतों से उच्च उपज देने वाले और नियमित फल देने वाले तथा गुलाबी फूल वाले वैरियन्ट सहित दो अक्सेशनों को एकत्र करके बनाये रखे गए।
- लौंग के यांत्रिक सुखाने पर अध्ययन ने संकेत दिया कि अधिकतम एसनश्यल तेल और ओलिओरसिन सामग्री क्रमश: ११.३ और १६.९% के साथ सुखाने के लिए ५५°Cका तापमान इष्टतम था।
- रासायमिक रूप से प्रेरित कटाई के लिए पादप हार्मोन आधारित फार्मुलेशन विकसित किया गया था। इस विधि से कटाई की लागत सूखे वज़न के आधार पर लगभग ६५ रुपए /कि. ग्रा. है।

गार्सीनिया

- गार्सीनिया की चार प्रविष्टियां जैसे जी. मोरेला, जी. वाइटी और जी गम्मी गट्टा को एकत्र करके बनाए रखे हैं।

आलस्पाइस

- आर. स्यूडोसोलानसीरमके प्रति पिमेंटा रेसमोसाएसनश्यल तेल की जीवाणुरोधी गतिविधि पर SEM अध्ययन में नियंत्रण नमूनों की अपेक्षा कोशिका मेम्ब्रेन के संरचनात्मक परिवर्तन, कोशिकाओं का टूटना, सेलुलार मेम्ब्रेन का इंडेंटेशन और जीवाणु की सतहों पर ब्लबिंग आदि दिखाया गया।

सामान्य

- खाद्य पदार्थों के लिए पैकेजिंग फिल्म के

विकास ने संकेत दिया कि २% कॉर्न स्टार्च और १:२ के प्लास्टिसाइज़र स्तर के साथ तैयार की गई फिल्म अधिकतम तन्मयता ताकत और न्यूनतम जल बाष्प पारगम्यता के मामले में सबसे अच्छी थी।

- एक दानेदार चूना आधारित ट्राइकोडर्मा फॉर्मुलेशन 'ट्राइकोलाइम' को विकसित किया गया और ग्रीन हाउस और खेत की परिस्थितियों के तहत परीक्षणों के बाद पेटेंट के लिए फाइल किया गया था। यह फॉर्मुलेशन पौधों की वृद्धि को बढ़ावा देने के साथ-साथ मिट्टी की अम्लता को बेअसर करता है और फसलों को मिट्टी से पैदा होने वाले रोगजनकों से बचाता है।
- राउल्टेला टेरिगेना का कंसोर्टिया, बी. सर्फेसिस, एसिनेटोबेसर स्पी. और बी. एमाइलोलिकिफेसिन्स का मूल्यांकन खेत की परिस्थितियों में हल्दी के पौधों पर किया गया।
- छह तापमान-सहिष्णु ट्राइकोडर्मा आईसोलेट्स में से, आईसोलेट टी. हर्ज़ियानम (आईआईएसआर एपीटी २) में हाइड्रोलाइटिकएंजाइमों जैसे प्रोटीज़ (५७८.१२ µg/ml), ग्लूकेनेज़ (१३२५.६१µg/ml) और चिटिनेज़ (१३२५.६१ µg/ml) का उच्चतम उत्पादन अंकित किया गया।
- कल्चर अर्क के एचपीएलसी और एलसीएमएस विश्लेषण से संकेत मिलता है कि एपीटी २ (टी. हर्ज़ियानम), के ए १५ (टी. लिक्सी) और एनएआईएमसीसी ००४९ (टी. एस्पेरेल्लम) के तीन आईसोलेट्स ने पेप्टाइबोल का उत्पादन किया। एलसी-एमएस विश्लेषण ने आईसोलेट, आईआईएसआर एपीटी २ (टी. हर्ज़ियानम) के लिए अधिकतम एलामेथिसिन सांद्रता (१४.८४ पीपीबी) अंकित की गई।
- $ZnSO_4$के विभिन्न स्तरों के साथ बी. सर्फेसिसके संयुक्त अनुप्रयोग से १००% $ZnSO_4$के अनुप्रयोग और पूर्ण नियंत्रण की तुलना में टिलर की संख्या, शूट की लंबाई, पत्तियों की संख्या, सूखी जड़ का वज़न और फ्ररोह का वज़न काफी बढ़ गया।
- एम. पिंगशैन्सके साथ कीटनाशकों की संगतता का अध्ययन करने से संकेत मिलता है कि फ्लूबेंडियामिडे, इमिडाक्लोप्रिड, स्पिनोसाद और क्लोरेंट्रानिलिप्रोल संगत पाए गए, जबकि क्विनालफोस, मैलथियोन, लैम्ब्डा सिहालोथ्रिन और नीम तेल ने कवक के विकासको रोक दिया।
- परीक्षण किए गए कवकनाशी में, टेबुकोनाज़ोल, मेटालक्सिल और कॉपर हाइड्रॉक्साइड को एम. पिंगशेन्स के विकास को रोकते हुए पाए गए, जबकि मेन्कोज़ेब और कॉपर ऑक्सिक्लोराइड को कवक के विकास और वृद्धि के लिए कम हानिकारक पाए गए।
- एंटोमोपैथोजनिक कवक की एक नई प्रजाति, मेटारिज़ियम इंडिकम, जिसकी प्रजाती का नाम इसके भारतीय मूल के नाम पर रखा गया है, को गार्सीनिया लीफहॉपर, बुसोनिओमस मंजुनाथी में एपिज़ूटिक्स प्रेरित करने के लिए पाया गया

था। नई प्रजाती की विशेषता उसकी विशिष्ट रूपात्मक विशेषताओं और बहु-जीन विश्लेषणों के आधार पर की गई थी।

- मसालों से पृथक अर्क और यौगिकों के औषधीय गुणों पर अनुसंधान करने के लिए एक ज़ीब्राफिश पशु सुविधा की स्थापना की गई थी।
- काली मिर्च की इक्कीस किस्मों को कोषिक्कोड और सीएचईएस, चेट्टाली में संरक्षित किया जा रहा है। क्षेत्रीय स्टेशन, अप्पंगला में पंद्रह इलायची किस्मों का रखरखाव किया जा रहा है। अदरक की २३ और हल्दी की ३५ किस्मों का रखरखाव और संवर्धन किया जा रहा है।
- मेटा-विश्लेषण के लिए नमूनों के पीसीए और सहसंबंध प्रोफाइल के प्रदर्शन के लिए डेटा विश्लेषण और विज़ुअलाइसेशन टूलकिट का एक चमकदार आधारित मॉड्यूल विकसित किया गया था।
- किसानों के लिए आईसीएआर प्रणाली से उच्च इनपुट प्रौद्योगिकियों तक पहुंचने की सुविधा के रूप में विभिन्न आईसीएआर संस्थानों के कृषि जैव इनपुट की बिक्री के लिए किसान सेवा केंद्र - 'बायो इनपुट संसाधन केंद्र सुविधा' की स्थापना की गई थी।
- वर्ष के दौरान,ITMU ने संस्थान में मसाला प्रसंस्करण सुविधा का उपयोग करने के लिए विभिन्न प्रौद्योगिकियों के लिए १६ लाइसेंस और चार लाइसेंस समझौते ज़ारी किए।
- संस्थान ने अपने हितधारक समुदायों के लिए विभिन्न अवधि के ५२ प्रशिक्षण कार्यक्रम आयोजित किए। प्रशिक्षण कार्यक्रम महिलाओं, ग्रामीण युवाओं और प्राथमिक उत्पादकों को उच्च स्तरीय कौशल और उद्यमिता सहायता हस्तांतरित करने पर केंद्रित थे।
- एनईएच क्षेत्र में विशेष रूप से आदिवासी और अनुसूचित जाति के लाभार्थियों और प्राथमिक उत्पादक हितधारकों पर ध्यान केंद्रित करते हुए २७ प्रशिक्षण कार्यक्रमों के साथ सामाजिक और भौगोलिक रूप से कमज़ोर समूहों का समर्थन किया गया।
- पौधों की सुरक्षा में पसंद की सीमाएं, विभिन्न प्रकार के प्रतिस्थापन की धीमी गति, जीएपी और जैविक प्रबंधन रणनीतियों के प्रभावी प्रौद्योगिकी प्रसार की कमी और मसाला फसलों के लिए एमआरएल मूल्यों की अनुपस्थिति को मसाला क्षेत्र में कुछ प्रमुख अनुसंधान-नीति अंतराल के रूप में पहचाना गया था।
- हींग अर्थव्यवस्था में बाधाओं की पहचान करने और प्रभावी नीति इनपुट विकसित करने के लिए प्रसंस्करण क्षेत्र, फसल परिचय, नीति पर्यावरण और व्यापार संबंधी मुद्दों पर ध्यान केंद्रित करते हुए देश में हींग क्षेत्र पर एक अध्ययन किया गया था।

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.
- 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 added to the collection.
- Hybridization was carried out between five varietal cross combinations *viz*., Thevam × Shakthi, Thevam × PLD-2, Thevam × Sreekara, Thevam × Panniyur1 and Panniyur-1 × Thevam and a total of 107 hybrid seeds were successfully germinated.
- 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 commercial production.
- Average Yield Relative Environment Maximum (YREM) and Best Linear Unbiased Predictor (BLUP) were observed as the most effective measures for evaluating cultivar performance. 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 .
- A total of 41 Heat Shock Transcription Factors (HSFs) family genes were identified in the *P. nigrum* genome and these genes were unevenly distributed on 19 chromosomes. Detailed annotation using the HEATSTER indicated that 19 belong to HsfA class, 21 belong to HsfB class, and one belongs to HsfC class.
- The fertigation trials (2015-2023) indicated that providing drip irrigation @ 8 L per plant and application of 50 % of recommended dose of fertilizer (N:P:K 140:55:270 g /plant) in 24 splits (May, June, Sep, Oct, Feb, March) recorded maximum yield with a BC ratio of 2.59.
- Cross-infectivity analysis of *Phytophthora* isolates showed the *Phytophthora* isolates that infect nutmeg, tomato, chilli, pumpkin, cucumber, and a few of the isolates were found to infect cardamom.
- 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 R x LR effectors (R x LR29 and R x LR132) 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 chlor-antraniliprole @ 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 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 four female parents (Appangala-1, IISR Avinash, *Njallani* green gold and IC 584058) and four male parents (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 Gopinath for three years revealed that Panikulangara Green Bold No. 1 (301.65 kg/ha) had the highest yield followed by Thiruthali (273.86 kg/ha).
- Multilocation trial 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 recorded in IISR Vijetha.
- Cardamom germplasm line IC 584058 (INGR23102) with compact flowering genotype, bold capsules (80% of the capsules are >7mm), moisture tolerance has been registered by Plant Germplasm Registration Committee (PGRC) of ICAR.
- Metallised polyester package was found to be the best packaging material for cardamom and black pepper flavored millet cookies with a shelf life of 120 days.
- 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.

GINGER

- Six hundred and sixty-eight accessions are being maintained in the field gene bank.
- Genetic fidelity of *in vitro* induced micro rhizomes screened using SSR and ISSR markers revealed monomorphic nature and true-to-type status of micro rhizome derived plants under *in vitro* as well as in field conditions.
- 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.
- *Ralstonia 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, *Bacillus amyloliquifaciens, B. velenzensis, Pantoea hercicii, Priestia megaterium, Pseudacidovorax intermedius against Pythium myriotylum* and *P. deliense* were isolated.
- Developed a linear regression model for leaf spot for high altitude and high rainfall regions of Kodagu. Correlation analysis revealed a positive correlation between PDI and rainfall, rainy days, and a negative correlation with temperature.
- Out of 19 cultivars and germplasm accessions screened for resistance against root-knot nematode, *Meloidogyne incognita*, cultivars *Jamaica* and *Queensland* and accessions 17, 578, 891, and 9073 were found to be resistant.
- Integrated Pest Management (IPM) package for the management of *C.punctiferalis* infesting ginger and turmeric indicated that application of insecticides (chlorantraniliprole, spinosad and lambda cyhalothrin) and a neem product in combination with a liquid formulation of *Metarhizium pingshaense* were effective in controlling the pest .

MANGO GINGER

- Based on the three-year coordinated varietal trial (CVT) on mango ginger, 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 ß pinene (14.53%) and with essential oil content of 0.32%.

TURMERIC

- 1404 *Curcuma* spp. germplasm 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 turmeric for speciality 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 turmeric 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 and recovery of cured turmeric in the order of IISR Pragati>Rajendra Sonali>NDH 8>CO-3.
- Categorization of genotypes based on reaction towards leaf blotch *(Taphrina maculans)* indicated that 31 seedling progenies were resistant to the disease.
- 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.
- Eleven varieties of turmeric were tested under five treatments *viz.*, organic 100%, organic 75%, INM (75% organic + 25% chemical), INM (50% organic + 50% chemical) and 100% chemical. Highest yield was recorded in Pragati, (40 t/ha) followed by Suguna and Sudharsana under INM (50% organic + 50% chemical). Under 100% organic management also var. IISR Pragati yielded highest fresh rhizomes (29.1 t/ha) followed by Suguna (26 t/ha)
- 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 of *Curcuma* species showed that rhizome oil of *C. amada* was mainly constituted by myrcene (63 %) and ß-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%).
- Studies on antioxidant potential of *C. caesia* revealed that eugenol, a minor component of the essential oil, possessed promising antioxidant potential with IC_{50} value of 140 µg/mL.
- Encapsulation of turmeric extract using ionic gelation showed that highest release of

curcumin was observed in the sample prepared with 0.5 % chitosan five hours after incubation.

- A non-chemical methodology for identifying adulteration in spice essential oils using optical properties was developed.
- The nematode population dynamics study revealed that the highest population of *Pratylenchus* spp.was during November, while no population was recorded in the months of February to May.
- 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%).
- Studies on the influence of plant phenology and time of planting on the occurrence of shoot borer (*Conogethes punctiferalis*) recorded 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. In the case of normal planting (June), the incidence of the pest was first noticed during the third week of July and the peak infestation was noticed during last week of October.

VANILLA

- A total of 77 accessions (65 *Vanilla planifolia* and 12 *Vanilla* sp.) are being conserved.
- Twenty-two genotypes of Vanilla accessions (11), Andaman collection (2), Wayanad collection (2) and other *Vanilla* spp. (7) were characterised using 11 SSR markers. Low similarity was observed between *V. tahitensis* and three genotypes (Acc. 4795, Wayanad collection 2 and *V. wightiana*) and between *Vanilla* sp. and three genotypes (Acc. 4795, Wayanad collection 2 and *V. wightiana*).
- *In vitro* seed germination of 150 day old beans in different media compositions showed protocorm like bodies (PLBs) in the cultures with BM^{-1} orchid medium+ 2,4-D (2 mg L^{-1}). BM^{-1} orchid medium supplemented with growth regulators like BAP (1 mg L^{-1}) + NAA (0.5 mg L^{-1}) under dark conditions regenerated into more shoots, whereas the same media without any growth regulators maintained under light regenerated into more roots.

TREE SPICES

NUTMEG

- 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.
- F1 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.

CINNAMON

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

CLOVE

- Two accessions including a high yielding and regular bearer and a pink flowered variant were collected and maintained 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 is around Rs.65/kg on dry weight basis.

GARCINIA

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

ALLSPICE

- 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 as compared to control samples.

GENERAL

- Development of packaging film for foods indicated that film prepared with 2% corn starch and plasticizer level of 1:2 was best in terms of a maximum tensile strength and minimum water vapor permeability.
- 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, Acinetobacter* 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^{-1}), glucanase (1325.61 µg/mL^{-1}) and chitinase (1325.61 µg/mL^{-1}).
- 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 Shiny based module of Data Analysis and Visualization Toolkit for performing PCA and correlation profiles of samples for meta-analysis was developed.
- 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.
- During the year, the ITMU issued 16 licenses for various technologies and four licenses 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 27 training programmes focusing 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 technology 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.

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 766), 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.2240.07 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, 14 and 4 of scientific, administrative, technical and supporting staff, respectively are in position. The KVK has a sanctioned strength of 1 scientific, 11 technical, 2 administrative and 2 supporting staff.

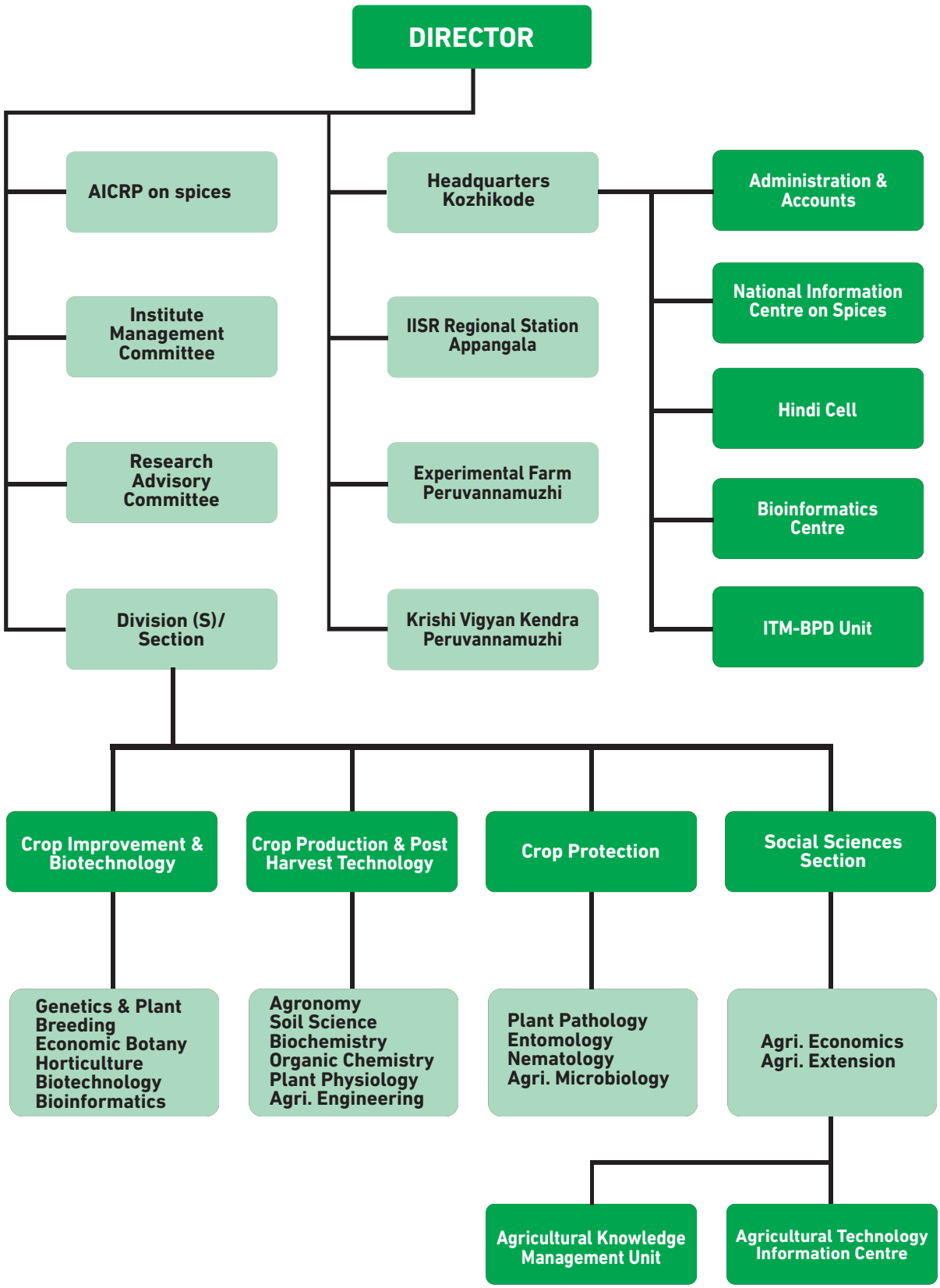
Staff position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientist	47	28	02	06	37	10
Technical	35	14	07	03	24	11
Administration	31	12	01	01	14	17
Supporting	31	01	01	02	04	27
Total	144	56	11	12	79	65

Staff position of KVK, Peruvannamuzhi

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

ORGANIZATIONAL CHART



PAST ACHIEVEMENTS

Black pepper

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

cDNA library of *Piper nigrum* leaf, stem and fourstages of berry (2MAP, 4MAP, 6MAP and 8MAP) were constructed for the evaluation of candidate genes and for combined co expression analysis. The *BAHD-AT* gene from Chromosome six showed a relative expression correlating with piperine content. Microsatellites developed in the past for *Piper* species were successfully used to detect polymorphism in black pepper cultivars. Additionally, six polymorphic ISSR primers for fingerprinting varieties of black pepper were also identified. Assembly and functional annotation of sequences derived from the transcriptome of *P. colubrinum* and *P. nigrum* helped in the identification of many genes involved in defense and secondary metabolism.

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

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

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

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

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

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

Genetic diversity of *Phytophthora* isolates from black pepper was studied by SSR profiling and ITS sequencing with the universal primers ITS 6 and ITS 4. A native isolate of *P. capsici* (98-93) infecting black pepper was completely sequenced using next generation sequencing platform. A new database, *Phytophthora* Genome Database (http://220.227.138.212/genomedb/) based on *Phytophthora* whole genome sequencing and annotation was developed. PhytoWeb, a comprehensive portal on *Phytophthora* diseases of horticultural crops in India was developed. Phytolib, an electronic database of research publications on phytophthora and database on *Radopholus* genus RADOBASE were developed and launched. A multiplex PCR assay has been developed for simultaneous detection of *Phytophthora*, *Pythium* and *Fusarium*. Climate analogues sites were identified for cultivation of pepper in newer areas to reduce climate change effects on production. The Carbon Equivalence (CE) from the shade trees commonly used as black pepper standards, *Ailanthus* spp. showed the highest C sequestration potential with 2.98 kg C per year (equivalent to 10.94 kg CO_2 sequestration per year) followed by *Glyricidia* spp. with a potential of 1.9 kg C per year (6.99 kg CO_2 sequestration per year).The level of adoption studies of recommended technologies indicated that the adoption level for aerial spraying of Bordeaux mixture for the control of fungal diseases was 57.14% and for application of

biocontrol agents was 64.2%. The adoption level for application of soil fungicides, fertilisers and pesticides were very low at 21.14%, 7.7% and 7.6 % respectively. A video on "Augmenting Black Pepper Production – A Success Story" (Malayalam, English, and Hindi) was produced. A facility for DNA fingerprinting and barcoding was established for undertaking fingerprinting services to facilitate varietal release from AICRPS centres. 31 varieties of spices have been fingerprinted and their uniqueness was established for the new varieties in comparison with its closely related/resembling varieties.

Cardamom

Germplasm collections are being maintained at the National Active Germplasm Site at IISR Regional Station, Appangala, Karnataka and IC numbers have been obtained for all the available 622 accessions. Four germplasm accessions with unique characters have been registered with NBPGR, New Delhi. Improved varieties such as Appangala-1, IISR Vijetha, IISR Avinash and Appangala-2 (hybrid) have been developed, which has immensely contributed in increasing the productivity of cardamom. Eight genotypes were evaluated under both irrigation and moisture stress conditions and the genotype IC349537, which out performed the other accessions was recommended for release as IISR Manushree.

Molecular profiles were developed for 100 accessions of small cardamom germplasm using 25 ISSR markers for studying the genetic diversity. Molecular profiling of Indian cardamom revealed the existence of two genetically distinct clusters such as "Kerala cluster" and"Karnataka cluster' among the germplasm collections. Characterization of export grade cardamoms from India, Sri Lanka and Guatemala based on physical, biochemical parameters and molecular techniques revealed the superiority of Indian produce. GC-MS study confirmed superiority of Indian cardamom over Guatemalan and Sri Lankan cardamom. High production technology has been standardized. Drip irrigation and sprinkler irrigation once in12 days significantly improved yield attributing characters. Soil and water conservation measures have been standardized in cardamom based cropping system. Organic packages and GAP have been developed and standardized. Cardamom accessions APG 257, APG 414 andAPG 434 were found to be promising for drought tolerance. Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations.

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

The survival of *C. gloeosporioides* infecting cardamom in infected plant part (leaves) was studied under laboratory, greenhouse and field conditions. *Colletotrichum gloeosporioides* isolate from cardamom showed the presence of dsRNA indicating association of a mycovirus. This is the first report of a mycovirus infecting *C. gloeosporioides* from India. A new bacterial wilt disease on small cardamom was noticed in

Wayanad, Kerala. The causative organism was identified as *Ralstonia solanacearum* biovar 3 phylotype 1, which is 100% similar to the ginger strain of *R. solanacearum*. An entomopathogenic fungus, *Lecanicillium psalliotae* (IISR-EPF-02) was found to reduce damage by thrips, *Sciothrips cardamomi* significantly and also promotes plant growth. Field screening of 180 cardamom germplasm accessions for three years at Appangala resulted in identification of eight accessions resistant to cardamom thrips. Different morphological traits such as panicle type, persistence of bract and nature of adherence of leaf sheath were found to impart resistance against thrips. A novel soil pH based micro nutrient mixture for enhancing growth, yield and quality of cardamom has been developed and non-exclusively licensed. The sustainability index of the soil was measured and the overall index was the highest under INM system followed by conventional and organic systems.

Ginger

Six hundred and sixty eight accessions are being maintained in field germplasm conservatory. Four varieties namely, IISR Varada, IISR Rejatha, IISR Mahima and IISR Vajra were released for their high yield and quality. A superior red ginger genotype with high essential oil (4.3%) along with high pungent principles, gingerol (1.92%) and shogaol (0.55%) has been identified. Acc. 195, a tetraploid having 2n=44, showed mean pollen fertility of 67.73%by glycero-carmine staining and 60.31% by *in vitro* germination and is suitable for future studies on induction of seed set. Three potential mutants have been identified through gamma ray irradiation which showed resistant reaction against bacterial wilt caused by *Ralstonia solanacearum*. "Gingerarium" a dedicated facility for conserving ginger accessions and related species collected from different parts of the country was established at IISR Experimental farm. Targeted yield equations for predicting nutrient requirements for fixed yieldtargets in soils with varying fertility levels were standardized with minimum deviations. The relationship between leaf P/Zn ratio and soil P/Zn ratio to rhizome yield has been established. The economic optimum in terms of profitable response for money invested was found to be Rs. 3.75/ bed for N, Rs. 1.30/ bed for P and Rs. 0.60/ bed of $3m^2$ for K. Novel soil pH-based micronutrient mixtures for enhancing growth, yield and quality of ginger has been developed and licensed. Under the evaluation of production systems on ginger, integrated management (75% organic + 25% inorganic) recorded maximum yield of 14.9 t/ha on par with organic (25%) + inorganic (25%) + seed treatment with Beejamrit (BA), Ganajeevamrit (GJA) and Jeevamrit (JA) (13.3 t/ha).

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

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

'Bacillich'. A protocol for priming rhizomes with *Trichoderma* spp. was developed to regulate the germination process, prevent the growth of dry rot pathogens during storage, to improve the vigour of buds and to provide uniform tillering of seed rhizomes.

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

The life cycle of shoot borer (*Conogethes punctiferalis*) on six resistant and six susceptible accessions was studied. The infectivity of EPNs strains IISR-EPN 01 to 08 was tested against shoot borer larvae under *in vitro* conditions. One species of EPN belonged to *Oscheius gingeri* and was identified as new species on the basis of morphological and molecular characterization.

Field studies indicated that spinosad, flubendiamide and chlorantraniliprole were effective in the management of ginger shoot borer (*Conogethes punctiferalis*) even at the lowest dose (0.3ml/litre of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect. The improved varieties and technologies developed on cropping system, nutrient and water requirement, pest and disease management and postharvest processing techniques were disseminated to farmers and other agencies through publications, training programmes and demonstrations. Large scale multiplication and distribution of elite planting material were also undertaken.

Turmeric

The germplasm with over 1404 accessions is being conserved in the field gene bank. These have been characterized for yield, quality, and resistance to pests, diseases and drought. Seven high curcumin and high yielding varieties, Suvarna, Sudarsana, Suguna, IISR Prabha, IISR Prathibha, IISR Alleppey Supreme and IISR Kedaram were released for commercial cultivation. Molecular genetic fingerprints of 16 *Curcuma* species using RAPD and ISSR markers revealed high degree of polymorphism. A total of 140 microsatellites containing genomic DNA fragments were isolated adopting the selective hybridization method with di and trinucleotide biotinylated probes. Two synonymous *Curcuma* species *viz*., *C. zedoria* and *C.malabarica* showed identical SSR profiles for 40 microsatellite loci. Efficient protocol for plant regeneration through organogenesis and somatic embryogenesis was standardized.

Variations in rhizome morphology were observed among calli-regenerated somaclones indicating somaclonal variation. Accessions with high curcumin and root knot nematode resistance were identified. About 40 seedling progenies with higher curcumin (> 3%) and dry recovery (> 20%) were identified. Three different curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) could be separated from oleoresin by employing chromatographic techniques. Turmeric essential oil components have been characterized by GC-MS. A PCR based method was developed to detect adulteration of turmeric powder with wild *Curcuma* species. Through transcriptome analysis the genetic basis and regulation of curcumin biosynthesis in *Curcuma* sp. were unravelled and microRNAs that showed differential expression with respect to curcumin in turmeric accessions with contrasting curcumin content have been identified. Land suitability assessment for turmeric in India was analysed based on the 5th Assessment Report Scenarios of IPCC. Climatic parameters such as temperature and rainfall and land characteristics such as soil drainage, texture, pH and depth and slope for 2020 & 2050.

Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations. The economic optimum in terms of profitable response for money invested per bed of size 3 × 1 m was found to be Rs. 0.65, 0.40, 0.85 for N, P and K respectively. Increase in curcumin content was recorded when sprayed with micronutrients like zinc and boron. The optimum spacing, nutrient and water requirement were standardized for different soils and an organic farming system was developed for turmeric. Among the management systems, organic system (75.0%) recorded maximum yield(13.9 t/ha) which was on par (13.8 t/ha) with integrated system (75.0%+25.0%). Maximum oil content (5.3%) was recorded by organic 100.0% and organic 75.0% management system. Among the 12 turmeric varieties evaluated under 100.0% organic management, significantly higher yield was recorded in IISR Pragati (22.1 t/ha) followed by Kanthi (19.2 t/ha). Higher oil content was noticed in varieties IISR Prathibha (6.0%) and IISR Alleppey Supreme (5.9%) and least oil content was noticed in Suvarna. Novel soil pH based micronutrient mixtures for enhancing growth, yield and quality of turmeric has been developed and licensed.

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

Basic data on distribution, bioecology, population dynamics of shoot borer (*Conogethes punctiferalis*) and its natural enemies and crop loss due to shoot borer was generated. Lamdacyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer. New generation insecticides such as, chlorantraniliprole, flubendiamide and spinosad were also found effective in the management of shoot borer even at the lowest dose (0.3 mL of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect. Evaluation of multi-trait PGPR, *Bacillus safensis* for plant growth promotion and zinc solubilization in turmeric showed that combined application of Zn and *B. safensis* was found to increase physico-chemical parameters like organic carbon, available nitrogen and dehydrogenase enzyme activity in soil. Spray application of *M. pingshaense* at 1×10^7 conidia/ml was found to be effective in managing shoot borer infesting ginger and turmeric Application of fluopyram (0.5 ml/L) effectively reduced the lesion nematode (*Pratylenchus spp.*)population, enhanced the number of tillers and the yield in turmeric. A novel soil pH based micronutrient mixtures for enhancing growth, yield and quality of turmeric, ginger, black pepper and cardamom were developed.

Tree spices

The germplasm of important tree spices like nutmeg, clove, cinnamon including cassia, garcinia and allspice are being conserved. A high yielding nutmeg accession; IC0645756 has been registered with ICAR-NBPGR (INGR22092) for its monoecious character. IC numbers for cinnamon, clove, nutmeg andallspice accessions were obtained from NBPGR, New Delhi. Cassia C1 (IC 370415) has been registered as INGR 05029 with NBPGR, New Delhi for its high oleoresin content (10.5%) besides a dwarf clove accession. The cassia elite line A1 (IC 370400) has been registered with NBPGR for high cinnam aldehyde content in bark oil (81.5%) and leaf oil (80.5%). Two high quality cinnamon varieties, IISR Navashree and IISR Nithyashree and a nutmeg variety, IISR Viswashree were released. Nutmeg accession, A11/25 was found to be promising for high yield. Nutmeg accession A9-71(IC-537220), as a source of high sabinene (45.0%sabinene in nutmeg oil and 41.9% sabinene in mace oil) was registered with NBPGR. Tissue culture protocols have been developed for nutmeg. Protocols for DNA isolation from nutmeg have been standardized. Performance of nutmeg on *M. malabarica*

continued to be better than other rootstocks for productivity. Green chip budding with orthotropic buds was standardized in nutmeg on *Myristica fragrans* rootstock with 90-100% success. GC-MS study revealed the presence of two chemotypes in *Cinnamomum verum*. GC-MSanalysis showed that eugenol, myrcene, chavicol and limonene were the volatile constituentsin leaves, berries and fruit stalk of *Pimenta racemosa*. Drying and processing methods for cinnamon, nutmeg and mace have been developed. A package was developed for enhancing sustainability of nutmeg in coconut based cropping system through site specific nutrient management. Antioxidant properties and food color value are being studied in tree spices. GC-MS analysis of the chemical constituents of essential oils in leaves of *C.sulphuratum, C. glaucescens, C. glanduliferum, C. macrocarpum* and *C. perrottetti* revealed that the major chemical constituents in these oils were α-phellandrene, β--phellandrene, camphor, t-*caryophyllene* and *germacrene*-D respectively. Vegetative propagation techniques were standardized for nutmeg, cassia and cinnamon. Major pests and diseases on tree spices were documented. The improved varieties and technologies developed on propagation and post-harvest processing were disseminated to the farming community. Unique ISSR markers, for distinguishing *Pimenta dioica* from *P.racemosa* have been identified.

Vanilla

Vanilla germplasm is being maintained in the repository with 82 accessions. Protocols for quantification of major flavour compounds *viz.,* vanillin, p-hydroxybenzoic acid,p-hydroxy benzaldehyde and vanillic acid were standardized.

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

Awards

Besides numerous prestigious fellowships and awards to scientists, the Institute was bestowed thrice with the Sardar Patel Outstanding ICAR Institution Award (1999, 2009 & 2021). The All India Coordinated Research Project on Spices (AICRPS) won the prestigious Chaudhary Devi Lal Outstanding Award for the best AICRPS in the year 2017-18. Other notable awards obtained by the Institute in the past include, Rajbhasha Shield Award 2013, 2014 & 2015, Best official Language Magazine Award 2015 for Masalon Ki Mehak, ICAR Swachhta Pakhwada Award Second Prize 2018, Fakhrudin Ali Ahammed Award for outstanding research in tribal farming systems 2019 etc. The Institute has been awarded eight patents for encapsulation technology, designer micro-nutrient formulations developed for black pepper, cardamom, ginger and turmeric etc.

RESEARCH ACHIEVEMENTS

BLACK PEPPER

Genetic resources

Three thousand five hundred and eleven accessions are being maintained in the germplasm nursery at the Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala. In the alternative germplasm site at CHES, Chettalli, Karnataka, 542 germplasm accessions are being maintained. Besides, a field gene bank consisting of 222 accessions and 80 core accessions are being maintained at ICAR-IISR, Kozhikode.

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* and *P. argyrophyllum*, were collected from the forests of Athirappilly, Vazhachal, Sholayar, Malakkappara and Valparai. *Piper hapnium* and *P. hymenophyllum* accessions were collected from the Kulathupuzha forest ranges of Kollam, Kerala. A unique line was identified and collected from the Boothanakadu estate, Madikeri, Karnataka (Fig. 1). The genotype has long spike with mean spike length of 27.20 cm, and an average of 166.40 mature berries per spike. Average weight of 5-spikes was 83.2 g and the bulk density ranged between 600-620 g/L

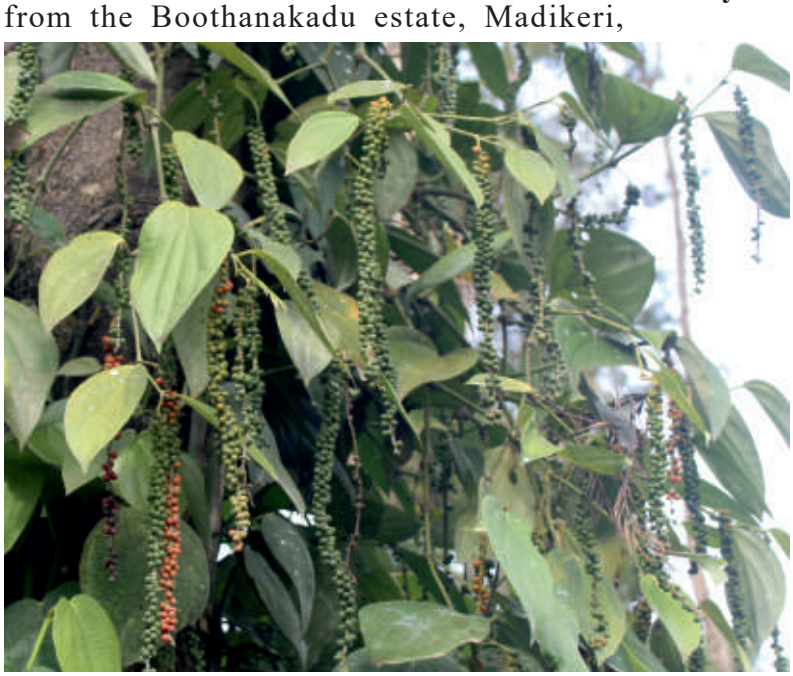


Fig. 1 : Unique pepper line with long spike and good setting

Hybridization

Hybridization was carried out between five cross combinations *viz.,* Thevam × Shakthi, Thevam × PLD-2, Thevam × Sreekara, Thevam × Panniyur1 and Panniyur-1 × Thevam. A total of 107 hybrid seeds successfully germinated from these crosses. A substantial cross combination involving Thevam × Panniyur-1 was undertaken, in which 51 seeds germinated out of 194 seeds sown.

Release and commercialization of hybrid *IISR Chandra*

An early maturing hybrid variety with high fruit set and long spikes developed by the Institute was released as *IISR-Chandra* (Fig. 2). The hybrid boasts an average spike length of 17.5 cm, which is longer than some of the commonly cultivated landraces and varieties. The spikes bear bold berries with compact setting and an average number of 90 berries/spike. This hybrid has a dry recovery of 33.5 %, piperine content of 5.1 %, essential oil content of 3.2 % and oleoresin content of 8.7 %. Average yield from six-year-old vine was 7.5 kg fresh (2.5 kg dry) with a maximum yield of 21.5 kg fresh and 7.1 kg dry (vine

height – 12-15 feet). Non exclusive licence agreements were signed with five nurseries in Kerala and two from Karnataka for its commercial production.

Predictive power of YREMs and BLUPs for selecting superior genotypes

Eleven genotypes were evaluated over three years to study the Genotype x Year interaction (GYI) pattern and its impact on yield, as well as for selection of parameters for identifying stable and high-yielding cultivars. Average Yield Relative Environment Maximum (YREM) and Best Linear Unbiased Predictor (BLUP) emerged as the most effective measures for evaluating cultivar performance, as they accounted for relative yield and stability. 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. Among the tested cultivars, OPKM demonstrated better stability estimates, but considering the high mean yield and stability, HP 2173 was ranked first.

Molecular characterization of *Piper* sp. using novel gene based SSR markers

In the black pepper genome, 63,466 inferred protein-coding gene sequences were analysed for the presence of simple sequence repeats (SSR). As a result, 5422 (8.54%) genes were found to contain 6751 SSR loci. 821 genes have multiple SSRs in their sequence of which 467 were compound SSRs (microsatellite repeats occurring within 100bp distance in the same gene). Among the SSR motifs, tri-nucleotide repeats were the most abundant (56.3%, 3803), followed by mono-nucleotide (29.3%, 1979), dinucleotide (13%, 899), hexa-nucleotide (0.58%, 39), penta-nucleotide (0.24%, 16) and tetra-nucleotide repeats the least present (0.22%, 15) (Fig. 3). The identified gene-based SSRs were found to be distributed throughout the 26 pseudo-chromosomes of the genome.

Fig. 2: *IISR Chandra*
a. Yielding vine;
b. Long spike with bold berries and compact setting

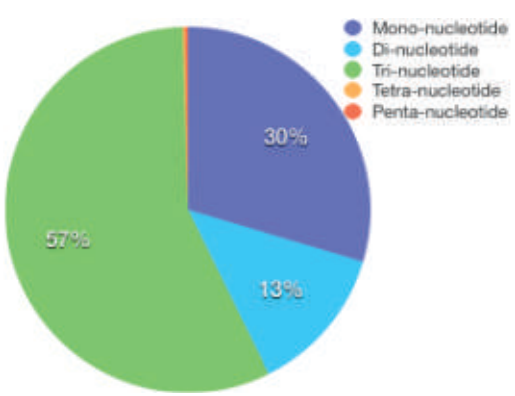


Fig. 3: Types of SSR motifs in the inferred protein-coding genes in black pepper genome

Identification of the heat shock transcription factor family genes

A total of 41 Heat Shock Transcription Factors (HSFs) family genes were identified in the *P. nigrum* genome through a genome-wide search and these genes were unevenly distributed on 19 chromosomes. Detailed annotation using the HEATSTER database for the different domains and motifs indicated that 19 belong to HsfA class, 21 belong to HsfB class, and one belongs to HsfC class. The Hsf genes in the same group had similar gene and protein structures with reference to HEATSTER database.

Impact of location on yield parameters

The yield characters such as number of spikes per 0.5 m^2, spike length, number of berries per spike and fruit set percentage was recorded in 30 black pepper plantations in Karnataka (Kodagu, Hassan and Chikmangalore districts) and Tamil Nadu (Valparai and Kulashekaram). The spike intensity, spike length, number of berries per spike and fruit set percentage recorded average values of 48.64, 12.81 cm, 57.14 and 66.91%, repectively per 0.5 m^2 canopy area. The values of spike intensity, spike length, number of berries per spike and fruit set percentage at the black pepper plantations in Tamil Nadu were observed to be 55.81, 9.81 cm, 49.74 and 73.36%, respectively per m^2 of canopy area.

Fertigation

The fertigation trials of seven years (2015-2023) indicated that providing drip irrigation @ 8 L per plant and application of 50 % of recommended dose of fertilizer (N:P:K 140:55:270 g /plant) in 24 splits (May, June, Sep, Oct, Feb, March) recorded maximum yield and profit with a BC ratio 2.59 (Fig. 4).

Chemo-diversity analysis of germplasm accessions

Fifty-six accessions maintained at CHES, Chettali were analyzed for their quality parameters. The piperine content ranged from 3.26 % (Acc. 4111) – 6.26 % (Acc. 1516); essential oil (EO) content from 1.33 % (Acc. 1516) – 4.0 % (Acc. 1411); oleoresin from 6.0 % (Acc. 1166) – 12.2 % (Acc. 1124) and the total phenolic content from 2.51 % (Acc. 1516) – 12.34 % (Acc. 1411).

Fig. 4. Black pepper fertigation field

Foot rot disease: Analyzing the virulence pattern of *Phytophthora* isolates

A study was undertaken to analyze the virulence pattern of *Phytophthora* species (*Phytophthora capsici*: 09-34, 09-41, 18-02 and *P. tropicalis*: 98-03, 98-02, 11-21) on several landraces *viz*., Uthirankotta, Kottanadan, Perumkodi, Narayakodi and Kalluvally. Among the *P. tropicalis* isolates tested, 98-02 was highly virulent on Kottanadan, Perumkodi, Narayakodi and Kalluvally and avirulent on Uthirankotta. The isolate 98-93 was avirulent on all the landraces. The isolate, 11-21 was avirulent on Uthirankotta, Kottanadan and Kalluvally. Among the *P. capsici* isolates, 09-34 was avirulent on Uthirankotta, Kottanadan and Narayakodi and highly virulent on Perumkodi and Kalluvally. The isolate, 09-41 was avirulent on Uthirankotta, Perumkodi and Kalluvally. However, 18-02 was avirulent on all the land races, except Kalluvally.

Cross-infectivity analysis of *Phytophthora* isolates

Sixteen isolates were used in cross-infectivity analysis under *in vitro* conditions. All the sixteen *Phytophthora* isolates tested were found to infect

nutmeg, tomato, chilli, pumpkin, cucumber, and a few of the isolates were found to infect cardamom (Fig. 5). However, none of the isolates were found to infect coconut, arecanut and vanilla.

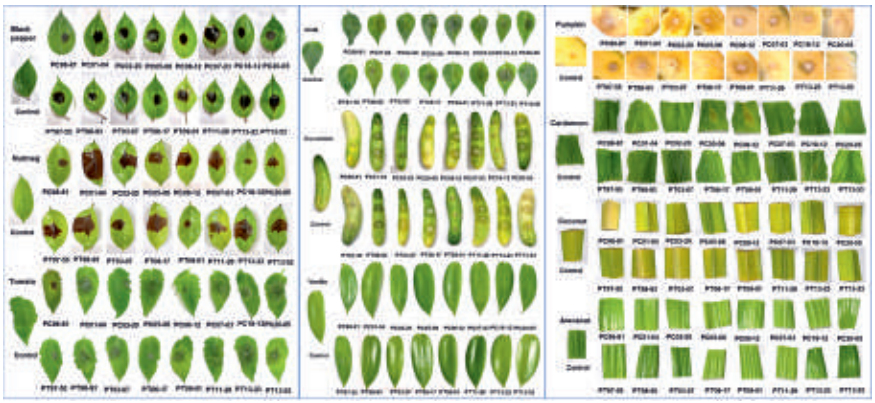


Fig. 5. Cross infectivity assay of *Phytophthora* isolates on nutmeg, tomato, chilli, cucumber, vanilla, pumpkin, cardamom, coconut and arecanut (PC and PT denotes *Phytophthora capsici* and *P. tropicalis*, respectively)

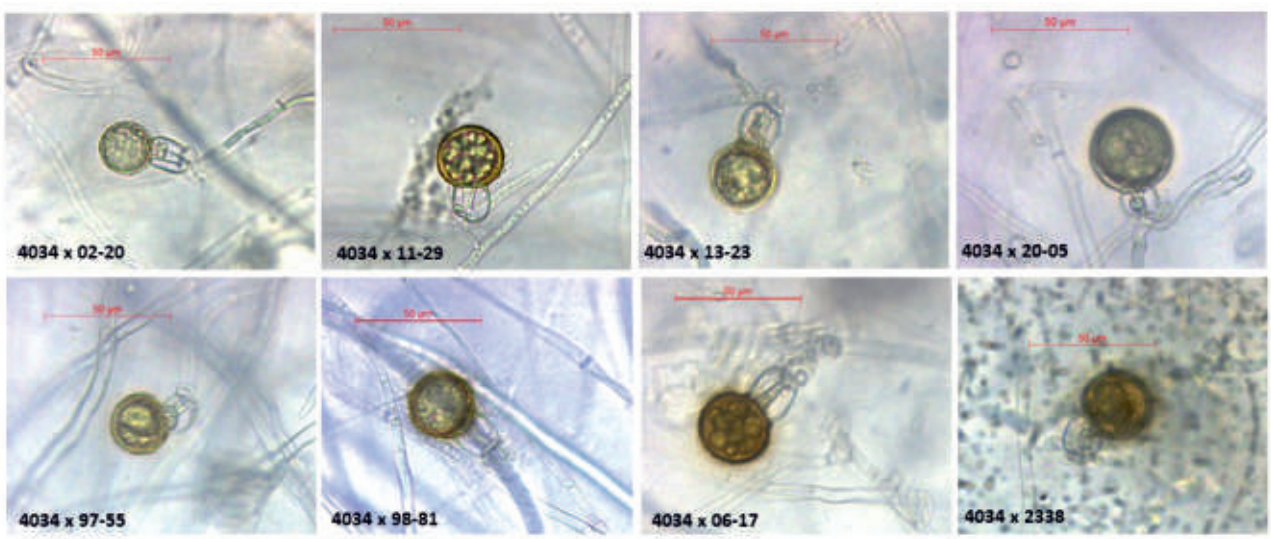


Fig.6 . Microscopic view of oospores produced in a pairing test with A2 reference isolate

Phytophthora mating type analysis

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 were used in pairing test with A1 (ATCC 2338) and A2 (ATCC 4034) reference isolates from ATCC. All the tested *P. capsici* and *P. tropicalis* isolates produced oospores when mated with an A2 reference isolate (ATCC 4034), which indicated that they belong to the A1 mating type (Fig. 6).

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

Sensitivity of selected isolates of *P. capsici* (05-06, 09-10, 09-34, 18-13, 20-04, 22-01, 18-02) and *P. tropicalis* (98-02, 98-93, 98-177, 11-21, 13-23) were tested against commonly recommended fungicides *viz.*, Bordeaux mixture, copper oxychloride and metalaxyl-mancozeb under *in vitro* conditions. The fungicides completely inhibited mycelial growth and significantly reduced the sporangial production of both *P. capsici* and *P. tropicalis* isolates at the recommended dosage. Among the two new molecules evaluated against *P. capsici* (05-06) and P. tropicalis (98-93), fluopicolide-fosetyl-Al and copper sulphate pentahydrate completely inhibited the mycelial growth at 0.3% and 0.5%, respectively.

Differential gene expression analysis of selected R x LR effectors and identification of host protein interacting with the R x LR effector protein

Differential expression of 11 R x LR effector genes during *P. capsici* infection was studied using a qPCR assay. Few R x LR effector genes were up-regulated at the early stage of infection (4 and 6 h after inoculation,). 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. Docking results confirmed that these two sets of proteins can interact with each other (Fig. 7).

Development of recombinase polymerase amplification-lateral flow assay (RPA-LFA) protocol for the detection of *Phytophthora* spp. and *Pythium* spp.

The RPA protocol with labelled primers was optimized for different concentrations of magnesium acetate (6, 8, 10, 12, 14 mM) and incubation time (5, 10, 20, 30, 40 min) to remove the non-specific band using healthy black pepper DNA as template. RPA-LFA was also optimized with different concentrations of betaine (0.6, 0.8, 1, 1.2, 1.4 M) and 1.2 M betaine was found optimum The developed RPA-LFA protocol was specific to *Phytophthora* and did not show cross-amplification of other pathogens like *Pythium* spp, *Fusarium* spp., *Colletotrichum* sp., *Rhizoctonia solani* and *Sclerotium rolfsii* (Fig.8). The assay was also validated using different isolates of *Phytophthora* and using infected black pepper leaves.

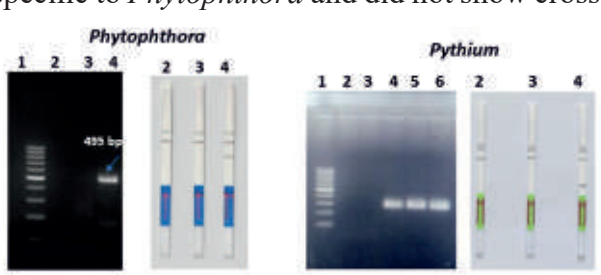


Fig. 8 RPA and RPA-LFA detection of *Phytophthora* and *Pythium* using optimized RPA-LFA conditions, Lane 1. 100 bp DNA Ladder, Lane 2. Water control, Lane 3. Healthy control, Lane 4. *Phytophthora*/*Pythium*, Lane 5. *Pythium*, Lane 6. *Pythium*

Production of recombinant protein-based antibodies against *Piper* yellow mottle virus (PYMoV)

The 303 bp region of the coat protein gene of PYMoV identified to give a good antigenic epitope, was cloned into the expression vector, pET28a+, and transformed into BL21 DE3. After confirming its orientation through sequencing, it was overexpressed using IPTG and the protein (13 kDa) was obtained in the insoluble phase. An IPTG concentration of 0.8 mM, temperature of 37 °C, and incubation time of 5 h, was found to be optimum for expression. The recombinant protein was purified under denaturing conditions using a Ni NTA column, renatured and used for antiserum production in rabbits. The antiserum collected on five, seven, and nine weeks after the first immunization showed a specific reaction against the PYMoV antigen and could be used to detect the PYMoV both in ELISA and western blotting.

Development of duplex recombinase polymerase amplification-lateral flow assay (RPA-LFA) for detection of PYMoV and cucumber mosaic virus (CMV)

Duplex recombinase polymerase amplification-lateral flow assay (RPA-LFA) for the detection of PYMoV and CMV was developed using TwistAmp DNA amplification reagents and total RNA isolated from the infected plant as a template. The forward and reverse primers specific for PYMoV were labelled with FAM and biotin and those for CMV were labelled with FAM and digoxigenin respectively at the 5′ ends.

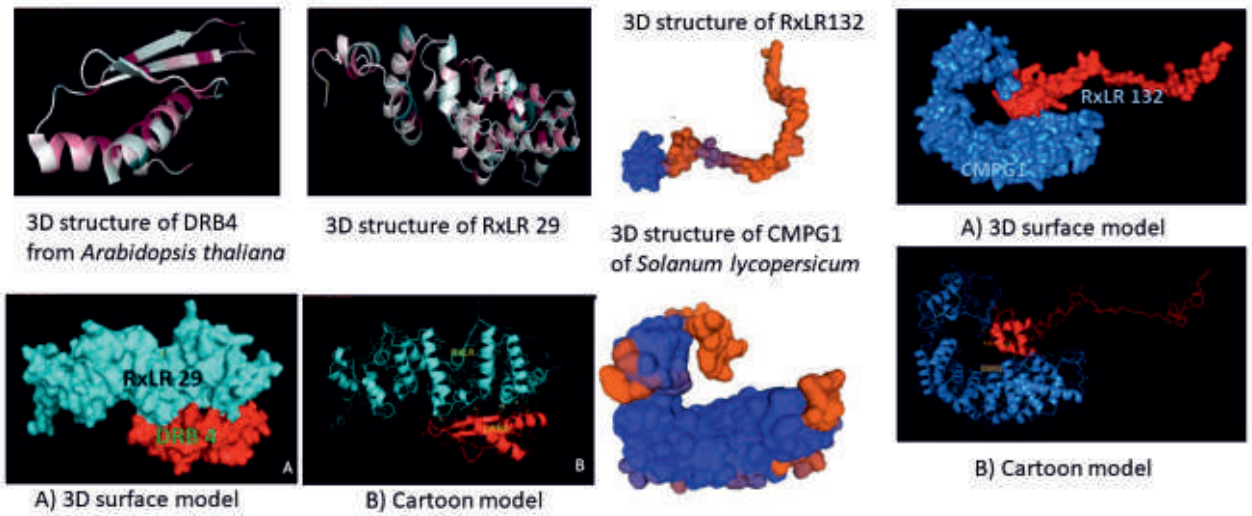


Fig. 7 Interaction of RxLR protein of *Phytophthora* with host proteins

The assay was optimized for parameters like concentration of magnesium acetate, betaine, temperature, and time. The formation of a coloured line at the digoxigenin test line and at the biotin test line was considered positive for CMV and PYMoV, respectively. The formation of the coloured line at the control line indicated method control. Thus, the coloured lines produced in both biotin and digoxigenin test lines indicated that the sample is infected by both viruses (Fig. 9). The detection limit of RT-RPA-LFA for the combined detection of both PYMoV and CMV was 10^{-2} dilution of the template RNA. The assay will be useful to identify virus-free mother plants.

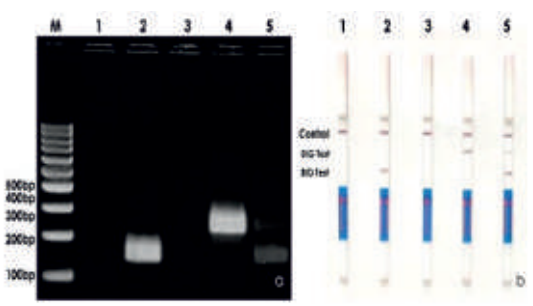


Fig. 9. Detection of PYMoV and CMV by duplex RT-RPA (a) and RT-RPA-LFA (b). Lane M: 100 bp ladder. Lane 1: negative control for PYMoV, Lane 2: PYMoV-positive control, Lane 3: negative control for CMV, Lane 4: CMV-positive control, Lane 5: PYMoV and CMV combined infection-positive control

Development of duplex recombinase polymerase amplification-lateral flow assay (RPA-LFA) for detection of PYMoV and cucumber mosaic virus (CMV)

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Management of *Radopholus similis*

Fluopyram 34.48SC was evaluated for the management of *R. similis* under field conditions. The different treatments included fluopyram 0.5ml/L, fluensulfone 20g/plant, carbosulfan 2ml/L (reference control) and absolute control (without treatment). Fluopyram and carbosulfan were applied as drench, while fluensulfone was broadcasted in the rhizosphere around the vine. The highest nematode reduction was recorded with fluopyram treatment. Pre- and post-monsoon application of fluopyram reduced nematode population by 95% compared to single application.

Screening of new generation low-risk insecticides against pollu beetle

Low-risk insecticides such as chlorantraniliprole, flubendiamide and spinetoram at two doses (0.3 & 0.5 ml/L) along with quinalphos (2 ml/L) as control were evaluated for their efficacy against pollu beetle, *Lanka ramakrishnai* under field conditions for the second consecutive year. Among the insecticides, chlorantraniliprole was found to be more effective in managing the pest.

Evaluation of low-risk insecticides against root mealy bug *Planococcus lilacinus*

Five low-risk insecticides *viz*., clothianidin, spiromesifen, flonicamid, spirotetramat, triflumezopyrim and thiamethoxam were evaluated for the management of root mealy bug under field conditions. 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%). Similarly, on the 40th day after drenching, the reduction in population of mealybugs was high with the application of spiromesifen 22.9 SC @ 1ml/L (92.2%), which was followed by clothianidin 50 WDG @ 1ml/L (89.8%) and spirotetramat 15.31 OD @1ml/L (84.8%).

CARDAMOM

Genetic resources

Six hundred twenty-eight accessions are being maintained in the National Active Germplasm Site (NAGS) of IISR, Regional Station, Appangala, which consist of 423 accessions from RS, Appangala; 102 accessions from CRC, Pampadumpara; 41 from ZAHRS, Mudigere, 59 from ICRI, RS, Sakaleshapura and 3 from ICRI, Myaldumpara. Seven distinctive accessions (CRSP85, CRSP86, CRSP87, CRSP88, CRSP89, CRSP156 and CRSP185) were submitted by the Cardamom Research Station (Kerala Agricultural University), Pampadumpara to NAGS.

Sixty accessions have been characterized based on morphological traits and yield parameters. The plant height, number of bearing tillers, number of leaves, number of panicles, number of capsules per plant were recorded. The highest fresh and dry weight (2094.80 g and 416 g, respectively) were recorded in the accession IC 547196. Essential oil content of 60 m accessions ranged from 6.11 % (IC 349508) to 8.96 % (IC 349426) and oleoresin content ranged from 2.30 (IC 547149) to 4.24% (IC 547204).

Hybridization

Hybridization was carried out between four female parents (Appangala–1, IISR Avinash, *Njallani* green gold and IC 584058) and four male parents (IC 349606, IC 547167, IC 349364 and IC 349358). From these cross combinations 80 hybrid progenies were developed.

CVT on farmers varieties

CVT on farmer's varieties *viz*., Arjun, Wonder Cardamom, Panikulangara green bold no.1, Thiruthali, Elarajan, Pachaikkai, Pappalu, Njallani green gold, PNS Gopinath supplied by

National Innovation Foundation (NIF) and a local check variety Appangala-1 was carried out. The pooled data of three years (2020-21 to 2022-23) revealed that Panikulangara Green Bold No. 1 (301.65 kg/ha) recorded the highest yield followed by Thiruthali (273.86 kg/ha).

CVT on hybrids

The CVT on nine hybrids *viz*., Bold × IC 547219, (GG×Bold) × Appangala 1, (GG×NKE 19) × Bold from ICAR-IISR RS, Appangala; MHC-1 & MHC-2 from ICRI, Myladumpara; SHC-1 & SHC-2 from ICRI RS, Sakaleshapura and PH-13 & PH-14 from Pampadumpara is under progress (Fig. 10). During 2023-24, hybrid Bold × IC 547219 recorded the highest fresh weight (1.71 kg/plant) as well as dry weight (0.32 kg/plant).

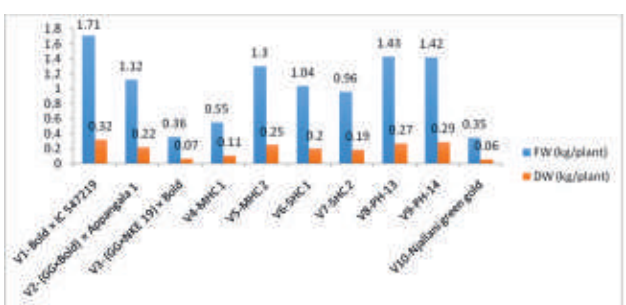


Fig.10: Fresh and dry yield per plant (kg) from different hybrids multilocation trial on leaf blight tolerant lines

Multilocation trial is in progress 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. Disease incidence (%) ranged from 11.66 to 23.33, with maximum disease incidence in IISR Vijetha.

Registration of unique germplasm

Cardamom germplasm line IC 584058 (INGR23102) has been registered by Plant Germplasm Registration Committee (PGRC) of ICAR on 22 November, 2023 (Fig.11). It is a compact flowering genotype with bold capsules (80% of the capsules are >7mm) and is relatively tolerant to moisture stress.


Certificate
Plant Germplasm Registration

It is certified that germplasm IC584058 (CRC 436/ APG 474) of Lesser Cardamom (INGR23102) developed by

SJ Ankegowda, KS Krishnamurthy, Alagupalamuthirsolai M, Sivaranjani R, Mohammed Faisal P, Shivakumar MS, Akshitha HJ, Honnappa Asangi, Balaji Rajkumar M and Biju CN
ICAR-IISR Regional Station, Appangala, Karnataka

has been registered by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on November 22, 2023.

Member-Secretary
PGRC

Chairman, PGRC
DDG (CS) ICAR

Fig.11: Plant Germplasm Registration Certificate

Development of RPA-LFA assay for cardamom mosaic virus (CdMV)

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 CdMV using crude extract from the plants. The entire RT-RPA-LFA from sample preparation to visualization of results could be completed within 40 min and the assay is suitable for point-of-care testing. The assay was validated using field samples collected from different cardamom-growing regions of Kerala and Karnataka.

Dose-response effects of arbuscular mycorrhizal fungi (AMF) for enhanced plant growth and nutrient uptake

Effect of different doses (5, 10, 15 g) of AMF (*Rhizophagus irregularis*) at different application intervals was studied on the growth, mycorrhizal colonization, nutrient uptake and disease incidence of seedlings for two years.The results showed that the shoot length and dry weight were significantly increased with 10 g of AMF. Three

applications of 5 g each were sufficient to improve the number of fibrous roots. While K uptake was unaffected by AMF inoculation, P and Ca uptake was highest with a 10 g dose. AMF inoculation also enhanced acid and alkaline phosphatase activity in the rhizosphere with 5 and 10 g doses, respectively. AMF structures, including hyphae, arbuscules, and vesicles were observed in the roots of inoculated seedlings.

Spray schedule optimization of low-risk insecticides against shoot and capsule borer

Field trial with two different spray schedules (1. Jan-Feb, Mar-April, Sep-Oct and 2. Feb-Mar, Sep-Oct) was initiated for three low-risk insecticides (spinosad, flubendiamide, chlorantraniliprole) and a neem based botanical insecticide with a standard check (quinalphos). Both the spray schedules were effective in reducing the shoot and capsule damage. The mean shoot damage recorded in chemical treatments ranged from 0 to 2.64%, whereas, in the case of neem-based insecticide, the shoot damage was in the range of 1.3 to 4.24%. In untreated control, up to 14.0% shoot damage was recorded.

Cardamom and black pepper flavored millet cookies

Standardization of spice contents in millet-based cookies was carried out and physical, biochemical and microbial quality were evaluated under MAP (Modified Atmosphere packaging) in two different packaging materials (Biaxially oriented polypropylene (BOPP) and metallized polyester). The metallised polyester package was found to be the best packaging material for spice flavoured millet cookies with a shelf life of 120 days (Fig. 12 a, b).

Fig. 12 a. Cardamom flavoured millet cookies

Fig. 12 b Black pepper flavoured millet cookies

GINGER

Genetic resources

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

Genetic fidelity of *in vitro* induced micro rhizomes

In vitro induced micro rhizomes were screened using SSR and ISSR markers and compared with the mother plant, various stages of subcultures (5-

8) and subsequent generations (V1 and V2). Five SSR primers (ZOC 11, ZOC 28, ZOC 92, ZOC 98, ZOC 100) and five ISSR primers (IS 02, UBC 813, UBC 840, UBC 857, ISSR 02) were used for the study. A total of 343 bands were produced, with sizes ranging from 100-3100 bp. Comparison of two generations of progenies of micro rhizomes with mother plant and *in vitro* subculture stages revealed monomorphic nature and true-to-type status of micro rhizome derived plants under *in vitro* as well as in field conditions. This protocol will be very useful for micro-propagation, germplasm conservation and genetic transformation studies in ginger and related species.

Effects of Nano Urea on N use efficiency and increased productivity

Application of nano urea as foliar spray @ 0.4 % combined with 50 % N as RDF increased the yield and use efficiency of applied N with good monetary returns. 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. There was no effect of nano urea on the quality as there was no increase in its essential oil or oleoresin contents. Spray of nano urea @ 0.4 % as additional supplementation over the farmers practice also resulted in 15 % increased yield.

Transcriptome analysis

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. Out of these 227 transcripts, there were 36 transcription factors, 6 kinases, 10 structural RNAs, 69 enzymes of various metabolic pathways and 109 other proteins.

Trial on disease tolerance

Ten entries (five from IISR, 3 from Pottangi, 1 from Raigarh, one control) were evaluated for three years. Based on the pooled data R 1.25/4 (mutant from IISR) recorded highest yield of 37.85 t/ha which was on par with V1E4 (Pottangi) (36.60 t/ha).

Modes of survival of bacterial wilt pathogen, *Ralstonia pseudosolanacearum*

On rhizomes, *Ralstonia pseudosolanacearum* formed microcolonies or co-aggregates 2 h post incubation and biofilm formation was noticed 3 h after incubation on the rhizome scales. Among the common weeds found in bacterial wilt sick plot, association of *R. pseudosolanacearum* with *Chromolaena odorata* (*Eupatorium odoratum*) was confirmed through artificial inoculation.

Identification and evaluation of potential bacterial endophytes from wild relatives for biocontrol

Endophytic bacterial colonies were isolated from the rhizome, stem, and leaves of seven different crop wild relatives of ginger. Screening for antifungal capabilities against *Pythium myriotylum* and *P. deliense* was conducted by dual culture assay. Out of the 50 isolates, 30 showed > 50% inhibition against *P. myriotylum*, and 12 isolates showed more than 85% inhibition against *P. deliense*. The methanolic crude extracts from the selected endophytic bacterial extracts showed complete inhibition of *P. myriotylum* at 40% concentration. Additionally, the growth of *P. deliense* was entirely inhibited at extract concentrations ranging from 80% to 90%. These promising isolates were identified as *Bacillus amyloliquifaciens* (ZM5), *B. velenzensis* (ZZ11), *Pantoea hercicii* (NCC7), *Priestia megaterium* (NCC4), *Pseudacidovorax intermedius* (NCC15).

Development of a linear model for leaf spot for high altitude and high rainfall regions of Kodagu

A linear regression model using R statistics for early prediction was developed. Correlation analysis revealed a positive link between PDI and rainfall, rainy days, and a negative correlation with temperature. Mean Percent Disease Index (PDI) ranged from 0.37% to 35.53%. IISR Rejatha had the highest disease incidence (35.55%) in September, contrasting with IISR Varada, lowest at 26.85%. Maximum Area Under Disease Progress Curve (AUDPC) occurred in IISR Rejatha (456.7) in August, opposite to PDI's peak in September. The study concludes that disease peaks during the monsoon and diminishes post-monsoon with rising temperature after September.

Root-knot nematode (*Meloidogyne incognita*)

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

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. Three insecticides (chlorantraniliprole, spinosad and lambda cyhalothrin) and a neem product in combination with a liquid formulation of *M. pingshaense* 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.

Lac resin-based coating for fresh rhizome storage

The experiments on coating of fresh rhizome to enhance the shelf life, using the lac resin based edible coating solution (20% formulation) developed at ICAR- National Institute of Secondary Agricultural (ICAR-NISA), Namkum, Ranchi coupled with sterilization using sodium hypochlorite revealed that the fresh rhizomes can be stored at 20°C up to 4 months with market acceptable traits. Reduction in weight loss and sprouting, minimum shrivelling and retention of essential oils were observed (Fig. 13).

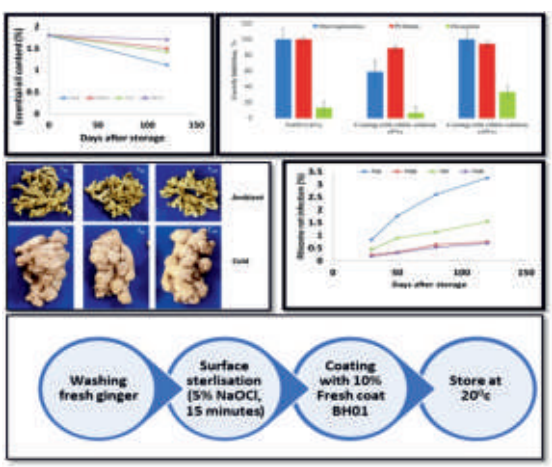


Fig. 13 Effect of lac resin-based coating on fresh ginger rhizomes

Ginger-lime juice powder

The operating conditions for the production of spray dried ginger-lime juice powder was optimized using response surface methodology (Fig. 14). Optimized conditions of 26.91 % maltodextrin level, 156.1°C inlet air temperature and 2207.6 rpm blower speed resulted in maximized encapsulation yield of 66.64 %.

Fig. 14 Ginger lime juice powder and rehydrated juice

MANGO GINGER

Based on the three-year coordinated varietal trial (CVT) on mango ginger, Acc. 347 recorded the highest average yield of 31 t/ha and a potential yield of 45.75 t/ha. 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%. Based on its performance, Acc 347 has been recommended for cultivation in all mango ginger growing areas of India by the All India Coordinated Research Project on Spices (AICRPS) and was christened as IISR Amrit (Fig. 15).

Fig. 15 Rhizomes of IISR Amrit (Acc. 347)

TURMERIC

Total of 1404 *Curcuma* spp. germplasm accessions are being maintained at ICAR-IISR. Among them 1132 are turmeric accessions, which have been characterized for morphological, rhizome characters and 817 accessions were characterized for quality characters.

CVT on high yield and high curcumin

Eleven entries (one from IISR, 2 from TNAU, 2 from Pottangi, 1 from Raigarh, 2 from Navasari, three control) were evaluated for two years. In the second year (2022-23) CL 272 (23 t/ha) and the two check varieties (IISR Pragati, IISR Prathibha) recorded high yield.

CVT on light yellow colour turmeric for specialty market

Eleven entries (five from IISR, 2 from TNAU, 1 from Pottangi, 1 from Kammarpally, two control) were evaluated for two years. In the second year (2022-23), Acc 849 recorded highest yield of 36.17 t/ha followed by Acc. 1545 (31.17 t/ha).

Flow Cytometry ploidy study

Among 92 turmeric genotypes studied, 83 were triploids and nine were tetraploids. Significant difference in plant height, number of shoots, petiole length, leaf length, length of mother rhizome, length of primary rhizomes, length of secondary rhizomes, girth of secondary rhizomes, inner core diameter of primary rhizome, weight of mother rhizomes, weight of primary rhizomes, total fresh yield of rhizome per plant and dry yield of rhizome per plant between triploid and tetraploid genotypes was observed among the genotypes (Fig. 16).

Evaluation of extra-long and bold turmeric lines

Thirteen accessions of Salem Local (Erode and Salem district of Tamil Nadu) and seven accessions of Mydukkur (Andhra Pradesh) were evaluated for yield and rhizome characters. Maximum yield (pooled) was recorded in SL5 (11.88 kg/3m^2) followed by SL3 (11.38 kg/3 m^2).

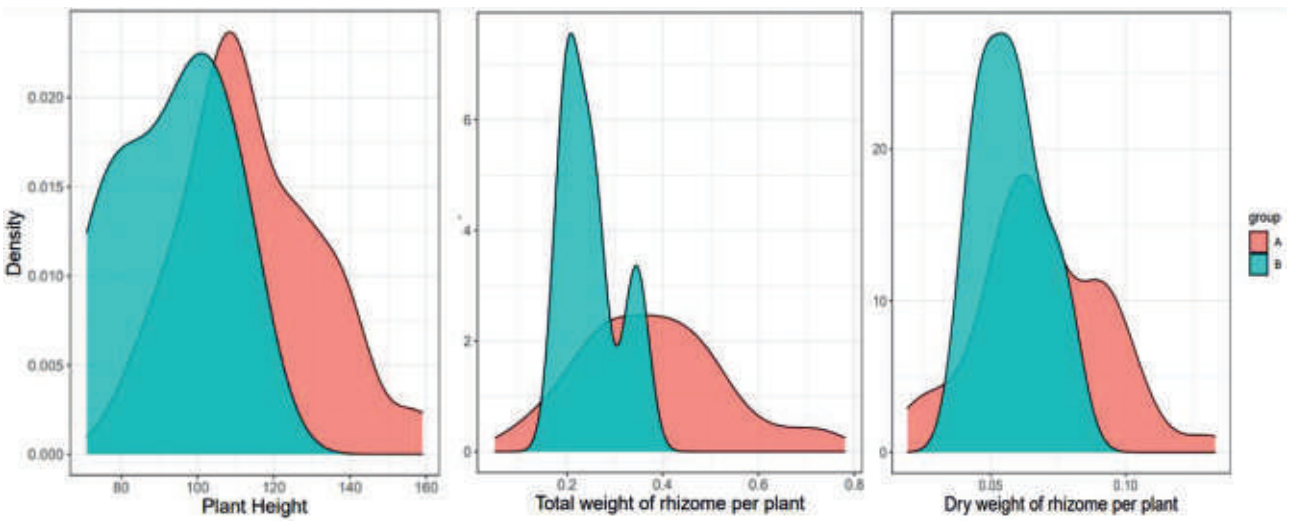


Fig. 16 Density plot summarises the trait variation in triploids (group A) and tetraploids (group B)

Evaluation of seedling progeny

Seedling progenies, somaclones and inbreds (113 Nos.) were evaluated in mini beds for yield and quality traits in augmented design. Among them, three accessions (69/5/22/$I_1$9/$I_2$1, 69/5/22/ $I_1$9, 69/5/22/ $I_1$9/ $I_2$4) produced high fresh rhizome yield per plant (>450 g/plant).

Response of genotypes for yield and quality under different production systems

A trial was taken up to study the response of genotypes for yield and quality under vertical structures, greenhouse growing conditions and field conditions. Fresh rhizome yield was maximum under greenhouse conditions followed by field conditions. IISR Pragati>Rajendra Sonali>NDH 8>CO-3 (>800 g/plant) performed better under greenhouse conditions. CIM Pitambar followed by IISR Pragati was found to be best under vertical structures. Among three environments, greenhouse conditions were found to be best for fresh yield and recovery of cured turmeric.

Site suitability analysis in Kerala for 2050 under various SSP scenarios

Present and future suitability of turmeric cultivation within the humid tropical region of Kerala, India was evaluated using advanced geospatial techniques. Presently, in Kerala, 28 % of area falls under highly suitable; 41% of area falls under moderately suitable and 11 % falls under not suitable for turmeric cultivation (Fig. 17). However, considering the projected scenarios for 2050 under the share socioeconomic pathway framework, there will be a 19% decrease in highly suitable area for cultivation.

Effect of Nano Urea on N use efficiency and increasing productivity

The first-year study showed that foliar supplementation of nano urea combined with 50 % RD of N did not produce encouraging results in terms of rhizome yield, as compared to 100 % RDF as soil application which recorded highest rhizome yield. Unlike yield, the quality in terms of curcumin content increased significantly with nano urea supplementation @ 0.2 %. The results showed that using lower rates of nano fertilizers (0.2 %) as foliar application proved to be an eco-friendly alternative with sustainable productivity.

Organic farming

Under Network Project on Organic Farming eleven varieties of turmeric were tested under

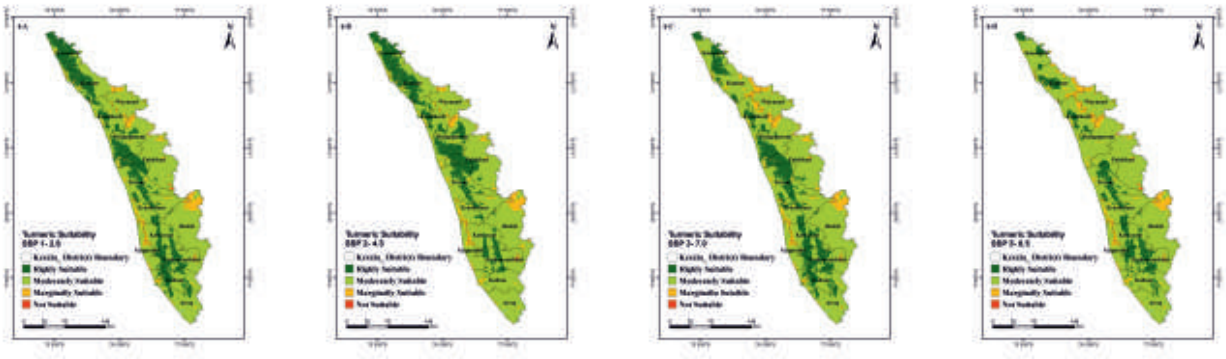


Fig. 17 Turmeric suitability map of Kerala for 2050 under different SSP scenarios

five treatments *viz*., organic 100%, organic 75%, INM (75% org + 25% chemical), INM (50% org + 50% chem) and 100% chemical for yield and quality. The soil pH, available P, Ca, Mg, Zn and Cu were significantly higher in 100% organic on par with 75% organic followed by integrated nutrient treatments (75+25% and 50+50%) over 100% inorganic management. Significant activities of acid and alkaline phosphatase were higher under organic and that of dehydrogenase was higher in integrated (50+50%) management systems. Significantly higher fresh rhizome yield was recorded in integrated (75:25 & 50:50) (23.5 t/ha) nutrient managements as compared to 75% organic (20.5 t/ha) and inorganic (18.1 t/ha). Among the varieties, Pragati, recorded significantly highest yield (40 t/ha) followed by Suguna and Sudharsana under integrated 50+50 management. Under 100% organic management also var. IISR Pragati yielded highest fresh rhizomes (29.1 t/ha) followed by Suguna (26 t/ha) as compared to other varieties and highest benefit cost return (2.80) was observed for these varieties under organic management. Geo tagged characterization of four organic and natural farming farmers of Kannur District was carried out.

Weed management practices under organic production

Results of three-year experiments on weed management (2020-2023) revealed that application of dried coconut leaves @ 5400 kg/ha effectively controlled the weed growth in under organic management. The B: C ratio of 1.97 and net return of Rs 2.81 lakhs were obtained with this practice of weed management.

Integrated organic farming system model for small and marginal farmers

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 is Rs 2.57 lakhs per acre.

Natural farming

Complete natural farming package which includes seed treatments with Beejamrit, and application (soil drenching) of Jeevamrit & Ghanajeevamrit at monthly intervals to plants till 120 DAP, intercropping with cowpea and residue mulching and *whapasa* was taken up in the variety Prathibha. Natural farming practices recorded maximum content of curcumin (5.3 %) and essential oil (4.6 %) whereas maximum oleoresin was noticed in AI-NPOF package.

Chemo-profiling of essential oils of *Curcuma* species

The chemical composition of the volatile components of rhizomes and leaves of three *Curcuma* species was determined. The 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. The *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%). Dominant components of *C. caesia* rhizome oil were curzerenone (22.5 %), furanogermenone (9.2 %), 1,8-cineole (9.4 %) β-elemene (5.7 %) and curzerene (5,8 %), while the major constituents of leaf oil was furanodienone (15 %), curzerenone (11.5 %), furanogermenone (9.4 %) and curzerene (5.7 %).

Antioxidant potential of *C. caesia*

Antioxidant potential of the compounds *viz*., 1, 8-cineole, camphor, 4-terpineol, linalool, borneol, isobornyl acetate, eugenol and their combinations were evaluated by DPPH free radical scavenging assay. The results revealed that eugenol, a minor component of the essential oil, possessed promising antioxidant potential with IC50 value of 140 µg/mL.

Encapsulation of spices extract using ionic gelation

The turmeric extract (T1- 0.05 %; T2 - 0.1 %; T3 - 0.15 %) was encapsulated with sodium alginate and the resultant calcium alginate beads were characterized for its encapsulation efficiency and *in vitro* release capacity (Fig. 18). The size of the beads was higher in control samples followed by beads prepared in chitosan (1 %). efficiency (EE %) in terms of curcumin was found in the sample encapsulated with 0.15 % turmeric with 1.0 % chitosan. The highest release of curcumin from beads was observed in the sample prepared with 0.5 % chitosan with 0.15% turmeric extract at 5th hour of incubation in phosphate buffer pH 7.0 (Fig. 19).

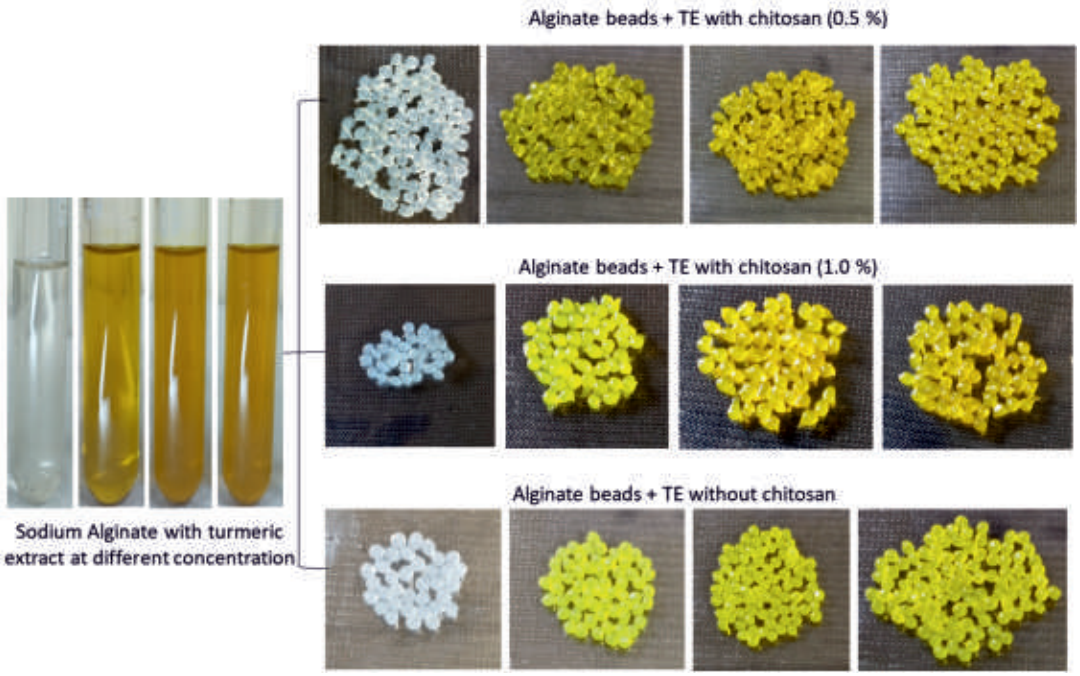
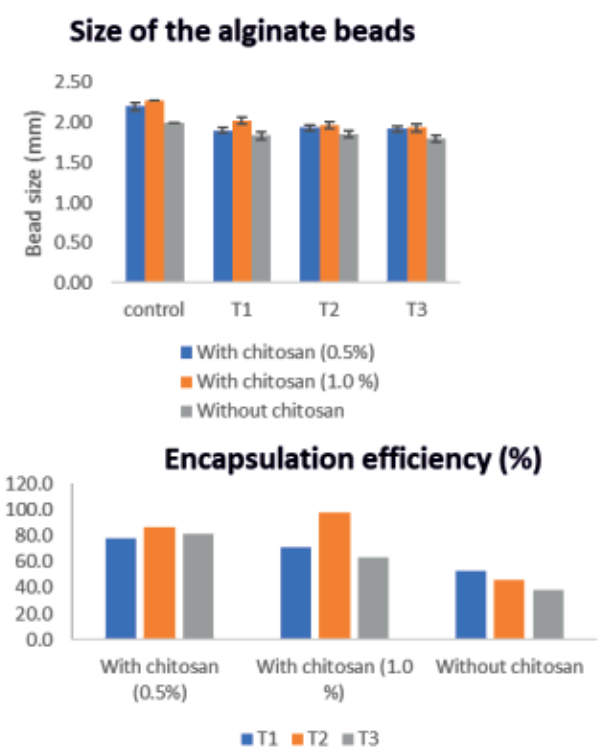


Fig 18. Encapsulation of turmeric extract in calcium alginate beads with or without chitosan



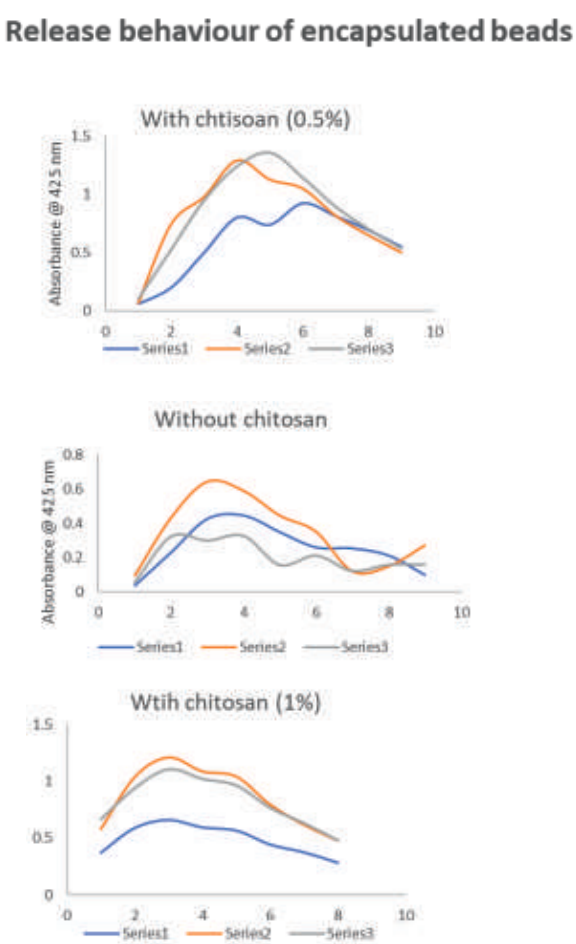


Fig. 19 Characterization of turmeric extract encapsulated calcium alginate beads

Methodology for identifying adulteration in spice essential oils using optical properties

A non-chemical method for detection of adulteration in spice essential oil using optical property was developed. Difference in the specific rotations due to adulteration was compared with specific rotation of pure oils and the extend of adulteration was detected. The study was successful in differentiating the adulterants in two cases viz. a) Turmeric rhizome oil with turmeric leaf oil (adulterant) and b) Cinnamon bark oil with cinnamon leaf oil (adulterant) (Fig. 20 a,b). Therefore, this method can be adopted as a confirmatory method for rapid detection of oil adulteration in spice essential oils with high efficiency and accuracy.

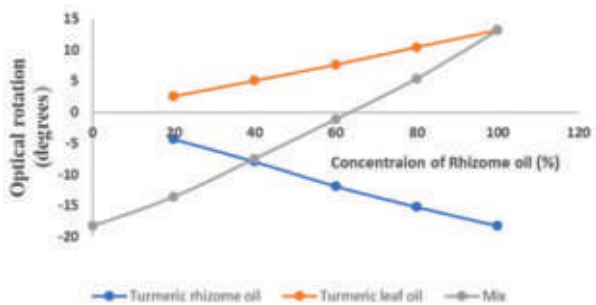


Fig. 20a Effect of mixing turmeric rhizome oil with varying degree of turmeric leaf oil

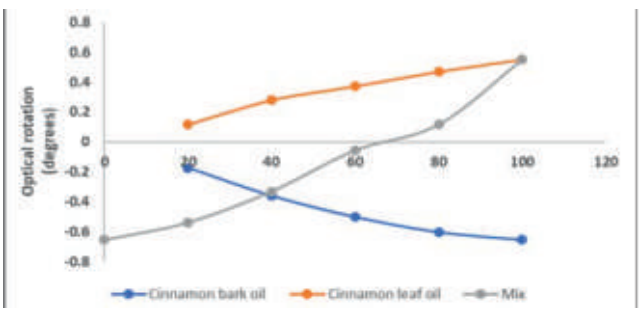


Fig. 20 b Effect of mixing cinnamon bark oil with varying degree of cinnamon leaf oil

Categorization of genotypes based on reaction towards leaf blotch (*Taphrina maculans)*

Among the 187 genotypes screened, the seedling progenies RRN 2, RRN 1, RRN 3, RRN 4, SL 3, SL 5, SL 9, SL 8, SL 6, SL 4, SL 2, SL 14, Mydukur 8/16, MK 1, MK 3, MK 4, MK 7, 69/5/22/$I_1$1, 69/5/22/$I_1$2, 69/5/22/$I_1$3, 69/5/22/$I_1$4, 69/5/22/$I_1$5, 69/5/22/$I_1$6, 69/5/22/$I_1$7, 69/5/22/$I_1$8, 69/5/22/$I_1$9, 69/5/22/$I_1$10, 69/5/22/$I_1$11,69/5/22/$I_1$12, BSR White and SLP 389/1 were found to be resistant to leaf blotch.

Lesion nematode (*Pratylenchus* sp.)

The population dynamics study revealed that the highest population of *Pratylenchus* sp.was during November while no population was recorded in the months of February to May. The interaction study between *Pratylenchus* spp and the oomycete (*Pythium*spp) carried out through pot culture 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)*

It was observed that in early planted crop (May), the incidence of the pest was first observed in the third week of July (i.e. about 75 days after planting) and the infestation reached its peak during last week of September. Whereas, in the case of normal planting (June), the incidence of the pest was first noticed during the third week of July (i.e. about 45 days after planting) and the peak infestation was noticed during last week of October.

VANILLA

Conservation

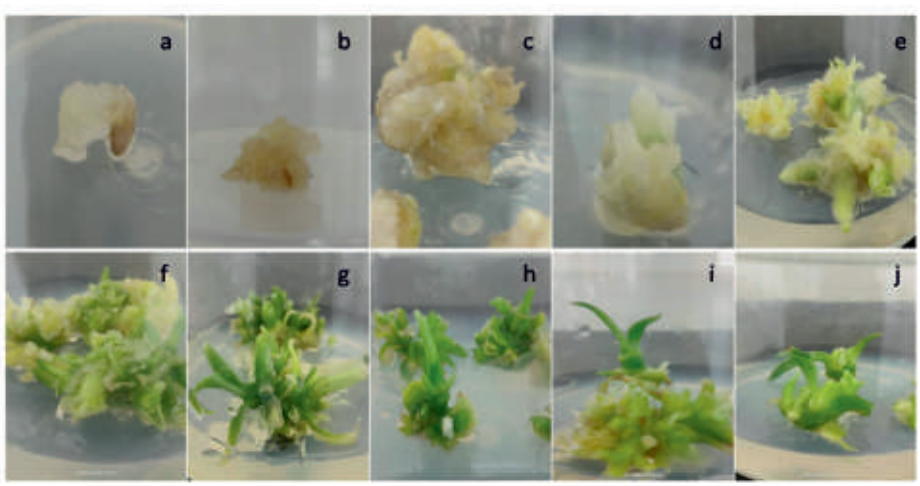
A total of 77 accessions (65 *Vanilla planifolia* and 12 *Vanilla sp*) are being conserved in the germplasm repository. Based on preliminary germplasm evaluation Acc. 4766 recorded fresh weight of 32.37g with maximum length of 21.33 cm.

Molecular characterization

Twenty-two genotypes comprising of Vanilla accessions (11), Andaman collection (2), Wayanad collection (2) and other *Vanilla* spp. (7) were characterised using 11 SSR markers. The similarity coefficients based on SSR markers ranged from 0 to 0.80. The genotypes Acc. JPN 20-69 and Acc. JPN 20-58 had maximum similarity (0.80). Low similarity was observed between *V. tahitensis* and three genotypes (Acc. 4795, Wayanad collection 2 and *V. wightiana*) and between *Vanilla sp.* and three genotypes (Acc. 4795, Wayanad collection 2 and *V. wightiana*).

In vitro seed germination

The seeds of 150 day old beans were extracted and cultured in different media compositions. A protocorm like bodies (PLBs) were formed in the cultures with BM^{-1} orchid medium+ 2,4-D (2 mg L^{-1}) (Fig. 21). These PLBs were inoculated into different media combinations maintained both under light and dark conditions. BM^{-1} orchid medium supplemented with growth regulators like BAP (1 mg L^{-1}) + NAA (0.5 mg L^{-1}) under dark conditions regenerated into more shoots (5.2), whereas the same media without any growth regulators maintained under light got regenerated into more roots (4.6).



a. Germination of seeds into protocorm like bodies (PLBs)
b.Formation of embryogenic callus from PLBs
c. Multiplication of embryogenic callus
d. Formation of green structures
e. Induction of shoot primordia
f. Multiple shoot formation
g. Formation of leaves
h. Induction of roots
i. Elongation of roots
j. Enlargement of leaves

Fig.21 Plant regeneration from protocorm like bodies (PLBs)

TREE SPICES

NUTMEG

Collection of wild *Myristica* sp.

A wild species of *Myristica*, *M. magnifica* was collected from the sacred grove, Vallikkattukavu, at Chellannur, Kozhikode and also from the *Myristica* swamps at Sasthanada, Kulathupuzha, Kerala (Fig. 22). *M. magnifica*, is one of the dominant species of *Myristica* swamps and have stilt roots that support the tree (Fig. 23). These roots emerge from the base of the main trunk and bend downwards to reach the ground. The stilt roots form a tangled network of roots around the tree. These swamps are water-logged for a large part of the year between June and December, and hence *M. magnifica* offers tolerance to water logging conditions.

Fig. 23 *M. magnifica* at Kulathupuzha

Fruit

Seed with aril

Hybridization

Hybridization was attempted in nutmeg using high yielding varieties as female parent and monoecious lines as male parent. 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.

Microwave pre-treatments on drying of mace

Effect of microwave pre-treatments on mace were studied under microwave power levels of 160, 320 and 480 W for an exposure time of 1 min. The drying time of the mace was reduced by 18.2, 27.3 and 36.4 % at microwave powers of 160, 320 and 480 W respectively. Microwave at optimal power of 320 W was found to have better retention of essential oil, oleoresin and colour of dried mace (Fig. 24).

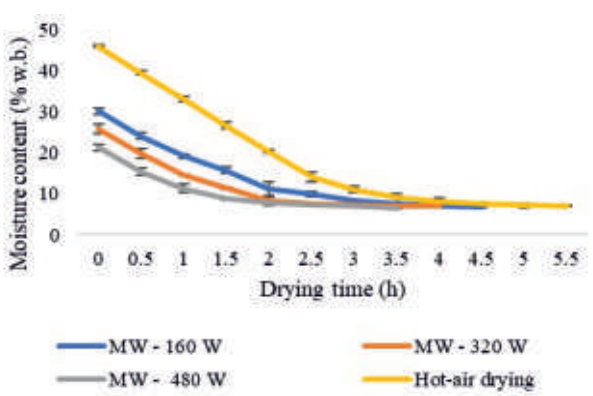
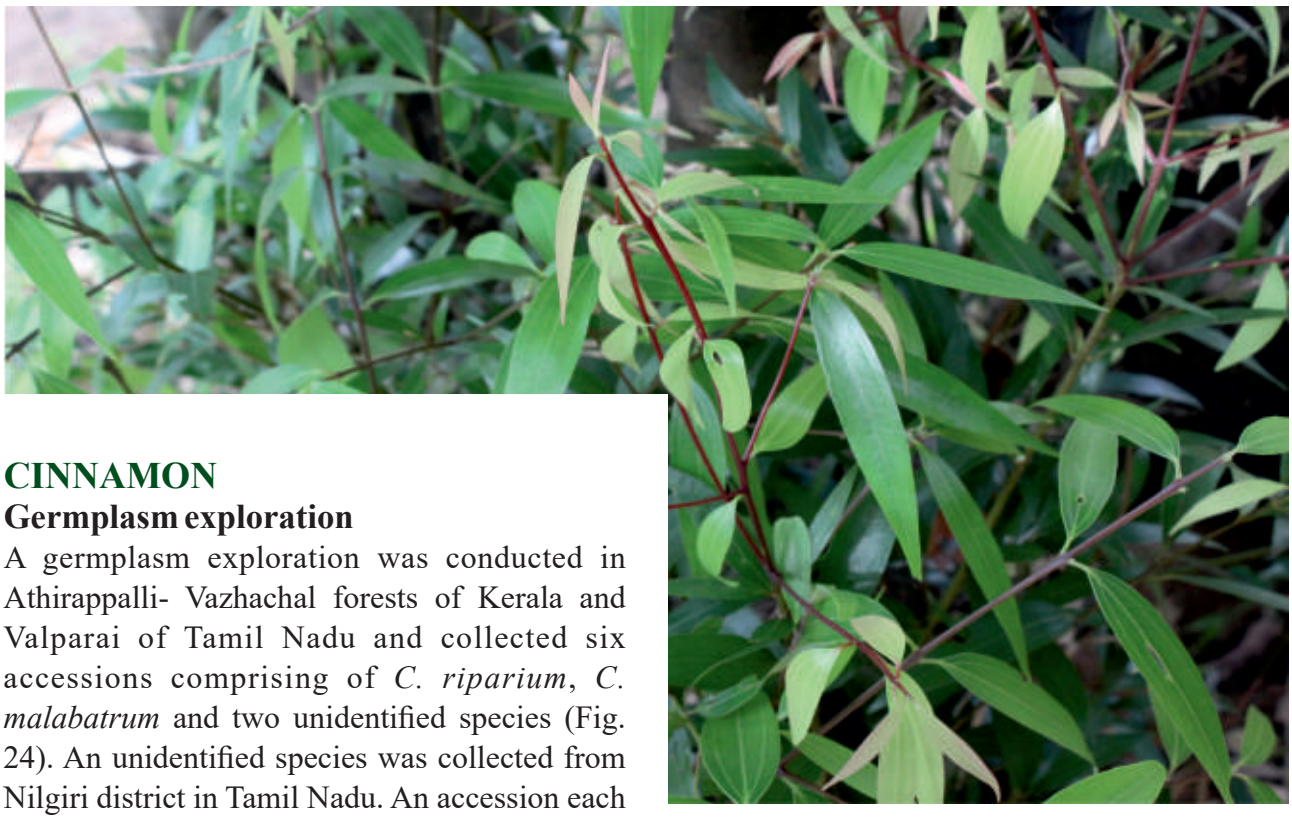


Fig. 24 Drying time versus moisture content for drying of mace

Development of eugenol infused membrane for packaging chilli and nutmeg and its evaluation

Preparation and characterisation of chitosan-based packaging film for slow release of eugenol was carried out and functional properties of the film were studied. Addition of clove oil to chitosan was found to enhance its anti-microbial and antioxidant potential, increase total phenol content, improve barrier and mechanical attributes.



CINNAMON

Germplasm exploration

A germplasm exploration was conducted in Athirappalli- Vazhachal forests of Kerala and Valparai of Tamil Nadu and collected six accessions comprising of *C. riparium*, *C. malabatrum* and two unidentified species (Fig. 24). An unidentified species was collected from Nilgiri district in Tamil Nadu. An accession each of *C. verum* and *C. riparium* were collected from Kondagaon district in Chhattisgarh and Malayattur forest division in Kerala, respectively.

CLOVE

Two accessions 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

Studies on mechanical drying of cloves were conducted in a lab model dryer at four different temperatures viz. 45, 50, 55 and 60 °C with sun drying as the control. Mechanical drying was completed in 23 h (60 °C) – 47 h (45°C), whereas sun drying recorded 72 h. Sun drying showed the highest essential oil and oleoresin content of 12.3 % and 17.3 %, respectively. However, in case of mechanical drying , temperature of 55 °C was found to be optimum with maximum essential oil and oleoresin content of 11.2 and 16.9 %, respectively (Fig. 26)

Fig. 25 *Cinnamomum riparium* collected from Vazhachal forest

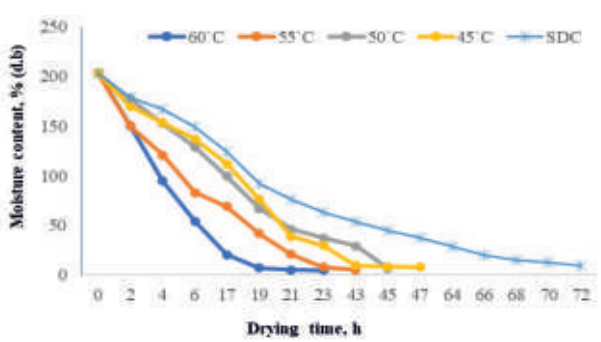


Fig. 26 Moisture content of clove at different temperatures

Plant-hormone based formulation for chemically induced harvesting

A plant-hormone based formulation was developed for chemical induction of bud fall. The method enables farmers to spray water soluble formulation on the leaves of the plant when the buds are ready to harvest. In this method, only flower buds fall from trees during the first 8 days of spray. The cost of harvesting using this method comes to around Rs.65/kg on dry weight basis.

GARCINIA

Three accessions comprising three species namely *G. morella, G. wightii* and *G. gummi-gutta* were collected from Athirappalli and Vazhachal forests in Thrissur district, Kerala. An accession of *G. wightii* was collected from Malayattur forest division, Kerala.

ALLSPICE

Essential oil of *Pimenta racemosa* against *Ralstonia pesudosolanacearum*

The *in vitro* anti-bacterial activity of *P. racemosa* essential oil against *R. pseudosolanacearum* was studied using SEM (Fig. 27). The treated bacterial culture showed structural alterations to the cell membrane such as breakage of cells, indentation of cellular membrane and blubbing in several bacterial surfaces as compared to control samples.

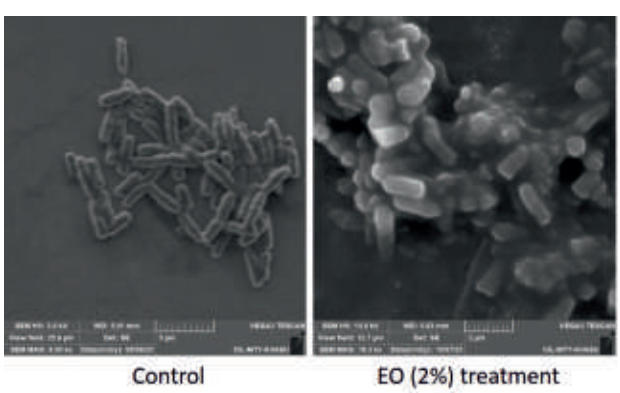


Fig. 27 SEM image of *R. pesudosolanacearum* with *P. racemosa* EO treatment

GENERAL

Investigations on development of packaging film for foods

Properties of corn starch and prosomillet starch-based films with starch concentrations 1.5, 2 and 2.5 % and plasticizer levels (polyethylene glycol: sorbitol) of 1:2, 1:3 and 1:4 were investigated. (Fig. 28a,b) The film prepared with 2% corn starch and plasticizer level of 1:2 was selected as best one in terms of functional properties. The film showed a maximum tensile strength of 3.47 N/mm^2 Young's modulus of 0.44 N/mm^2 and minimum water vapor permeability of 1.35 $g.mm/m^2/day$.

Fig. 28a
Corn starch-based film

Fig. 28b
Proso millet starch-based film

Development and evaluation of a novel *Trichoderma* formulation

A granular lime-based *Trichoderma* formulation named 'Tricholime' was developed and a process patent was filed after trials under greenhouse and field conditions (Fig. 29). This formulation neutralizes the soil acidity while promoting plant growth and shields crops from soil-borne pathogens, all in a single application. This formulation also benefits the crop by improving the physical condition of the soil and enhances secondary nutrient availability by boosting soil microbial activity.

Fig. 29 Tricholime

Evaluation of a PGPR consortium under field conditions in turmeric

Consortia of *Raoultella terrigena*, *B. safensis*, *Acinetobacer* sp. and *B. amyloliquefaciens* were

evaluated on turmeric plants under field conditions. Observations on growth parameters, PDI, plant and soil nutrient status recorded at 90 DAP showed no rhizome rot incidence in turmeric treated with consortia with different doses of recommended fertilizers (100, 75, and 50% NPK & Zn*)* compared to fertilizer alone treatments and absolute control. Among the treatments, the one with consortia plus 100% N P K, Zn, and consortia plus 75% N P K, Zn registered significantly higher rhizome yield.

Studies on hydrolytic enzyme production by temperature-tolerant *Trichoderma* isolates

Six selected isolates of *Trichoderma viz.,* APT1 *(T. erinaceum)*, APT2 (*T. harzianum)*, TN3 (*T. asperellum)*, KL3 (*T. harzianum)* KA15 (*T. lixii)* and NAIMCC0049 (*T. asperellum)* were compared for their ability to produce hydrolytic enzymes. Among the six tested isolates, the isolate *T. harzianum* (IISR APT2) showed highest production of hydrolytic enzymes *viz*., protease (578.12 µg/ml), glucanase (1325.61 µg/ml) and chitinase (1325.61 µg/ml).

Studies on peptaibol production and bioactivity by temperature-tolerant *Trichoderma* isolates

In vitro well assays with concentrated culture extracts of temperature tolerant *Trichoderma* isolates showed that all the isolates inhibited growth of *P. deliense* and *P. capsici*. The HPLC and LCMS analysis of concentrated culture extracts indicated that three isolates 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).*

Evaluation of selected plant beneficial rhizospheric microorganisms for Zn solubilization potential and disease antagonism under field conditions

Among the treatments, the combined application of *Bacillus 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. Rhizome rot was not observed in turmeric treated with a combined application of *B. safensis* with 50% or 75% or 100% $ZnSO_4$, compared to treated control. The treatment, *B. safensis* + 75% $ZnSO_4$ recorded significantly higher soil available Zn (6.36 ± 0.14mg kg^{-1} and higher fresh rhizome yield and the increase was 147.97% and 93.28% compared to control (100% $ZnSO_4$) and absolute control, respectively.

Compatibility of pesticides with *M. pingshaense*

Laboratory studies were conducted to ascertain the compatibility of different pesticides with *M. pingshaense*. Among the insecticides tested, flubendiamide, imidacloprid, spinosad and chlorantraniliprole were found to be compatible, whereas quinalphos, malathion, lambda cyhalothrin and neem oil were found to inhibit the growth of the fungus. Among the fungicides tested, tebuconozole, metalaxyl, and copper hydroxide were found to inhibit the growth of the fungus, whereas mancozeb and copper oxychloride were found to be less harmful to the growth and development of the fungus.

Compatibility of insecticides and fungicides used in spice crops

Laboratory studies were conducted to assess the compatibility of fungicides such as metalaxyl, Bordeaux mixture, copper oxychloride, copper hydroxide, tebuconazole with insecticides like

Fig. 29 (a) Leafhopper infected by *Metarhizium indicum* (b) Scanning electron micrograph of the developing phialides and conidia of the fungus on the insect host

chlorantraniliprole, flubendiamide and spinosad used in spices. Results indicated that the tested insecticides and fungicides are compatible based on emulsion stability and flocculation tests.

A new species of entomopathogenic fungus, *Metarhizium indicum*

A new species of entomopathogenic fungus, *Metarhizium indicum* S *sp. nov.,* which derives its species name after its Indian origin was found to induce epizootics in garcinia leafhopper, *Busoniomimus manjunathi* (Fig. 29 a,b). The fungus was found to cause more than 60% mortality under field conditions. The new species was characterized based on its distinct morphological features and multi-gene analyses. Phylogenetic analyses with internal transcribed spacer region (ITS), DNA lyase (APN2) and with a concatenated set of four marker genes [translation elongation factor 1-alpha (TEF), β-tubulin (BTUB), RNA polymerase II largest subunit (RPB1) and RNA polymerase II second largest subunit (RPB2)] along with marked differences in nucleotide composition and genetic distance unambiguously supported that the fungus is a new addition to the *Metarhizium* taxa infecting leafhoppers.

Zebrafish facility

A zebrafish animal facility was established to undertake research on pharmacological properties of extracts and compounds isolated from spices. The facility at present holds around 100 adult zebrafish. To work with this model, an Institute Animal Ethics Committee (IAEC) is also constituted with five members from the Institute and three nominated members by CCSEA (Committee for Control and Supervision of Experiments on Animals).

DUS testing facility

Twenty one example varieties of black pepper are being conserved at Chelavoor 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 at Peruvannamuzhi and Kozhikode. Preliminary on site DUS test evaluation of the candidate variety of black pepper, MDBP 16 was conducted at Kondagaon, Chhattisgarh. This candidate variety grows luxuriously in Bastar region of Chhattisgarh, which is considered to be one of the non-traditional area for black pepper cultivation (Fig. 30a,b)

Fig. 30a MDBP 16 at Chhattisgarh

Fig. 30 bTeam for on-site DUS test evaluation along with the farmer

Bioinformatics centre

Development of data-driven pipelines and tools for multiple high throughput sequencing

A comprehensive database scheme for drought transcriptome including the differentially expressed gene information from black pepper is currently being developed. At its present stage the database includes 2780 DEGs and 58 DEmiRNAs. A Data Analysis and Visualization Toolkit is being developed in R that enables intuitive exploration, multidimensional analyses and visualization of genomic data from any NGS experiment. A Shiny based module of Data Analysis and Visualization Toolkit for performing PCA and correlation profiles of samples for meta-analysis was also developed .

Production of quality planting materials

One and half lakh numbers of rooted black pepper cuttings of improved varieties were produced from Main campus, Experimental Farm and Regional Station and distributed to Farmers and developmental agencies. Twenty thousand suckers and seedlings of small cardamom and 20 kgs of seed capsules were produced from Regional Station and supplied to farmers. Three tonnes of improved varieties of ginger both from IISR and in participatory mode with farmers were produced and supplied to farmers. Twelve tonnes of improved turmeric rhizome seeds were produced and distributed. During this crop season, 1100 beds of IISR turmeric varieties IISR Pragati, IISR Prathibha, IISR Prabha, IISR Aleppey Supreme and IISR Kedaram were planted for seed production at Experimental Farm. At main campus 100 beds of IISR ginger varieties, IISR Varada, IISR Mahima and IISR Rejatha were planted for seed production. Participatory mode of ginger seed production is also implemented with five farmers during this year. In addition, around 500 grow bags of these ginger varieties were also raised for seed production. Five thousand cinnamon seedlings and 3000 nutmeg grafts were produced and distributed.

Economics and Policy Studies

Delineation of research-policy gaps in spices sector

There are areas where effective research based solutions/strategies are available for deployment, but require effective policy support for the widespread adoption/dissemination of the developed solutions. The key areas where research-policy gap needs to be addressed urgently are the choice limitations in plant protection, slow pace of varietal replacement, lack of effective technology dissemination of

GAP and organic management strategies and absence of MRL values for spice crops etc. It is important to bridge the research-policy gaps in a timebound manner to ensure better economic prospects for the primary producers and other value chain constituents in the spice sector.

Estimate of planting material demand for major spice crops

The annual demand for planting materials of black pepper, cardamom, ginger, turmeric and nutmeg for the crop season 2024-25 was estimated based on factors like spread of improved varieties, replacement demand, estimated growth in area, pace of varietal replacement, estimate of planting material produced for own use by farmers etc. It was estimated that the planting material requirement in black pepper would be about 19.88 million planting units to meet the demand for modern varieties. In the case of cardamom, the planting material requirement would be 2.6 million planting units to meet the targeted varietal replacement and to meet the requirement from new plantations. In case of ginger and turmeric, the possibility of establishment of a traditional seed chain system was also explored as an additional parameter in developing the estimates. Without the presence of a seed multiplication chain, the certified seed material requirement in ginger and turmeric was estimated to be 24460 and 32642 tonnes respectively. The requirement for foundation seed can be significantly reduced by nearly 80 per cent with the establishment a single level seed multiplication chain. The requirement of nutmeg planting material to be supplied through planting material system was estimated to be 86,000 planting units.

Study on Asafoetida sector in India

Asafoetida is one of the commonly used spice ingredients in Indian cuisine. However, India is dependent on its imports for meeting its domestic demand. During 2022-23, India imported 1441 tonnes of asafoetida valued at Rs. 1504 crores (188 million USD), which is about 15.6 per cent of the total spice imports by the country. The asafoetida industry requires focused attention to explore the opportunities for attaining self-sufficiency and to enhance the efficiency of the asafoetida compounding industry. A comprehensive study on the asafoetida sector in the country was undertaken with focus on the processing sector, efforts on asafoetida crop introduction in India by CSIR-IHBT, policy environment and trade related issues. Detailed surveys were undertaken in Hathras district of Uttar Pradesh (a major asafoetida processing centre in India), Palampur and Mumbai for in-depth analysis of production, processing and trade in asafoetida. The study found that the unorganized sector in asafoetida lacks uniform processing protocols and they need to be incentivized in adopting good manufacturing practices to address the concerns of food safety. Given the significant instability in import price of the raw material, India should give strong production support to activities aimed at asafoetida production in the country.

AGRICULTURAL TECHNOLOGY INFORMATION CENTRE (ATIC)

- A total of 51 general training programmes aimed at transfer of technology were organized. These include training programmes conducted under various project platforms, online training programmes, on-demand customized modules, off campus programmes etc.
- More than 6000 primary producers, processors, entrepreneurs, rural youth and women farmers directly benefitted from these training programmes.
- The district seminar on Production technologies for black pepper cultivation in tropical plains was organized at Pudukottai in collaboration with Department of Horticulture, Govt of Tamil Nadu under MIDH scheme on 08 Mar 2023.
- The Institute facilitated 64 Educational Training Programmes for student groups spanning graduate, post graduate and other professional courses.
- Four training programmes/technical support sessions on scientific and technological approaches for sustainable black pepper production, ICM in ginger and pepper cultivation and post-harvest management of spices were organized with the institutional support of Directorate of Spices and Arecanut Development and Spices Board India.
- The Institute has organized four entrepreneurship development programmes: EDP on value addition in millets, conducted during 03-04 May, entrepreneurship awareness Programme with special focus on spices organized in association with MSME (12 Jan), EDP on processing and value addition of ginger in collaboration with MSSRF Wayanad (19 Oct) and the EDP on 'Mushroom production, value addition and marketing (08 Dec).
- A special training programme for SHG members among the PMFME beneficiaries was organized in collaboration with KAU, 04 Dec 2023. The training programme focused on financial management, seed capital use and technology capability enhancement of the beneficiaries.
- A customized training programme, sponsored by CML Tata Trust, Guwahati,for the benefit of participants from NEH region was organized on current trends in technology for high performance black pepper production systems during 19-23 Jun 2023.
- The Institute partnered with Indian Society for Spices in organizing a seminar on "Scientific and technological approaches for sustainable spices production of black pepper, ginger and cardamom" at Madikeri, Karnataka on 14 Sept 2023.
- The Institute provided technical training for five batches of Diploma in Agricultural Extension Services for Input Dealers (DAESI) from various districts in Kerala and Karnataka. The participants were provided comprehensive training on plant protection strategies in major spice crops.
- The Institute also partnered with the Agricultural Technology Management Agencies (ATMA) at the district level across Kerala and other states to undertake farmer training and exposure visit programmes. Eight such programmes were organized by ICAR-IISR during the year .
- An innovative workshop in collaboration with KIRTADS, Govt of Kerala during

13-17 Mar 2023 on tribal foods was organized for tribal beneficiaries from most vulnerable tribal communities across Kerala.

- A special programme titled "Spice entrepreneurship orientation training" for underprivileged tribal students from Kerala was organized on 21 Nov 2023 in collaboration with Malabar Botanical Garden.
- Seven training programmes were organized exclusively for SC beneficiaries on various aspects of spice production, processing and value addition. Among them, the training on innovative technologies and plant protection strategies in Horticulture was organized in Bangalore with technical support and collaboration of UHS, Bhagalkot.
- Under the NEH component, a customized training on advanced technologies in horticultural crop production was organized in collaboration with ICAR-Research complex for NEH region Mizoram center- Kolasib during Feb 2023. Apart from this, a series of 16 training programmes focusing on ginger and turmeric cultivation technologies for NEH regions was organized in Manipur, Meghalaya, Mizoram, Nagaland, Arunachal Pradesh, Assam and Sikkim.

Sale of technology inputs

The ATIC supported and supplemented the technology dissemination initiatives of the Institute by providing sales and supply services of technology inputs to various stakeholders across the country. The total value of revenue generated from the sale of various technology inputs and products was Rs. 52,99,871.

Sales profile of ATIC: 2023

Particulars	Revenue
Planting material (MIDH)	6,80,570
Planting material (General farm)	1,75,060
Farm produce	4,06,024
Diagnostic services	56,000
Trichoderma talc formulation	15,300
Pochonia talc formulation	7,200
Micronutrients	4,89,500
Biocapsules	20,02,000
Publications	23,555
Milk	2,99,496
Others (Including GST & postage collected)	11,45,166
TOTAL	**52,99,871**

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

Dr. D Prasath assumed charge as the new Project Coordinator, AICRP on Spices, ICAR-Indian Institute of Spices Research, Kozhikode on May 02, 2023.

XXXIV Annual Group Meeting of ICAR-All India Coordinated Research Project on Spices (AICRPS)

The XXXIV Annual Group Meeting of ICAR-All India Coordinated Research Project on Spices (AICRPS) was held at UHS Bagalkot, Bengaluru, Karnataka from October 30-November 01, 2023. The workshop was inaugurated by Dr. S. V Suresha, Hon'ble Vice Chancellor, UAS, Bengaluru, Karnataka; Dr. Sudhakar Pandey, ADG (FVS & MP), ICAR presided over the function.

During the inaugural session, the best AICRPS centre award was conferred on SKN, College of Agriculture, Jobner, Rajasthan. Shri. Ramakanth Ramachandra Hegde, a progressive farmer was honoured for his endeavour in conserving indigenous landraces and his contribution in developing farmer variety 'Sigandini'. A database on spice varieties -"Spice Var" was launched which gives detailed information on the significant characters of the spice varieties. About 15 technical bulletins in various regional languages and Annual Reports of the AICRPS were released during the occasion.

New spice varieties During the XXXIV group meeting of spices, four new spice varieties were identified for release:

1. Gujarat Ajwain-3: high-yielding Ajwain cultivar with an average seed yield of 1035 kg/ha, greater number of umbels per plant and seeds per umbel with bold seed size.
2. Hisar Kalonji-12: medium maturing, 145-150 days and high yielding nigella variety, seeds contain 24.84% total oil, showing moderately tolerant to root rot.
3. IISR Amrit: high yielding mango ginger variety having high yield potential (average yield 31 t/ha, potential yield 45.75 t/ha), bold and plumpy rhizomes, light yellow core having desirable flavour with myrcene (55.54 %) & β pinene

Gujatat Ajwain 3 (GA-3)

Hisar Kalonji-12 (HKL-12)

Kamakhya-1

(14.53%).

4. Kamakhya 1: a black pepper variety suited for Assam condition with 2.14 kg dry yield, compact spike, essential oil content (3.43%), piperine (5.1%), and oleoresin (9.36%).

During the work shop eight technologies were recommended for release

1. **Black pepper-based mixed cropping system for sustainable productivity and food security:** Mixed cropping systems in pepper with elephant foot yam is highly productive and profitable technology, with an average yield of 0.84 kg of dry pepper per vine, along with a 6.12 kg yield of EFY from an $8m^2$ interspace. The system can achieve a commendable benefit-to-cost (B:C) ratio of 3.21, compared to the sole cropped control of 1.77. This technology is recommended for regions of Karnataka, Kerala, and Maharashtra.
2. **Biological control of soil-borne pathogens in black pepper:** Soil application of *Trichoderma harzianum* and *Pochonia chlamydosporia* at 50g/vine (twice) during the months of May/Jun and Aug/Sep along with the foliar spray with Bordeaux mixture (1%). This technology is recommended for regions of Karnataka, Kerala, and Maharashtra.
3. **Management of pseudostem rot in cardamom:** Application of *Trichoderma harzianum* (50g with 1kg neem cake) + *Pseudomonas fluorescens* (2% spray) is effective in controlling psuedostem rot in cardamom and is recommended for Karnataka region.
4. **Intercropping of seed spices with vegetables for higher yield and income:**

- Intercropping of coriander with garlic is an excellent way to increase productivity (44.2 over 14.8 q/ha) and profitability, with the highest benefit-to-cost (B:C) ratio (2.86 over 1.8) from the coriander sole cropped area. This technology is recommended for Bihar, Uttar Pradesh, Chhattisgarh and Madhya Pradesh
- Intercropping of fennel with garlic is highly productive (35.7 over 18.2 q/ha) and profitable with a BC ratio of 5.4 over 3.25 in sole fennel-cropped area. This technology is recommended for Rajasthan
- Intercropping of fennel with carrot is highly productive (18.9 over 12.07 q/ha in sole fennel plot), with a profitable BC ratio of 1.8 over 1.2 in sole cropped area This technology is recommended for Gujarat

5. **Integrated pest and disease management in coriander**:

- Two foliar sprays of *Lecanicillium lecanii* 1.15WP ($1x10^9$ cfu/g) (40g/10 L) + spray of propiconazole 25 EC @ 0.05% (first spray) + carbendazim @ 0.1% (second spray) is recommended for the control of stemgall and aphid. This technology is recommended for Bihar.
- Three sprays of hexaconazole 5 EC@ 0.005% + first foliar spray of emamectin benzoate-5%SG@ 4.0g/10 L and second spray of azadiractin 3000 ppm @ 3 ml/L is effective for the management of stem gall, powdery mildew and aphid. This technology is recommended for Uttar Pradesh.
- Spray of carbendazim 0.1% at 45 DAS and wettable sulphur 0.2% at 65 DAS + imidacloprid @0.03% is effective for the management of aphid and PM. This technology is recommended for Chhattisgarh

- Sprays of propiconazole 25 EC @ 0.025 % (first & second spray) + two sprays of acetamiprid 20SP (0.004%) is effective for the management of powdery mildew and aphid. This technology is recommended for Rajasthan and Gujarat
- Two foliar sprays of acetamiprid 20SP (0.004%) + propiconazole 25 EC @0.05% (first spray)+ carbendazim 50 WP @ 0.1% second spray effective for the management of aphid and PM. This technology is recommended for Madhya Pradesh
- Spray of carbendazim 50 WP @ 0.1% (20 g/10 L water) (first & second spray) + two foliar sprays of acetamiprid 20SP (0.004%) is effective for the management of PM. This technology is recommended for Uttarakhand.

6. **Foliar application of iron and zinc on growth, yield and quality of fennel**: Foliar spray of zinc sulphate and iron sulphate, each @ 4g/l with RDF at 60, 75 and 90 days after sowing in fennel is recommended for higher yield of 14.7% over untreated and net returns with high BC ratio of 20.8% over untreated plot. This technology is recommended for Rajasthan, Gujarat, UP and Bihar.
7. **Fertigation schedule for fenugreek:** Drip irrigation (2.1L discharge/hrs) at four-day interval along with recommended dose of fertigation NPK (20:30:30 kg/ha) and micronutrients $ZnSO_4$ (15 kg/ha), $FeSO_4$ (25 kg/ha), MnO (14 kg/ha) and B (10 kg/ha) in two splits (flowering and pod filling stage) is recommended for higher yield of 0.78%, increasing from 1,427 Kg/ha in the control to 1,738 kg/ha in the recommended treatment. This approach enhances water use efficiency by 23.7%, rising from 7.16 in the control to 8.86 kg/ha mm in the recommended method, leading to improved economic returns and a higher B:C ratio of 6.3%, increasing from 2.11 to 2.85 (control over recommended method). This technology is recommended for Tamil Nadu and Uttarakhand regions.
8. **Integrated aphid management in cumin:** Two foliar sprays of thiamethoxam 25WG @ 0.0084% (first spray at initiation of aphid and the second spray after 10 days of the first spray) were found effective against aphid infestation in cumin.This technology is recommended for Gujarat and Rajasthan regions. These technologies collectively represent a transformative stride toward ecological safety, sustainability, and enhanced profitability for farmers across diverse agricultural landscapes.

Central Varietal Release Committee Approves Six New Spice Varieties for Cultivation in India

The 30th meeting of the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops was held on 4th May, 2023 six varieties of spice crops were recommended for release and notification in the committee. These included Coriander (CG Raigarh Dhaniya-3/RCC 12-7), Ajwain (Gujarat Ajwain 2 and Chhattisgarh Ajwain-1 (CG Ajwain-1)), Nigella (CG Karayat-1), Turmeric (Chhattisgarh Raigarh Haldi-3/IT 36), and Saffron (Shalimar Saffron-1 /SD-1-13).

KRISHI VIGYAN KENDRA (KVK)

The KVK imparted regular training programmes of various durations in agriculture and allied fields for the farmers, farmwomen, rural youth and extension functionaries. Total 58 on-campus, 28 off-campus capacity-building trainings were organized for the benefit of more than 2137 farmers and 483 youth. Topics like plant propagation, pepper plants production, seasonal vegetables cultivation, mushroom production, organic inputs production, ornamental fish production, value addition of spices and millets, banana fibre extraction, backyard poultry rearing and crop pest and disease management are highly demanded. Paid training programme on mushroom spawn production and value addition to SC beneficiaries are other highlighted programmes. Sponsored training programmes on ornamental fish breeding, feed management and aquarium setting, training on banana fibre extraction machine and rubber tapping machine, mushroom cultivation and organic vegetable production, bee keeping, back yard poultry rearing, nutmeg propagation and cultivation were also conducted.

During 2023, KVK, IISR implemented five OFTs on assessing the performance of strawberry varieties in high altitude areas of Kozhikode district, assessment of okra varieties for yield and yellow mosaic virus disease resistance, assessment of different traps against mango fruit flies, assessment of strawberry varieties for grow bag cultivation and assessment of marie gold varieties for cultivation in Kozhikode district. Fourteen FLD programmes on late bolting and multi cut Amarath (Var: KAU Vaika), pepper variety IISR – Thevam cultivation, grafted pepper cultivation, nutmeg variety IISR – Keralasree cultivation, integrated management of Tanjore wilt in coconut, IPM in banana; Tricho cake for coconut bud rot management; parasitic infestation in cattle, CIFAX for fish health improvement, culture of snake head (Murrels) and scampi, mushroom value addition and drone usage for nutrient application in paddy and small onion cultivation were demonstrated. Farm Field School on disease free seed production of ginger variety IISR Vajra and nutri-garden establishment are also in the status of implementation. Moreover, about 100 demonstrations of drone usage in farmer fields in agricultural proposes were conducted to create awareness.

Special programmes were conducted for SC beneficiaries sponsored by ATARI, in Perambra Block where chicks, chick cages, fruit plants, vegetable seeds were distributed to SC beneficiaries. KVK celebrated world pulses day, 8th National Ayurveda Day, live webcasting of PM Kisan Samman Nidhi, World Environment Day and World Soil day. KVK was actively involved in Vikshit Bharat Sankalp Yatra, GoI's flagship programme.

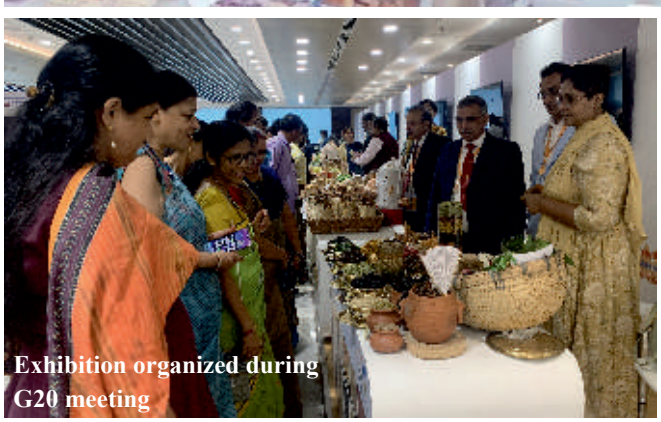
KVK also documented two success stories *viz.*, jack fruit processing unit by Smt Shylamma, Kurachundu and millet cultivation and processing by Kudumbasree unit, Kayana. KVK generated revenue by selling seedlings of vegetables, rooted cuttings of black pepper, bush pepper, nutmeg grafts, arecanut seedlints, seed materials of turmeric and ginger, bio inputs such as vermicompost, *Trichoderma* and goat manure, layer chicks and ornamental fishes.

1. VBSY inaugural of Kozhikode district Padmasree Cheruvayal Raman
2. 23rd SAC meeting held at IISR
3. Distribution of cages and layer birds to SCSP beneficiaries
4. Millet cafeteria at KVK

INSTITUTE TECHNOLOGY MANAGEMENT - AGRIBUSINESS INCUBATION (ITM-ABI) UNIT

- During the period sixteen (16) licenses were issued for various technologies developed by ICAR-IISR and a revenue of 17.5 Lakhs was generated.
- Trademark registered for 'iFAME'þ Incubation Facility for Microbial Encapsulation, the newly established incubation facility of IISR.
- Patent Application No. 202241010858 entitled "Granular lime based microbial formulation and a process for its preparation published in the patent journal.
- Four license agreements were executed for utilizing the Spice Processing facility at HQ/ Peruvannamuzhi.
- Facilitated three consultancy visits to black pepper plantations of Karnataka and Tamil Nadu and a contract research programme with Bayer Crop Science Pvt Ltd.
- Executed an assignment deed between ICAR-IISR and National Research Development Corporation (NRDC) for parallel marketing of the technology 'Granular Lime Based Microbial Formulation and a Process for its Preparation'.
- Executed acollaborative research agreement between ICAR-IISR and Jain Irrigation Systems Ltd, Jalgaon, Maharashtra for research on Black pepper, Turmeric and Ginger and any other possible crops on 27th June 2023.
- Completed technology know-how transfer cum training programme for the International Licensee Lysterra LLC, Moscow, Russia for the technology,"A novel method of storing and delivering PGPR/Microbes through biocapsules".
- Conducted virtual interactive session as part of World Intellectual Property day on 26th April 2023 under the theme "Women and IP: Accelerating Innovation and Creativity". Ms. Amrita G (Registered Patent Agent, R.K. Dewan and Co.) delivered a lecture on the topic "Sowing the seeds of innovation and IP in agriculture" during the occasion.
- Conducted Techno Commercial Assessment Committee (TCAC) meeting with Agrinnovate for evaluation of technologies developed at ICAR-IISR.
- Conducted business meetings for technology commercialization with various private firms such as, IFFCO, New Delhi, IPL Biologicals, Haryana, Coromandel International Limited, Secundrabad, Bannari Amman Sugars Ltd, Tamil Nadu.
- Organized an Entrepreneurship Development Programme in collaboration with MSME Development & Facilitation Office, Thrissur on 12th Jan 2023. 39 prospective entrepreneurs participated in the programme.
- Participated in Poopoli International flower show & exhibition at Regional Agricultural Research Station, Kerala Agricultural University, Ambalavayal, Wayanad from1 - 15January 2023 and showcased various technologies of the Institute and conducted sale cum promotion of spice-based value-added products of startup incubatees.
- Participated in VAIGA international exhibition at Putharikkandam Maithanam, Trivandrum organized by Department of Agriculture and Farmers Welfare from 25th February to 2nd March 2023 and bagged third prize for the section ‘Message conveyed and interaction’.
- Launched Traditional "Curry blends" developed by a women entrepreneur Mrs. Nisha Manimala of Kattipara Coconut Industries Pvt. Ltd
- Organized an awareness programme as a part of International Year of Millets 2023. Mr. Faizy Mohammed, Managing Director, Kisan

Exhibition organized during 95th ICAR foundation day celebrations



Exhibition organized during G20 meeting

Launch of "Curry blends" by Dr Beena Philip,Mayor, Kozhikode Corporation

Technology transfer and knowhow training to Lysterra LLC, Moscow, Russia

Appreciation award for message conveyance and interaction during VAIGA

Pravasi Agri Spices Farmer Producer Company Ltd., Pathanamthitta delivered the talk on the topic 'Millets; varieties and important features.'

- Participated in an exhibition cum farmers meet at CPCRI regional Station, Kayamkulam. The exhibition was organized in connection with the valedictory function of the Kalpa Vajra 2023, Jubilee celebration year of the regional station.
- Inaugurated 'Kisan Seva Kendra Bio Input Resource Centre. The facility is for the sale of farm bio inputs of ICAR institutes and intends to support farmers across the country by facilitating easy access to ICAR technology-based inputs.
- Signed a MoA with Elements Homestead Products Pvt Ltd. On 9th June 2023 for marketing of organic certified spices and cashew nut under the theme 'Partnering Biodiversity Preservation' through ABI sales counter "SPIISRY" and online portal https://spiisry.in.
- Participated in the technology day cum 95th ICAR foundation day celebrations at Dr. C Subramanian Symposia Hall, NASC Complex, PUSA, New Delhi. Showcased various technologies of the institute and value-added products of incubatee startups in the programme. The exhibition was organized from 16 - 18 July 2023.
- Participated in National Horticulture Fair 2023 at ICAR- Indian Institute of Horticulture Research, Bangalore from 22 February to 25 February 2023.
- Participated in an exhibition cum farmers meet at ICAR- Central Tuber Crops Research Institute, Trivandrum. Showcased various technologies of the Institute and value-added products of incubatee startups in the programme. The exhibition was organized in connection with the diamond jubilee celebrations of the institute on 22 July 2023. Hon. DG ICAR visited the stall on the occasion.
- Established a new sales facility at Sreekaryam in association with Agri Business Incubator, ICAR- Central Tuber Crops Research Institute, Trivandrum. Startups will be supported by extending marketing facility through the sales outlet.
- Organized a meeting with Senior officials of HDFC Bank to discuss about modalities for utilizing CSR funds and bank finance for the startup incubatees.
- Participated in G20 Leaders' Summit Spouse Programme and showcased Indian Spices to the G20 leaders' spouses. The spouses explored the exhibition displaying different spices and its value chain. The event was organized as part of G20 summit held at New Delhi during 09 - 10 September 2023
- Participated and showcased diversity in Indian Spices and IISR technologies.Visitors explored the exhibition displaying different spices and its value chain, diversity in spices varieties and won the first position pavilion award. The event was organized as a part of XVI Agricultural Science Congress held at Le Méridien, Kochi during 10 - 13 October 2023.
- Participated and showcased IISR technologies and incubate products at the "Millet and Fish Fest" held at ICAR - Central Marine Fisheries Research Institute, Kochi during 28-30 December, 2023.
- Organized an Entrepreneurship Development Programme on Mushroom cultivation, value addition and marketing on 8 December 2023. Women and young entrepreneurs from different parts of Kerala attended the programme

Agricultural Knowledge Management Units (AKMU)

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

Library portal of ICAR-IISR, Kozhikode

IISR-Library

Library has a collection of 5683 books and 6010 bound journals.

CeRA

IISR Library is part of the Consortium of electronic Resources in Agriculture (CeRA) and more than 3500 full text journals on agriculture and allied subject are accessible.

JOURNALS

Library has subscribed Twenty Five Indian Journals and Eight Foreign Journals during the year in addition to journals accessible under CeRA.

KOHA

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

DSpice

The Institutional Digital repository software 'DSpice' was also updated during 2023

ICAR - Krishiportal

Updated with reports, research publication and, media resources etc.

हिंदी अनुभाग

राजभाषा कार्यान्वयन समिति की बैठक

वर्ष २०२३ में राजभाषा कार्यान्वयन समिति की चार बैठकें आयोजित की गयी। बैठकें दिनांक ०९ फरवरी २०२३, ०१ मई २०२३, ०९ अगस्त २०२३ तथा २७ दिसंबर २०२३ को 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 २०२३ 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, श्री. के. राजेष, वरिष्ठ प्रबंधक, यूनियन बैंक ऑफ इंडिया, कोषिक्कोड, श्रीमती एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी, आईसीएआर-आईआईएसआर, श्री. एम. अरविंदाक्षन, वरिष्ठ अनुवाद अधिकारी, कर्मचारी भविष्य निधि संगठन, कोषिक्कोड तथा डॉ. पी. एन. ज्योति, कनिष्ठ अनुवाद अधिकारी, सुपारी और मसाला विकास निदेशालय ने क्रमशः दिनांक २१.०२.२०२३, १७.०५.२०२३, ८ अगस्त २०२३ तथा ८ नवंबर २०२३ को "राजभाषा कार्यान्वयन को कैसे आसान बनायें", "राजभाषा नियम", "आधुनिक प्रौद्योगिकियों के माध्यम से राजभाषा कार्यान्वयन" तथा "राजभाषा का प्रकार्यात्मक प्रयोग" आदि विषयों पर व्याख्यान दिया।

दिनांक २१ फरवरी २०२३ को आयोजित कार्यशाला


दिनांक 17 मई २०२३ को आयोजित कार्यशाला


दिनांक 8 अगस्त २०२३ को आयोजित कार्यशाला

दिनांक 8 नवंबर २०२३ को आयोजित कार्यशाला

हिंदी प्रशिक्षण

- डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं हिंदी अधिकारी तथा श्रीमती षजिना ओ., तकनीशियन ने केंद्रीय हिंदी प्रशिक्षण संस्थान द्वारा आयोजित पारंगत परीक्षा उत्तीर्ण की।
- श्री. जयप्रकाश पी. टी., उच्च श्रेणी लिपिक तथा श्रीमती एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने केंद्रीय हिंदी प्रशिक्षण संस्थान द्वारा आयोजित हिंदी शब्द संसाधन परीक्षा उत्तीर्ण की।

- श्रीमती एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने विश्व हिंदी दिवस के अवसर पर १० जनवरी २०२३ को आईसीएआर-आईआईएसडब्ल्युसी, देरादून, उत्तर प्रदेश द्वारा आयोजित ऑनलाइन अंतर्राष्ट्रीय वेब संगोष्ठी में भाग ली।
- श्रीमती एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने २७ जनवरी २०२३ को राजभाषा विभाग द्वारा टैगोर थियेटर, वषुतक्काड, तिरुवनंतपुरम में आयोजित क्षेत्रीय राजभाषा सम्मेलन एवं पुरस्कार वितरण समारोह में भाग लिया।
- श्रीमती एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने राजभाषा विभाग, गृह मंत्रालय, भारत सरकार द्वारा १४-१५ सितंबर २०२३ को श्री शिव छत्रपति स्पोर्ट्स काम्प्लक्स, बालेवाडी, पुणे में आयोजित हिंदी दिवस एवं तृतीय अखिल भारतीय राजभाषा सम्मेलन में भाग लिया।

संसदीय राजभाषा समिति

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान क्षेत्रीय स्टेशन, अप्पंगला के संबंध में माननीय संसदीय राजभाषा समिति का निरीक्षण १५.०७.२०२३ को होटल ताज वेस्ट एन्ड, बंगलूरू में संपन्न हुई। प्रस्तुत बैठक में संस्थान से डॉ. एस. जे. आंके गौडा, अध्यक्ष, भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान क्षेत्रीय स्टेशन, अप्पंगला, सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी, भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड तथा श्री. जनार्द्दनन टी. ई., वरिष्ठ प्रशासनिक अधिकारी, भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड ने भाग लिया।

माननीय संसदीय राजभाषा समिति के निरीक्षण की झलकियां

नगर राजभाषा कार्यान्वयन समिति

नगर राजभाषा कार्यान्वियन समिति की 71वीं अर्धवार्षिक बैठक 11 जुलाई 2023 को संपन्न हुई। प्रस्तुत बैठक में संस्थान से डॉ. एन. के. लीला, प्रधान वैज्ञानिक एवं प्रभारी हिंदी अधिकारी ने भाग लिया।

हिंदी प्रकाशन

- मसाला समाचार जनवरी-जून २०२२
- मसाला समाचार जुलाई-दिसंबर २०२२

- मसालों की महक २०२३
- एआईसीआरपीएस वार्षिक प्रतिवेदन का कार्यकारी सारांश २०२२
- आईसीएआर-आईआईएसआर के वार्षिक प्रतिवेदन का कार्यकारी सारांश २०२२
- प्रमुख मसाला फसलों की खेती से संबंधित मृदा की समस्याएं एवं समाधान
- उत्तर-पूर्वी क्षेत्रों में प्रमुख मसाला फसलों का जैविक उत्पादन (काली मिर्च, अदरक, हल्दी एवं बड़ी इलायची)

राजभाषा रिपोर्ट

- संस्थान के राजभाषा कार्यान्वयन की जनवरी-मार्च २०२३, अप्रैल-जून २०२३, जुलाई-सितंबर २०२३ तथा अक्तूबर-दिसंबर २०२३ 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 पखवाडा **202३**

राजभाषा हिंदी की प्रोन्नति के लिए भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में १४ सितंबर से २९ सितंबर तक हिंदी पखवाडा मनाया गया। उद्घाटन समारोह राजभाषा विभाग, भारत सरकार द्वारा १४-१५ सितंबर को शिव छत्रपति स्पोट्स कॉम्प्लक्स, बालेवाडी, पुणे में आयोजित हिंदी दिवस एवं तृतीय अखिल भारतीय राजभाषा सम्मेलन के साथ संपन्न हुआ। सुश्री. एन. प्रसन्नकुमारी, सहायक मुख्य तकनीकी अधिकारी ने प्रस्तुत समारोह में भाग लिया।। माननीय गृह राज्य मंत्री श्री अजय कुमार मिश्रा ने हिंदी दिवस समारोह का उद्घाटन किया। माननीय गृह मंत्री श्री अमित शाह का ऑनलाइन वीडीयो संदेश प्रस्तुत किया था। १५ सितंबर के कार्यक्रम में केरल के माननीय राज्यपाल श्री आरिफ मुहम्मद खॉन मुख्य अतिथि थे।

संस्थान में १८ सितंबर से हिंदी पखवाडे का कार्यक्रम शुरू हुआ। हिंदी पखवाडे के अवसर पर अनुशीर्षक लेखन, निबंध लेखन, टिप्पणी एवं मसौदा लेखन, हिंदी टंकण, श्रुतलेखन, कविता रचना, ऑनलाइन राजभाषा प्रश्नोत्तरी, हिंदी गीत आदि प्रतियोगिताएं आयोजित कीं। अनुशीर्षक लेखन के लिए चित्र प्रदर्शित किया और उसका अनुशीर्षक चार दिन के अंतर जमा करने का निर्देश दिया था। इसमें २६ प्रविष्टियां प्राप्त हुई थीं। निबंध लेखन के लिए विषय भारत में वैज्ञानिक चमत्कार-आज़ादी के बाद दिया था। प्रत्येक प्रतियोगिता के प्रथम, द्वितीय और तृतीय स्थान पर आनेवालों को पुरस्कार दिया गया। सभी प्रतियोगिताओं के लिए कुल **82** सदस्यों ने भाग लिया। जिस प्रतिभागी को पुरस्कार नहीं मिलता है उन्हें समाश्वास पुरस्कार भी दिया गया।

हिंदी पखवाडे का समापन समारोह ०३ अक्तूबर २०२३ को संपन्न हुआ। डॉ. पी. आई. मीरा, विभागाध्यक्ष, हिंदी विभाग, ज़ामोरिन्स गुरुवायुरप्पन कालेज, कोषिक्कोड मुख्य अतिथि थी। निदेशक डॉ. आर. दिनेश, समारोह के अध्यक्ष थे। मुख्य अतिथि ने अपने भाषण में हिंदी भाषा

के विकास तथा डिजिटल युग में हिंदी की प्रोन्नति के बारे में प्रकाश डाला। इस समारोह में मुख्य अतिथि के द्वारा पिछले वर्ष में सर्वाधिक हिंदी शब्द लिखकर पुरस्कार के पात्र बने श्री. वी. सी. सुनिल, सहायक प्रशासनिक अधिकारी को सम्मानित किया गया। उसके बाद विभिन्न प्रतियोगिताओं के विजेताओं के लिए पुरस्कार वितरण भी संपन्न हुआ। सुश्री. एन. प्रसन्नकुमारी ने हिंदी पखवाडे की रिपोर्ट प्रस्तुत की।

14 सितंबर 2023 से 03 अक्तूबर 2023 के दौरान आयोजित हिंदी पखवाडे की झलकियां

इन्टेर्नशिप प्रशिक्षण

प्रस्तुत अवधि में हिंदी अनुभाग द्वारा केरल केंद्रीय विश्वविद्यालय, कासरकोड के एक स्नातकोत्तर छात्र श्री. अश्विन कृष्णा बी. को राजभाषा कार्यान्वयन पर १५ दिवस का इन्टेर्नशिप प्रशिक्षण दिया गया।

HUMAN RESOURCES DEVELOPMENT (HRD)

Memorandum of Understanding (MoU)

Sl. No.	Colleges/Universities
1.	Kodagu university, Kodagu , Karnataka
2.	Vellore Institute of Technology, Vellore, Tamil Nadu
3.	National Institute of Technology, Calicut, Kerala
4.	KMCT, Dental College, Mukkam, Kozhikode , Kerala
5.	Sri Konda Laxman Telangana State Horticultural Universit y, Telangana

Training attended

Sl. No	Name	Name of the program	Organizer	Date
Scientific Staff				
1.	Dr. R. Gobu	CAFT training programme on "Advances in Statistical Techniques for Efficient Agricultural Experimentation"	ICAR-IASRI, New Delhi	04 - 24 January 2023
2.	Dr. C. Sarathambal	Training on Advanced Microscopy	KSCSTE-Malabar Botanical Garden	03 - February 2023
3.	Mr. S Mukesh Sankar			
4.	Dr. Honnappa Asangi	Winter school training programme on Approaches for doubling farmers income through secondary and smart Agriculture: A way forward	ICAR-IARI, New Delhi	10 - 30 March 2023
5.	Ms. R. Sivaranjani	Hands on Workshop on "Zebrafish in Biomedical Research"	Agharkar Research Institute and IISER, Pune	20 - 24 March 2023
6.	Mr. VA. Mohammed Nissar	International Seminar on Ginger	Malabar Botanical Garden and Institute of Plant Sciences	1-3 March 2023

7.	Ms. Sona Charles	Online training programme on "Train the trainers	Gallantries & ELIXIR-Goblent	12 - 15 June 2023
8.	Dr. Muhammed Faisal Peeran	Gene Editing and Technology management in agriculture	ICAR-NAARM, Hyderabad	10 - 14 July 2023
9.	Dr. N.K. Leela	Online Orientation training programme for Retiring Government Officials (OTP-RGO-14)	ISTM New Delhi	18-19 September 2023
10.	Dr. C. Sellaperumal	Omics Data Analysis: Genome to Proteome	ICAR-Indian Agricultural Statistics Research Institute, New Delhi	09- 18 October 2023
11.	Dr. B. Manimaran			
12.	Dr. K. Kandiannan	Online Workshop On Biological Data Exploration And Visualization Using R	ICAR-IISR, Kozhikode	6-8 November 2023
13.	Dr. C. Sarathambal			
14.	Dr. K. Anees			
15.	Dr. A. Jeevalatha			
16.	Dr. S.R. Maneesha			
17.	Dr. R. Gobu			
18.	Dr. C. Seelaperumal			
19.	Dr. Muhammed Azharudheen T.P.			
Technical Staff				
1.	Mr. K. Jayarajan	Geo-tagging of RKVY Assets	Govt of Kerala	14 February 2023
2.	Ms. N. Karthika	Online training programme on Trace Level Analysis of Pesticides,	ICAR-IARI, New Delhi	15-21 February 2023
3.	Mr. K. Krishnadas	Online Orientation training programme for Retiring Government Officials (OTP-RGO-14)	ISTM New Delhi	18-19 September 2023
4.	Mr. K. Jayarajan	One day Regional Training cum awareness workshop -on J Gate@CeRA for Southern Region	TNAU Tamil Nadu	05 December 2023
5.	Mr. E. S. Sujeesh	Training programme on 'Irrigation Water Management-Micro Irrigation and Advanced Irrigation Techniques	CWRDM, Kozhikode	20-23 November 2023
6.	Dr. Pavan Gowda			

Administrative Staff				
1.	Mr. T.E. Janardhanan	Two days Online Workshop on Stress Management (SM-10)	ISTM, New Delhi	07 - 08 August 2023
2.	Mr. R.K. Babu			
3.	Mr. P.T. Jayaprakash	Training Programme-Technical Service Rules	ICAR-NAARM, Hyderabad	10 - 11 July 2023
4.	Mr. V.C. Sunil	Online Orientation training programme for Retiring Government Officials (OTP RGO-14)	ISTM New Delhi	18-19 September 2023
5.	Mr. K. Faisal	Online Pre-Examination training for Limited Departmental Audit & Accounts Examination	ICAR-National Institute of Abiotic Stress Management, Pune, Maharashtra	20 July 2023 - 06 October 2023
6.	Mr. P. T. Jayaprakash			
7.	Mr. P. K. Rahul			
8.	Ms. N. Rebeena			
9.	Mr. P.C. Krishnakumar	Online workshop on Noting & Drafting	ISTM New Delhi	25-26 September 2023

Seminar/Symposium/Conferences attended

Name	Organizer	Date
Dr. R. Praveena	IPS Platinum Jubilee Conference on "Plant and Soil Health Management Issues and Innovation" at University of Mysore, Mysuru, Karnataka	02-04 February 2023
Dr.C. Sarathambal	International conference on Current Trends and Future Prospects of Plant Biology organized by the Department of Plant Sciences, School of Life Sciences, University of Hyderabad, Telangana.	23 - 25 February 2023
Dr. C.K Thankamani	National conference on Agro-Ecology based Agri-Food Transformation Systems organized by the IIFSR Modipuram	27-28 January 2023
Dr. C K Thankamani	30thSwadeshi Science Congress organised by NIT Calicut	25-27 May 2023
Dr. P. Rajeev	National Seminar on "Evolving Extension Science Towards Secondary Agriculture for Sustainable development organized by University of Agricultural Science Bangalore	22 - 24 June 2023

Dr. S. Aarthi	Second International conference on Prospects and challenges of environment and biological sciences in food production system for livelihood security of farmers (ICFPLS-2023) is organized by ICAR-CIARI, Port Blair, Andaman & Nicobar Island, India (online)	18 - 20 September 2023
Dr. K.M. Prakash Dr. P. Rathakrishnan	National seminar on Abiotic Stress Management for Sustainable Millet based Production Systems organized by Society for Agricultural Research on Abiotic Stress (SARAS), at ICAR-NIASM, Baramati	22 - 23 August 2023
Mr. S. Mukesh Sankar	International conference on millets: Breeding, physiology, genomics, biotechnology and nutraceuticals-2023(ICAM-BPGBN-2023) organized by Rajagiri college of Social Sciences, Kochi	5 - 7 July 2023
Dr. A. Ishwara Bhat Dr. A. Jeevalatha Dr. C.N. Biju Dr. R. Praveena	National Symposium on Plant Health management : Current trends and Novel Mitigation strategies organized by ICAR-ICAR-Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram	11 -13 September 2023
Dr. E. Jayashree Ms. P.V. Alfiya Dr. Sharon Arvind Dr. S. Mukesh Sankar Dr. S.R. Maneesha Dr. N.K. Leela Dr. K. Anees Dr. P. Rajeev Dr Lijo Thomas	XVI Agricultural Science Congress -Transformation of Agri-Food Systems for Achieving sustainable Development Goals at ICAR-Central Marine Fisheries Research Institute, Kochi	10-13 October 2023
Dr. N.K. Leela	National Symposium on Crop Health Management Safeguarding Crop through Diagnostics and innovations organized by ICAR- ICAR-Vivekananda Parvatiya Krishi AnusandhanSansthan, Almora, Uttarakhand	02 – 30 September 2023
Dr. S.J. Ankegowda	Fifth World Coffee Conference, Coffee Board, Ministry of Commerce and Industries at Bengaluru	25 - 28 September 2023

Dr. S.J. Ankegowda	Spices, Aromatic and Medicinal Plants for Economic Prosperity and Ecological Sustainability-2023, at ICAR- Central Island Agricultural Research Institute, Port Blair, Andaman & Nicobar Islands	5-6 October 2023
Dr. S.R. Maneesha Ms. R. Sivaranjani Dr. R. Gobu	International Seminar on Exotic and underutilized Horticultural crops, organised by ICAR-IIHR, Bengaluru	17 - 19 October 2023
Ms. P.V. Alfiya	National Conference on Spices, Aromatic and Medicinal Plants for Economics Prosperity and Ecological sustainability 2023- ICAR-CIARI, Port Blair	05 - 06 October 2023
Ms. Sona Charles	Indian Conference in Bioinformatics, VIT, Tamil Nadu	24-26 November 2023
Dr. A. Jeevalatha	International conference on Plant Health Management- Innovation and sustainability (ICPHM 2023) organized by Plant Protection Association of India and Professor Jayashankar Telangana State Agricultural University (PJTASU), Hyderabad	15 - 18 November 2023
Dr. A. I.Bhat	VIROCON-2023, organised by Indian Virological Society and ICAR-NRCB at Tiruchirappalli	1-3 December 2023

Ph. D Awarded

Sl. No	Name	University	Guide	Subject
1.	Ms. R. S. Aparna	University of Calicut	Dr. T. E. Sheeja	Biotechnology
2.	Mr. S. Raghuveer	Dr. Y.S.R Horticulture University	Dr. D. Prasath	Horticulture

Ph.D. registrations

Sl. No	Name	University	Guide	Subject
1.	Mr. Muhamad Fayad	University of Calicut	Dr. T. E. Sheeja	Biotechnology
2.	Ms. Anitta Abraham	University of Calicut	Dr. C. Sarathambal	Microbiology
3.	Ms. Meera Mohan	Kerala University of Fisheries and Ocean Studies	Dr. E. Jayashree	Food Science and Technology

New Post-Doctoral registration

Sl. No	Name	Guide	Fellowship
1.	Dr. C.P. Sreena	Dr. R. Dinesh	Chief Minister's Navakerala Post-Doctoral Fellowship

MSc projects completed

Sl. No	Name	Subject	Guide
1.	Ms. C. Sneha	Food Processing	Ms. P.V. Alfiya
2.	Ms. C. Aswathy	Food Processing	Dr.E. Jayashree
3.	Mr. Ranjith.K	Food Processing	Dr. E. Jayashree
4.	Mr. Murali Manohar	Food Processing	Dr. E. Jayashree
5.	Mr. Jinto Sebastian	Food Processing	Ms. P.V. Alfiya
6.	Ms. J.A. Shalini	Biotechnology	Dr. T.E. Sheeja
7.	Ms. K. P. Krishnendu	Biotechnology	Dr. A. Jeevalatha
8.	Ms. K. Sangeetha	Biotechnology	Dr. T.E Sheeja

9.	Ms. S. Avathika	Food Science and Technology	Ms. P.V. Alfiya
10.	Ms. K.P. Seena	Food Science and Technology	Dr. E. Jayashree
11.	Ms. Anagha Udayan	Microbiology	Dr.C. Sarathambal
12.	Ms. K.S. Surya	Microbiology	Dr.R. Praveena
13.	Ms. Anjana Radhakrishnan	Microbiology	Dr. R.Dinesh
14.	Ms. Priyanka Bheera	Bioinformatics	Ms. Sona Charles
15.	Ms. Mekha M.B.	Biotechnology	Dr. P.S. Divya
16.	Ms. V. Varsha	Biotechnology	Dr.T.E. Sheeja

Post MSc students

Sl. No	Name	Subject	Guide
1.	Ms. N. Hibah	Bioinformatics	Ms. Sona Charles
2.	Ms. Shahanas Arif	Bioinformatics	Ms. Sona Charles
3.	Ms. Farsana Shameer	Biotechnology	Dr. Sharon Aravind

1. Summer Internship Programme on 'Advanced techniques in Microbiology, Biochemistry, Biotechnology and Bioinformatics' (02 – 31 May 2023 at ICAR – IISR, Kozhikode.

ICAR – Indian Institute of Spices Research, Kozhikode conducted a Summer Internship Programme on 'Advanced techniques in Microbiology, Biochemistry, Biotechnology and Bioinformatics' during 02-31 May 2023. Twelve students from Central University of Kerala, Kannur University and Kerala University for Fisheries and Ocean Studies participated in the programme. The one-month program equipped the students with skills and knowledge in the cutting-edge areas in the field of microbiology, biochemistry, biotechnology, and bioinformatics. Apart from conventional theory and practical sessions, the programme covered exposure visits, field visits and lectures from eminent external faculties as well.

2. Online Workshop on Biological Data Exploration and Visualization Using R

A three day online hands-on workshop Biological Data Exploration and Visualization using R was organised by the Bioinformatics Centre, ICAR- Indian Institute of Spices Research, Kozhikode from 6-8 November 2023 for Research Scholars, Scientists and Assistant Professors. The workshop included theory as well as hands-on sessions on introduction to R, statistics and data visualization. 48 participants were selected from over 120 applicants from various ICAR/ SAUs and colleges for the workshop.

MAJOR EVENTS

International Women's Day

The Institute celebrated International Women's Day on 8 March 2023 on the theme "*DigitALL: Innovation and technology for gender equality*". A gathering representing "Embrace Equity" was organized and the chief guest Honorable Mayor of Kozhikode district, Dr. Beena Philip, delivered a talk on Innovation and technology for gender equality. A traditional "Curry blends" developed by a women entrepreneur Mrs. Nisha Manimala of Kattipara Coconut Industries Pvt. Ltd., was launched during the programme. In solidarity with the International Year of Millets 2023, a programme named 'Mill e´ Meal' was also launched by the Mayor at the Institute.

International Women's Day Celebration

World Intellectual Property Day

The Institute celebrated World Intellectual Property Day 2023 on 26 April 2023 by organizing a virtual interactive session under the theme "Women and IP: Accelerating Innovation and Creativity in collaboration with ICAR-National Research Centre on Seed Spices, Ajmer, Rajasthan and ICAR-Central Plantation Crop Research Institute, Kasaragod, Kerala. Ms. Amritha G (Registered Patent Agent, R.K. Dewan and Co. Bengaluru) and Ms. Meenakshi Chotia, Patent Lawyer & Managing Associate at LexOrbis, Bengaluru delivered the lectures on the topics "Sowing the seeds of innovation and IP in agriculture" and "Women & IP: Accelerating Innovation and Creativity" respectively during the occasion.

Environmental day tree planting ceremony at the Experimental farm, Peruvannamuzhi

Environment day Celebrations

A "Memorial planting" was carried out in memory of former Directors of ICAR-IISR by the Director and Heads of various Divisions. This was followed by the inauguration of "Kisan Seva Kendra," an outlet for the sale of farm bio-inputs of ICAR Institutes, by Dr. Abdul Hameed E, an environmentalist and former scientist at KSCSTE - CWRDM. A lecture on "Water scenario in Kerala" was organized at ICAR-Indian Institute of Spices Research, Kozhikode, where the Chief Guest, Dr. Abdul Hameed E highlighted the different aspects of water availability, constraints on water resources, and its way forward in Kerala.

Brainstorming Meeting on label claim expansion for spices

The Institute organized a brainstorming session on Label Claim Expansion for Spices on 18 April in hybrid mode. Invitees from various organizations including Spices Board,

Directorate of Arecanut and Spices Development (DASD), Central Insecticides Board and Registration Committee (CIBRC), Food Safety and Standards Authority of India (FSSAI), ICAR-National Research Centre on Seed Spices (ICAR-NRCSS), All India Network Project on Pesticide Residues (AINP-PR), All India Coordinated Research Project on Spices (AICRPS) centers, World Spice Organization (WSO), and representatives from pesticide industries participated in the discussion.

7th Dr. Y.R. Sarma memorial lecture

7th Dr. Y.R. Sarma Memorial Lecture

ICAR-IISR organized 7th Dr. Y.R. Sarma Memorial Lecture on 9th June 2023 in hybrid mode. Dr. Bir Pal Singh, Former Director, ICAR-Central Potato Research Institute, Shimla delivered the lecture titled "Managing impact of late blight disease on potato production in India". About 70 delegates, comprising scientists, research scholars, former colleagues, and postgraduate students participated in the event and interacted with the speaker.

Prof. Dr. Rajanikant G K, Dean Academics, NIT (C) addressing the staff of IISR on National Science Day

National Science Day- 2023

ICAR-IISR, Kozhikode celebrated National Science Day- 2023 on 28 February 2023. Dr. Rajanikant G K, Professor & Dean (Student's Welfare), NIT, Calicut was the Chief Guest of the function. Dr. Rajanikant G.K., delivered Science Day Lecture on the topic 'Leveraging Science to improve global well- being'. An 'Inter-collegiate Science Quiz Competition' was also conducted. Eleven teams from different colleges of Kozhikode district participated in the event.

Summer internship programme -2023

Summer Internship Program

Summer Internship Programme on 'Advanced techniques in Microbiology, Biochemistry, Biotechnology and Bioinformatics' was organized during 02-31 May, 2023. The programme was inaugurated by Dr. R Dinesh, Director, ICAR - IISR on 2 May 2023. Twelve students from Central University of Kerala, Kasaragod, Kannur University and Kerala University for Fisheries and Ocean Studies, Panangad participated in the programme. The program provided students with hands-on training in cutting-edge techniques in the fields of microbiology, biochemistry, biotechnology, and bioinformatics

International Year of Millet Celebration

As a part of the International Year of Millets Celebration-2023, Entrepreneurship Development Programme on 'Value Addition in Millets' was organized at ICAR-Indian Institute of Spices Research, Kozhikode during 03 – 04 May, 2023. The programme was inaugurated by Dr. R. Dinesh, Director, ICAR-IISR, Kozhikode. Dr. B. Dayakar Rao, Principal Scientist, ICAR-IIMR, Hyderabad delivered the keynote address on the topic 'Landscape of Millet Nutrition, Production, Processing and its Commercialization.' Ms. Bindu Gowri, Coordinator, Agri Business School, KVK, Coimbatore delivered a special address on 'Perspective of Millets in Kerala.' Hands on training on millet-based value-added products were imparted to 64 participants.

Institute Foundation Day Celebration

ICAR-Indian Institute of Spices Research celebrated its 48th foundation day on 3 July 2023. Dr. R Dinesh, Director, ICAR-IISR welcomed the gathering and Dr. Sudhakar Pandey, Assistant Director General (Horticultural Sciences), ICAR presided over the function. Institute honored its employees for their contributions for the cause of spices. As a part of Foundation Day celebrations, institute recognized the farmers and entrepreneurs for adopting and popularizing technologies developed by the institute. Dr Sandhyarani, Professor & Dean, Research & Consultancy, NIT Calicut delivered foundation day lecture on “Harnessing the potential of advanced materials for a greener future”.

EDP on value addition in millets

48th Institute foundation day celebration

Workshop on Advances in value addition in spices

Workshop on 'Advances in Processing and Value Addition in Spices’

A workshop on 'Advances in Processing and Value Addition in Spices' was conducted at ICAR

– Indian Institute of Spices Research, Kozhikode during 08 – 11 August 2023 for tribal farmers of 'Giri Chaitanya Farming and Marketing Mutually Aided Cooperative Society, Alluri Sitharama Raju District, Andhra Pradesh. The programme was inaugurated by Dr. D Prasath, Project Coordinator, AICRPs and was attended by 22 beneficiaries including 12 men and 10 women. The workshop covered theory and practical sessions on cultivation, processing value addition of black pepper, ginger and turmeric.

Farmers Seminar at ICAR- IISR, RS, Appangala

The Indian Society for Spices, Kozhikode, in collaboration with ICAR-Indian Institute of Spices Research, Kozhikode, organized a one-day Farmers' Seminar on "Scientific and Technological Approaches for Sustainable Spices Production" on September 14, 2023, at ICAR-IISR, Regional Station, Appangala, Madikeri. The program was inaugurated by Professor Ashok S Alur, Vice-Chancellor of Kodagu University, Kushalnagar and the program was presided over by Dr. R. Dinesh, Director , ICAR -IISR. More than 150 farmers from various regions of Karnataka participated in the seminar.

Swachhta activities

The Swachhta Pakhwada was organized during

Vigilance awareness week valedictory function

02 – 31 October 2023 The Swachhta pledge was taken by the staff of Headquarters & Regional Station, ICAR-IISR, Experimental Farm and KVK, Peruvannamuzhi followed by the cleanliness activities. Various cleanliness drives and outdoor swacchta programmes were organized during the period. Second schedule of Swachhta Pakhwada 2023 was conducted during 16-31 December, marking a two-week celebration of cleanliness and awareness.

Vigilance Awareness Week 2023

Vigilance Awareness Week was observed from 30 October to 5 November 2023 .To raise awareness about vigilance and combat corruption, a series of activities were organized at ICAR-IISR Campus and in schools. A Vigilance Awareness Rally was conducted from ICAR-IISR Campus to Chelavoor, with posters distributed to the public. On the valedictory day the Chief Guest, Mr. Abdul Razak K.P., Superintendent of Police, Vigilance and Anti-corruption Bureau, Special Cell, provided insights on vigilance and anti-corruption activities.

First Meeting of X Research Advisory Committee

The first meeting of the X Research Advisory Committee was held during 22-23 November 2023 at ICAR-IISR under the chairmanship of Dr. M.R. Dinesh, Former Director, ICAR- IIHR, Bengaluru. Members of the committee Dr. S.K.Singh, Head, FHT, IARI, Dr. Madan Pal, Pr.Scientist, Plant Physiology IARI, Dr. Bir Pal Singh, Former-Director, CPRI, Dr. Sunil Pareekh, Pr.Scientist, NIFTEM, Sonipat, Haryana, Dr.Suresh Pal, Former-Director, NIAEPR, Dr. Sudhakar Pandey, ADG, Horticultural Sciences, ICAR, Mr Jayachandran, IMC Member attended the meeting.

Entrepreneurship Development Program on Mushroom Production, Value Addition, and Marketing

The Agri Business Incubation Centre at the ICAR - IISR organized an Entrepreneurship Development Program on 'Mushroom Production, Value Addition, and Marketing' on 08 December 2023. The program was attended by 18 existing and potential entrepreneurs in Mushroom cultivation from Kozhikode and Wayanad districts.

First meeting of the Research Advisory Committee

EDP on Mushroom Production, Value Addition, and Marketing

Miller Exhibition organized at ICAR – IISR

Millet Exhibition

ICAR-IISR organized a Millet Exhibition as part of the International Year of Millets Celebrations. Various millet varieties, including little millet, proso millet, finger millet, pearl millet, foxtail millet, barnyard millet, and browntop millet, were displayed in the event showcasing the rich diversity of these nutritional powerhouses. Our inhouse cardamom flavoured Sorghum cookies made from the nutrient rich sorghum millet was also displayed.

RESEARCH PUBLICATIONS

1. Akshitha, H.J., Shivakumar, M.S., Sivaranjani, R., Ankegowda, S.J., Faisal, P.M., Asangi, H. and Rajkumar, M.B., 2023. Effect of different methods of drying on appearance and quality of black pepper. National Academy Science Letters. 1-3.
2. Amrutha Lakshmi, M., Suresh, K., Challa, G.K., Fathimath Zumaila, Priya George and Praveena R., 2023. Effect of plant protection chemicals on the survivability of *Phytophthora Piper nigrum* spp. infecting black pepper (L.) Journal Mycology Plant and Pathology, 53 (4),381-391
3. Alagupalamuthirsolai, M., Suresh, R., Thankamani, C.K., Srinivasan, V., Sivaranjani, R., Krishnamurthy, K.S., Sarathambal, C., Gobu, R., Asangi, H., Akshitha, H.J. and Peeran, M.F., 2023. Application methodology and physiological insights of melatonin hormone for water stress alleviation in black pepper (*Piper nigrum* L.). International Journal of Environment and Climate Change, 13(8), 219-228.
4. Alfiya, P.V., Rajesh, G.K., Murali, S., Delfiya, D.A., Samuel, M.P., Prince, M.V. and Sudheer, K.P., 2023. Process optimization for drying of Shrimp (*Metapenaeus dobsoni*) under hot air-assisted microwave drying technology using response surface methodology. Journal of Food Process Engineering, e14338.
5. Alfiya, P.V., Jayashree, E. and Sneha, C., 2023. Development and shelf-life evaluation of spice flavoured sorghum (*Sorghum bicolor*) cookies: A study on valorisation of millets for food security. The Pharma Innovation Journal. SP-12(12), 96-112.
6. Bhat, A. I., Selvarajan, R. and Balasubramanian, V., 2023. Emerging and re-emerging diseases caused by Badnaviruses. Pathogens, 12(2), p.245.
7. Dinesh, R., Patinharekkara, S.C., Elampilay, S.T., Payatatti, V.K.I., Charles, S., Veeraraghavan, S., Kadiyalath, J., Vandana, S., Purayil, S.K., Prasadam, H. and Anitha, S.J., 2023. New insights into bacterial Zn homeostasis and molecular architecture of the metal resistome in soil polluted with nano zinc oxide. Ecotoxicology and Environmental Safety, 263, 115222.
8. Dinesh, R., Sreena, C.P., Sheeja, T.E., Charles, S., Srinivasan, V., Sajith, V., Subila, K.P. and Haritha, P., 2023. Metagenomics indicates abundance of biofilm related genes and horizontal transfer of multidrug resistant genes among bacterial communities in nano zinc oxide polluted soil. Science of The Total Environment, 859, 160032.
9. Dinesh, R., Sreena, C.P., Sheeja, T.E., Kumar, I.V., Praveena, R., Charles, S., Srinivasan, V., Jayarajan, K., Sajith, V., Subila, K.P. and Haritha, P., 2023. Soil polluted with nano ZnO reveals

unstable bacterial communities and decoupling of taxonomic and functional diversities. Science of The Total Environment, 889,164285.
10. Greeshma, M. and Bhat, A.I., 2023. Complete genome sequence of a divergent strain of cardamom mosaic virus. Archives of Virology, 168(10), 242.
11. Greeshma, M., Bhat, A.I. and Jeevalatha, A., 2023. Rapid onsite detection of piper yellow mottle virus infecting black pepper by recombinase polymerase amplification-lateral flow assay (RPA-LFA). Journal of Virological Methods, 315, 114695.
12. Jayashree, E. and John Zachariah, T., 2023. Modeling for thin layer drying of black pepper (*Piper nigrum*) in a reverse air flow dryer. Journal of Food Process Engineering, 46(1), e14202.
13. Jayashree, E., Shakkira, P. K. and Anees, K. 2023. Quality evaluation of turmeric press residue – A by-product obtained from turmeric juice extraction industry. Indian Journal of Horticulture, 80 (1), 119-125.
14. Jayashree, E., 2023. Changes in physico-chemical characteristics of kokum (*Garcinia indica*) based RTS beverage during storage. The Pharma Innovation Journal, 12 (2), 1552-1559.
15. Jayashree, E. and Aiswarya, P., 2023. Physico chemical quality evaluation of turmeric powder (*Curcuma longa*) stored at different temperatures. The Pharma Innovation Journal, 12(11), 294-300.
16. Jeevalatha, A., Siddappa, S., Kumar, R., Tiwari, R.K., Lal, M.K., Sharma, S., Chakrabarti, S.K. and Singh, B.P., 2023. RNA-seq analysis reveals an early defense response to tomato leaf curl New Delhi virus in potato cultivar Kufri Bahar. Functional & Integrative Genomics, 23(3), 215.
17. Murali, S., Delfiya, D.A., Alfiya, P.V., Samuel, M.P. and Ninan, G., 2023. Development of sensible heat storage based solar hybrid dryer with evacuated tube collector and biomass gasifier for shrimp drying. Solar Energy, 262, p.111836.
18. Neenu, M.G., Aswathi, A. and Prasath, D.,2023. Synthetic polyploidy in spice crops: A review. Crop Science. 2-23.
19. Prasath, D, Matthews, A., O'Neill, W.T., Aitken, E.A. and Chen, A., 2023. *Fusarium* yellows of ginger (*Zingiber officinale* Roscoe) caused by *Fusarium oxysporum* f. sp. *zingiberi* is associated with cultivar-specific expression of defense-responsive genes. Pathogens. *12*(1),141.
20. Peeran, M.F., Biju, C.N., Rajan, G., Ankegowda, S.K.J., Sharon, A. and Akshitha, H.J.G., 2023. Biochemical defence reactions of black pepper varieties against *Colletotrichum gloeosporioides* incitant of anthracnose disease. Journal of Applied Horticulture, 25(1), 92-97.
21. Raghuveer, S., Madduri, Y.K., Sounderarajan, A. and Duraisamy, P., 2023. Patterns in genetic variation and character association of yield components in turmeric (*Curcuma longa* L.). Journal of Spices and Aromatic Crops, 32(1), 14-23.

22. Raghuveer, S., Madduri, Y.K., Sounderarajan, A. and Prasath, D., 2023. Multivariate analysis for various agro-morphological traits of turmeric (*Curcuma longa* L.). Journal of Horticultural Sciences, 18(2).
23. Saleena, P., Jayashree, E. and Anees, K., 2023. A comprehensive review on vacuum impregnation: Mechanism, applications and prospects. Food and Bioprocess Technology,1-14.
24. Saljuna K.P., Thankamani, C.K., Krishnamurthy K.S., Gayathri Pavithran and Alagupalamuthirsolai, M. 2023 Effect of growth regulators on the growth and yield of ginger (*Zingiber officinale* Rosc.) under polyhouse condition, Journal of Plantation Crops 51(1). 16-22.
25. Sarathambal, C., Jeevalatha, A., Sivaranjani, R., Biju, C.N., Charles, S., Srinivasan, V., George, P., Peter, B. and Radhika, R., 2023. Arbuscular mycorrhizal colonization alters biochemical, molecular defense responses and root exudate composition against *Phytophthora capsici* infection in black pepper. Rhizosphere, 25, 100651.
26. Sarathambal, C., Sivaranjani, R., Srinivasan, V., Alagupalamuthirsolai, M., Subila, K.P. and Anamika, B., 2023. Effect of arbuscular mycorrhizal inoculation on growth, mineral nutrient uptake, photosynthesis and antioxidant activities of black pepper cuttings. Journal of Plant Nutrition, 46(10), 2508-2524.
27. Sellaperumal, C., Eapen, S.J., Manimaran, B., Berliner, J., Senthamizh, S.B., Mahendar, B., Giridhar, K. and Sivakumar, V., 2023. Plant-parasitic nematodes, a looming threat to turmeric cultivation in India: results of recent surveys. Nematology, 1(aop), 1-9.
28. Senthil Kumar, C.M., Jacob, T.K., Devasahayam, S., Rajeshkumar, K.C., Lad, S.S., D'Silva, S. and Geethu, C., 2023. *Metarhizium indicum*, a new species of entomopathogenic fungus infecting leafhopper, *Busoniomimus manjunathi* from India. Journal of Invertebrate Pathology, 198, 107919.

ONGOING PROJECTS

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

1. Gen. XXVIII (813): Conservation and characterization of *Piper* germplasm (2008-2025) [Dr. 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. R. Gobu, Dr. H. J. Akshitha, Dr. D. Prasath & Dr. N. K. Leela] (External support: Dr. C. N. Biju)

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

4. Gen. XXXVI (813): Genetic resources management in tree spices (2018-2028)[Mr. V. A. Muhammed Nissar, Dr. Sharon Aravind, Dr. Honnappa Asangi & 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

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 Azharudheen T. 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 - 2024) [Dr. H. J. Akshitha, Dr. S. J. Ankegowda, Dr. M. Balaji Rajkumar, Dr. M. S. Shivakumar, Dr. Mohammed Faisal Peeran & Dr. Honappa Asangi]

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. V. Srinivasan, 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 (2021-2024) (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) (Ms. 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. A. Jeevalatha, Dr. M.S. Shivakumar, Ms. Sona Charles, Dr. Muhammed Azharudheen T.P, Dr. U.B.Angadi & Dr. Sunil Kumar)

9. DUS project (2010-2024) [Dr. Sharon Aravind, Dr. R. Gobu, 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)

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

1. Phy. X (813): Evaluation of black pepper and cardamom elite lines for yield and quality under moisture stress (2010–2024) [Dr. S.J. Ankegowda, Dr. K.S. Krishnamurthy, Dr. M. Alagupalamuthirsolai) (External support: Dr. H. J. Akshitha & Dr. M.S. Shivakumar]

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

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 N.K. Leela, Dr. Ankegowda S.J. and Dr. Kandiannan K.]

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

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

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

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

4. 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)

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

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

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

1. ICAR-CP 1. ICAR-Consortium research project on borers in network mode (2014-2024) [Dr. C.M. Senthil Kumar & Dr. M. Balaji Rajkumar]

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

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

4. Nema. VII (813): Prevalence of lesion nematodes in turmeric growing tracts of India and their economic significance (2018-2024) [Dr. C. Sellaperumal & Dr.B. Manimaran] [External support: Dr. R. Praveena]

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

6. Path. XXVII (813): Development of microbial biostimulants for growth promotion and disease resistance in major spices (2018-2024) [Dr. C. Sarathambal & Ms. R. Sivaranjani] (External support: Dr. Mohammed Faisal Peeran]

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

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

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

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

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

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

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

1. Ext. VI (813). Capacity building and front-line intervention programmes for (spice sector development in NE states and tribal empowerment (2014-24) (Dr. P. Rajeev & Dr.Lijo Thomas)

2. Eco. IV (813): Developing models for enhancing technology and policy impact in spices sector (2020-2025) (Dr. Lijo Thomas, Dr. P. Rajeev, 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. Sharon Aravind, Dr. Maneesha S R, Mr Muhammed Nissar V. A., Dr. Shivakumar M. S., Dr. Gobu R., Dr. C. K. Thankamani, Dr. K. Kandiannan, Dr. V. Srinivasan, Dr. Anees K., Ms 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. Sheeja T. E.)

Other Externally Funded Projects

1 Institute Technology Management – Agri Business Incubation (ABI) Unit

2 RKVY- CIB-1: Production and popularization of orthotropic shoots and bush pepper for increasing black pepper productivity (2022-2024) [Dr M S Shivakumar, Dr. S. J. Ankegowda, Dr. H.J. Akshitha, Dr. HonnappaAsangi & Dr. Mohammed Faisal Peeran]

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

PERSONNEL

HEADQUARTERS

SCIENTIFIC

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. C.K Thankamani	Principal Scientist (Agronomy)
7.	Dr. N K Leela	Principal Scientist (Organic Chemistry)
8.	Dr. K Kandiannan	Principal Scientist (Agronomy)
9.	Dr. K S Krishnamurthy	Principal Scientist (Plant Physiology)
10.	Dr. P Rajeev	Principal Scientist (Agriculture Extension)
11.	Dr. E Jayashree	Principal Scientist (Agricultural Engineering)
12.	Dr. C M Senthil Kumar	Principal Scientist (Agricultural Entomology)
13.	Dr. C N Biju	Principal Scientist (Plant Pathology)
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. Sajesh V.K	Senior Scientist (Agricultural Extension)
19.	Dr. C Sarathambal	Senior Scientist (Agricultural Microbiology)
20.	Dr. C Sellaperumal	Senior Scientist (Nematology)
21.	Dr. Sharon Aravind	Scientist (Spices Plantation Medicinal & Aromatic Plants)
22.	Dr. Maneesha S.R	Scientist (Fruit Science)
23.	Dr. Muhammed Azharudheen T P	Scientist (Genetics & Plant Breeding)
24.	Ms. S Aarthi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
25.	Mr. V A Muhammed Nissar	Scientist (Spices Plantation Medicinal & Aromatic Plants)
26.	Ms. R Sivaranjani	Scientist (Plant Biochemistry)
27.	Dr. V Vinu	Scientist (Genetics & Plant Breeding)
28.	Ms. Sona Charles	Scientist (Agricultural Bioinformatics)
29.	Smt. Alfiya P.V	Scientist (Agriculture Structure & Process Engg.)

30.	Mr. Mukesh Sankar S	Scientist (Genetics & Plant Breeding)
31.	Dr. Manimaran B	Scientist (Nematology)

ADMINISTRATIVE STAFF

1.	Mr. T E Janardhanan	Senior Administrative Officer
2.	Mr.. Babu R.K	Senior Finance & Accounts Officer
3.	Mr. P Sundaran	Administrative Officer
4.	Ms. C K Beena	Private Secretary
5.	Mr. Sunil V.C	Assistant Administrative Officer
6.	Mr. V V Sayed Mohammed	Assistant Administrative Officer
7.	Mr. Ajith K.S	Assistant Administrative Officer
8.	Ms. M Seema	Upper Division Clerk
9.	Ms. Rebeena N	Upper Division Clerk
10.	Mr. P K Rahul	Upper Division Clerk
11.	Mr.Krishnakumar P.C	Lower Division Clerk
12.	Ms.Archana N	Lower Division Clerk

TECHNICAL

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.	Mr. K Krishnadas	Technical Officer
7.	Ms. P K Chandravally	Technical Officer
8.	Ms. Priya George	Technical Officer
9.	Mr. Vijesh Kumar I.P	Technical Assistant
10.	Ms. N Karthika	Senior Technician
11.	Mr. O G Sivadas	Senior Technician
12.	Mr. V S Binoy	Senior Technician
13.	Mr. Vishnu B	Technician
14.	Ms. Shajina O	Technician

MULTI TASKING STAFF

1.	Mr. Abhi Balagopal K P	Multi Tasking Staff

IISR EXPERIMENTAL FARM, PERUVANNAMUZHI

TECHNICAL

1.	Mr. Pavan Gowda M	Senior Technical Officer
2.	Mr. T R Sadasivan	Senior Technical Assistant
3.	Ms. Rejina P Govind	Senior Technician
4.	Mr. Hareesh B T	Senior Technician
5.	Mr. Rasmish A R	Senior Technician
6.	Mr. Nikhil C M	Technician
7.	Mrs. P N Kausalya	Technician

ADMINISTRATIVE

1.	Mr. K Faisal	Personal Assistant

MULTI TASKING STAFF

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 (Subject Matter Specialist-Hort.)
2.	Dr. S Shanmugavel	Chief Technical Officer (Subject Matter Specialist -Vet. Sc.)
3.	Mr. K M Prakash	Chief Technical Officer (Subject Matter Specialist - Agro.)
4.	Dr. B Pradeep	Asst. Chief Technical Officer (S M Specialist - Fisheries)
5.	Ms. A Deepthi	Asst. Chief Technical Officer (S Matter Specialist (H. Sc.)
6.	Dr. K K Aiswariya	Asst. Chief Technical Officer (S Matter Specialist (Pl. Prot.)
7.	Mr. T C Prasad	Technical Officer (Driver-cum-Mechanic)
8.	Mr. C K Jayakumar	Technical Officer (Programme Assistant)(Computer)

MULTI TASKING STAFF

1.	Mr. C Ravindran	Multi Tasking Staff

IISR – REGIONAL STATION, APPANGALA

SCIENTIFIC

1.	Dr. S J Anke Gowda	Head I/C Regional Station, Appangala
2.	Dr. Balaji Rajkumar	Scientist (Agri. Entomology
3.	Dr. Muhammed Faisal Peeran	Scientist (Plant Pathology)
4.	Ms. H J Akshitha	Scientist (Spices Plantation Medicinal & Aromatic Plants)
5.	Dr. Honappa Asangi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
6.	Dr. M S Shivakumar	Scientist (Genetics & Plant Breeding)

ADMINISTRATION

1. Mr. Abdul Rasheed T K	Assistant Administrative Officer
2. 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 STAFF

1.	Sri. Marigowda	Multi Tasking Staff
2.	Mr. Sachin K.P	Multi Tasking Staff

WEATHER DATA

RAINFALL (mm)

Month	Main Campus		Regional Station		Experimental Farm	
	Total Rainfall	Rainy days	Total Rainfall	Rainy days	Total Rainfall	Rainy days
January	0.0	0	15.8	1	4.5	1
February	0.0	0	0.0	0	0.0	0
March	0.0	0	0.0	0	12.4	1
April	0.0	0	31.8	4	39.6	3
May	11.1	4	278.6	13	245.8	17
June	243.6	17	130.6	14	625.2	22
July	710.0	25	108.5	30	1269.1	30
August	38.1	6	124.2	11	154.6	12
September	569.7	20	300.2	22	601.3	20
October	256.8	13	95.8	8	290.4	13
November	200.2	11	72.2	7	419.8	13
December	52.4	3	8.0	1	60.8	5
TOTAL	**2081.9**	**99**	**2142.2**	**111**	**3723.5**	**137**

Temperature (°C)

Month	Regional Station		Experimental Farm	
	Maximum	Minimum	Maximum	Minimum
January	26.90	14.00	33.8	19.0
February	27.98	15.12	35.3	19.7
March	29.41	16.57	36.9	20.1
April	30.95	19.64	36.6	23.0
May	27.46	20.33	34.6	23.7
June	25.00	19.68	31.1	23.0
July	22.61	19.39	29.3	23.0
August	22.49	19.05	31.9	22.3
September	22.43	19.59	30.0	21.9
October	22.52	20.06	31.6	22.4
November	22.33	20.55	32.5	22.8
December	22.53	19.41	33.0	22.2
MEAN	**25.22**	**18.62**	**33.05**	**21.93**

New species of entomopathogenic fungus,
Metarhizium indicum

IISR Amrit
Mango ginger variety

भाकृअनुप
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वार्षिक प्रतिवेदन
ANNUAL REPORT

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