Annual REPORT
वार्षिक प्रतिवेदन
2020

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान
कोषिक्कोड

ICAR- Indian Institute of Spices Research
Kozhikode

वार्षिक प्रतिवेदन
Annual Report
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(ISO 9001:2015)

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान

ICAR-INDIAN INSTITUTE OF SPICES RESEARCH

(Two times winner of Sardar Patel Outstanding ICAR Institution Award)

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Correct Citation
Praveena R, Dinesh R, Prasath D, Lijo Thomas, Srinivasan V
Krishnamurthy K S and Santhosh J Eapen (Eds.) (2020)
Annual Report 2020, ICAR-Indian Institute of Spices Research
Kozhikode, Kerala, India, p.97

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

Cover Design
True Speciality Prints

Hindi Translation
Anees K & Prasannakumari N

Photographs
A Sudhakaran

ISBN: 978-81-86872-62-8
January 2021

Printers
True Speciality Prints
Kozhikode, Kerala

Front Cover Pictures
Metarhizium pingshaense conidia
Conogethes punctiferalis infected by *M. pingshaense*
Garcinia rubro-echinata
Trichoderma primed rhizomes
IISR Vajra-new ginger variety

PREFACE

It is a great honor to present the 2020 Annual Report of the ICAR-Indian Institute of Spices Research, Kozhikode, Kerala. We are a national institute with focus on spice cultivation and diversification with cutting-edge technologies and products and with a vision to make India the global leader. Our varieties enhance yield and double farmer's income, crop management plans build and maintain environment quality, diagnostics provide treatment solutions and make our crops stay healthy and our BPD-ITMU harnesses these technological innovations and fosters spicepreneurship among the startups.

The year 2020 was a bizarre year due to the pandemic. But even with the pandemic as an omnipresent backdrop, our research went on. We used the digital network to remain more connected than ever. We could even reach the NEH region and tribal areas in different states of India through networking. It has made us more committed to improving the quality of life and supporting tribal and rural populations. This has significantly broadened and deepened our institute's presence in these far flung areas. We now have strong roots and a more prominent identity that is raising both our visibility and our reputation. Besides research, during this period, we also had discussion on public health and public good and the other issues we face as societies. Of course, we did execute all the Covid guidelines issued by the Central and State Governments. So the focus was also on wellbeing, patience, flexibility, and safety.

In spite of the lockdown, significant advancements in research and development were made during the year. A new ginger variety, IISR Vajra was released, a ginger conservatory (Garden of Gingers) was established with funds from DBT, an NASF project on risk assessment of nanoparticles was initiated, a value chain incubation facility for processing of spices was inaugurated, eleven technologies were commercialized by the ITM-BPD unit and MSME recognised ICAR-IISR as host institute to setup/establish business incubation.

However, we need to greatly enhance the competitiveness of our services, promote open innovation, and create greater value–both for our farmers and society at large. This is the only way we can seize the opportunities presented by the digital and intelligent transformation of agriculture, and maintain robust growth in the long run. We now have personnel with superb skills, temperament, and experience to carry its legacy forward and to serve everyone who depend on us.

I am extremely thankful to the ICAR for the unfailing support and wholeheartedly thank Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for his guidance and encouragement. I am also highly grateful to Dr. A.K. Singh, Deputy Director General (Horticultural Science) and Dr. Vikramaditya Pandey, Assistant Director General (Hort-II) for their constant support, guidance and motivation. Special thanks to the editors for bringing out this report.

Kozhikode
30 January 2021

J. Rema
Director

OUR VISION

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

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काली मिर्च

- भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान प्रायोगिक प्रक्षेत्र, पेरुवण्णामुषि, कोषिक्कोड, केरल में जर्मप्लाज़म नर्सरी में लगभग 3467 अक्सेशनें बनाये जा रहे हैं।
- 18 जीनोटाइप को पेरिकारप की मोटाई, वसूली और जैवरासायनिक घटकों जैसे पाइपरिन, ओलिओरसिन, प्रोटीन फिनोल के रूप में दर्शाया गया था, जो पेरिकारप में शर्करा और स्टार्च सामग्री को कम करता है।
- PnLRR - RLP मार्कर को काली मिर्च - फाइटोफ्थोरा पारस्परिक संबंध के दौरान प्राप्त किया गया था और 2-डी बारकोड को सिग्नल पेप्टाइड और एलआरआर डोमेन में अद्‌वितीय परिवर्तनशीलता का उपयोग करके विकसित किया गया ।
- केएएएस-केईजीजी विश्लेषण से बेरी ट्रान्स्क्रिप्टोम से 17 महत्वपूर्ण माध्यमिक उपापचय मार्गों की पहचान की गयी।
- तीन किस्मों जैसे, आईआईएसआर थेवम, गिरिमुंडा और शक्ति के पैदावार और गुणवत्ता के लिए ड्रिप फरटिगेशन को मानकीकृत किया गया।
- स्थान विशिष्ट पोषक तत्व प्रबंधन के माध्यम से नारियल आधारित फसल प्रणाली में काली मिर्च की स्थिरता को बढ़ाने के लिए पैकेज को मानकीकृत किया गया था।
- *फाइटोफ्थोरा* न्यूक्लियस की कल्पना के लिए धुंधला प्रक्रिया एसवाईबीआर ग्रीन और प्रोपिडियम आयोडाइड डाई का उपयोग करके मानकीकृत की गई थी।
- *फाइटोफ्थोरा पिथियम* और *फुसेरियम* का एक साथ पता लगाने के लिए एक मल्टीप्लक्स पीसीआर परख विकसित की गई।
- हरे रंग के लेबल वाले कीटनाशक, क्लोरंट्रानिलिप्रोल को 0.3 मि.लि./लि. और 0.5 मि. लि./ लि. का प्रयोग और उसके बाद फ्लूबंडियामिडे और स्पिनेटोरम का उपयोग पोल्लू बीटल (*लंका रामकृष्णई)* को नियंत्रित करने के लिए प्रभावी था, जो पौधों को संक्रमण से मुक्त रखता है।

इलायची

- खेत जीन बैंक में 622 अक्सेशनें बनाये जे रहे हैं, जिसमें अप्पंगला से 423 अक्सेशनें, पांपाडुमपारा से 102 अक्सेशनें, मुडिगेरा से 41 अक्सेशनें तथा सकलेशपुर से 56 अक्सेशनें शामिल है।
- छः जीनोटाइप (आईसी 349537, आईसी 584058, जीजीxएनकेई-12, आईसी 584078, सीएल 668, एचएस 1, आईसी 584090) के साथ एक चैक (अप्पंगला1) को सूखे सहिष्णुता के लिए मूल्यांकन किया गया।

- निश्चित लक्षित उपज के लिए मृदा में पोषण अपेक्षाओं का पूर्वानुमान करने हेतु विभिन्न उर्वरता स्तरों के साथ लक्षित उपज समीकरण को न्यूनतम विचलन के साथ मानकीकृत किया गया था।
- दो आईसोथेरमल आणविक परख अर्थात्, रिवेर्स ट्रान्स्क्रिप्टेस लूप मीडियेटड आईसोथेरमल एम्प्लिफिकेशन (आरटी-एलएएमपी) और रिवेर्स ट्रान्स्क्रिप्टेस रीकोम्बिनेस एम्प्लिफिकेशन (आरटी-आरपीए) को सीडीवीसीवी का पता लगाने के लिए विकसित किया गया।

अदरक

- खेत जीन बैंक में 668 अक्सेशनों को बनाए गए हैं।
- एक नई किस्म, आईआईसआर वज्रा, एक क्लोनल चयन (अक्से. 247) का विमोचन किया गया, जो मोटे और प्लंपी प्रकंद, कम रेशा (5.67%) और उच्च उपज क्षमतावाली (26.38 टन हेक्टर) है।
- भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान में एक नई संरक्षिका (अदरक का गार्डन) की स्थापना की गई।
- उच्च तीखे सिद्धांतों जिंजरोल (1.92%) और शोगल (0.55%) के साथ उच्च एसनश्यल तेल (4.3%) के साथ एक बेहतर लाल अदरक जीनोटाइप की पहचान की गई है।
- जीवाणुक प्रतिपक्षी *बासिलस सफेन्सिस* (आईआईएसआर टीबी4) और *बी. सेरेस* (आईआईएसआर जीबी 7 (3)) ने मृदु गलन रोगकारक *पाइथियम मिरियोटिलुम* और पर्ण रोगजनक *कोलेटोट्राइकम ग्लोयिस्पोरियोयिड्स* और *एक्सरोहिलुम रोस्ट्राटम*) का उच्च दमन दिखाया।
- *ट्राइकोडर्मा* स्पीसीस के साथ प्रकंदों को भड़काने के लिए एक प्रोटोकॉल अंकुरण प्रक्रिया को विनियमित करने के लिए, भंडारण के दौरान सूखे सड़ांध रोगजनकों की वृद्धि को रोकने के लिए, कलियों की ताकत में सुधार करने के लिए और बीज प्रकंदों की एक समान जुताई प्रदान करने के लिए विकसित किया गया।
- दो आईसोथेरमल परख, RT-LAMP और RT-RPA को विकसित किया गया जो GCFaV-1 और GCFaV-2 के त्वरित पता लगाने के लिए विधिमान्य थे।

हल्दी

- खेत जीन बैंक में लगभग 1404 अक्सेशनों को बनाए जा रहे हैं और जर्मप्लाज़म संरक्षिका में अंडमान द्वीप समूह से तीन नये कुरकुमा लोंगा और पांच कुरकुमा स्पीसीस को जोड़कर समृद्ध बनाया था।
- हल्दी के 155 अक्सेशनों, आठ किस्मों और चार जीआई (ईरोड हल्दी, सांगली हल्दी, वाइगन हल्दी और कंधमल हल्दी) को विभिन्न गुणवत्ता पैरामीटर्स के लिए चरित्रांकित की गई और उनके कुरकुमिन की मात्रा में 0.6% से 5.2% का अंतर है।
- तुलनात्मक ट्रान्स्क्रिप्टोम विश्लेषण के माध्यम से bHLH, WD 40, NAC, WRKY and bZIP वर्गों के बीस टीएफ की पहचान की गई थीं।

- विभिन्न प्रबंधन प्रणालियों के मूल्यांकन से संकेत मिलता है कि जैविक प्रणाली (100%) ने अधिकतम उपज (34.78 टन/हेक्टर) अंकित की, जिसके बाद एकीकृत प्रणाली (50%+50%) (31.8 टन/हेक्टर)। बारह किस्मों में, सुगुणा ने उच्चतम उपज (40.8टन/हेक्टर) अंकित की तत्पश्चात् प्रगति 38.6टन/हेक्टर)
- हल्दी दूध की तैयारी के लिए हल्दी, अदरक और दालचीनी के साथ एक नवीन मसाला संयोजन को विकसित किया गया; एक हल्दी स्वाद युक्त तुरंत उपयोग करने वाले है और दूसरा तुरंत मिक्स पाउडर के रूप में हल्दी दूध है। प्रौद्योगिकियों को मिल्मा में व्यावसायीकरण किया गया।
- *कोनोगीथस पंक्टिफरालिस* से एक कीटाणुनाशक कवक को वियुक्त किया गया और उसे रूपवैज्ञानिक लक्षणों और आणविक अध्ययनों के आधार पर *मेटारहिज़ियम पिंग्शेन्से* के रूप में पहचान की गई।
- सूत्रकृमियों के संक्रमित हल्दी प्रकंदों को ठंडे जगह में संचित करने के फलस्वरूप यह सूचित होता है कि सूत्रकृमि संक्रमित प्रकंदों को 35 दिन ठंडे जगह (4-8^{0}c) संचित करने पर साधारण तापमान की अपेक्षा सूत्रकृमियों का मृत्यु दर 100% हो गये।

वानिला

वानिला प्लानिफोलिया के 65 अक्सेशनें, अंडमान से 7 वानिला स्पीसीस, वानिला पीलिफेरा, वानिला अफिल्ला, वानिला टहिटेन्सिस और वानिला वाइटियाना के एक एक, वयनाड से दो स्पीसीस, असम से एक स्पीसीस और लिटिल अंडमान से तीन स्पीसीस को वानिला संरक्षिका में जोड दिया गया।

वृक्ष मसाला

- जायफल के लंबे फलों के साथ एक उच्च उपजवाली मोनोशियस प्रकार, एक मोनोशियस अक्सेशन जो गुच्छों में फल लगाती है और उच्च उपजवाली मादा अक्सेशन है जिसे कर्नाटक के सिरसी से एकत्र किया गया।
- स्थान विशिष्ट पोषक तत्व प्रबंधन के माध्यम से नारियल आधारित फसल प्रणाली में जायफल की स्थिरता को बढ़ाने के लिए एक पैकेज विकसित किया।
- अंडमान और निकोबार द्वीप समूह से दालचीनी के चार अक्सेशनों और दो वन्य स्पीसीसों को एकत्र किया गया था। अगस्त्यमला बयोस्फियर रिज़र्व, केरल से सिनमोमम वलाइवरेस और सी. केमुंगियानम को एकत्र किया गया।
- केरल के कट्टिप्पारा से मोटे कलियों वाले लौंग अक्सेशन, अगस्त्यमला बयोस्फियर रिज़र्व, केरल से सिज़िजियम और अंडमान और निकोबार द्वीप समूह से 5 वन्य स्पीसीस को एकत्र करके संरक्षित किया गया।
- अंडमान और निकोबार द्वीप समूह से गार्सीनिया के छः स्पीसीस, अगस्त्यमला बयोस्फियर रिज़र्व, केरल से गार्सीनिया के 5 स्पीसीस और एक वन्य अक्सेशन, त्रिशूर और निलंबूर से जी. गम्मिगट्टा

के दो उच्च उपज वाले अक्सेशन, जी. इंडिका के उच्च उपजवाले लाल फलों युक्त एक अक्सेशन और सिरसी से पीले फलों वाले दो अक्सेशन को संचित करके संरक्षित किया गया।

- जीसी-एमएस विश्लेषण से पता चला कि यूज़ीनोल, मिरसेन चाविकोल और लिमोनेन पिमेंटा रसिमोस की पत्तियों, बरियों और फलों के डंठल में बाष्पशील घटक।

सामान्य

- भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान काली मिर्च, अदरक, हल्दी तथा छोटी इलायची के लिए नोडल डीयुएस परीक्षण केंद्र है और केंद्र ने 19 हल्दी प्रजातियों और 7 अदरक प्रजातियों के लिए डीयुएस परीक्षण पूरा किया।
- डीएनए फिंगर प्रिंटिंग और बारकोडिंग सुविधा ने इलायची, अजवाइन और निगेल्ला में डीएनए वियुक्तीकरण और पीसीआर प्रोटोकॉल को अनुकूलित किया गया। काली मिर्च प्रजातियों के फिंगर प्रिंटिंग के लिए छः पोलीमोरफिक आईएसएसआर प्राइमर्स की पहचान की गयी और उसको लघु सूचिबद्ध किया गया।
- जीवाणु वियुक्तियों जैसे, बी. सफेन्सिस (आईआईएसआर टी बी 4), बी. मारिसफ्लेवी (आईआईएसआर जीबी 6), बी. सेरेस (आईआईएसआर जीबी 7) कुशलतापूर्वक तरल और मिट्टी मे ट्राई कैल्शियम फॉस्फेट (टीसीपी) से घुलित होते है।
- एक डायरी यूनिट के साथ मसालों सहित विभिन्न घटक फसलों के साथ स्थापित कृषि प्रणाली मोडल प्लोट एक एकड़ से 1.66 लाख रुपए के लाभ के साथ 415 श्रमिक दिन/वर्ष का रोज़गार पैदा करता है।
- अदरक किस्मों (महिमा, वरदा) के सूक्ष्म प्रकंदों को उपसंस्कृत किया गया और अदरक के 2200 पौधे उगाए गए थे और नर्सरी के तहत प्रोट्रे और पोली बैग में कठोर किये जा रहे है।कठोरीकृत 500 सूक्ष्म प्रकंदों को ग्रो बैग में विकसित किया गया था और 11 महीने में प्रत्येक क्लंप से 300-500 ग्राम ताज़े प्रकंदों की उपज प्राप्त हुई है।
- काली मिर्च (आईआईएसआर श्रीकरा) के जड़ लगाए कतरनों को एएमएफ के साथ जोड़ा जाता है, जिसमें असिंचित नियंत्रण की तुलना में उच्च जड़ लंबाई, प्ररोह लंबाई और सूखी बयोमास दिखाया गया है और टीका लगाने के 30, 60, 90, 120 और 150 दिनों में एरियल बयोमास की अपेक्षा रूट बयोमास में अधिक प्रमुख थे।
- सूत्रकृमि प्रतिपक्षी कवक, पी. क्लामीडोस्पोरिया ने काली मिर्च के जड़ों के उपनिवेशन में 7वें दिन से 28वें दिन तक टीकाकरण के बाद लगातार वृद्धि दिखाई, जो कवक के एंडोफाइटिक उपनिवेशन को सूचित करता है।
- बी. सफेन्सिस, बी. मरिसफ्लेवी और प्स्यूडोमोनस एरुगिनोसा जैसे जीवाणु को तरल परख में अलग करता है जिसमें फोस्फोरस (ट्राइकैल्शियम फोस्फेट) और ज़िंक (Zno) के अघुलनशील

सबस्ट्रेट होता है और जिसमें क्रमशः 793, 317 और 347 µg/mL और 404, 269 और 566 µg/mL का अधिकतम कार्बणिक अम्ल उत्पादन होता है।

- प्रयुक्त उर्वरकों का कार्बन समतुल्य (सीई) 2000, 2010 और 2019 में क्रमशः 156.6, 247.6 और 297.6 Gg थे और उपयोग किये गये कीटनाशक 926.6, 936.7 और 584.4 Mg थी।
- 2018-19 तक मसालों के उत्पादन की निरंतर गिरावट दर लगातार पिछले तीन दशकों के दौरान खाद्याहन और तिलहन की तुलना में लगातार अधिक रही है, जो प्रौद्योगिकी के बेहतर विकास और परिणामी उत्पादन वृद्धि को बेहतर बनाता है।
- 1997 से 2018 की अवधि के लिए थोक मूल्यों में मिर्च, काली मिर्च, अदरक और हल्दी जैसे प्रमुख मसालों के लिए 2007 के बाद मूल्य अस्थिरता में स्पष्ट गिरावट का संकेत दिया गया।
- उत्तर पूर्व राज्यों में मसाला क्षेत्र के विकास में जनजातीय आबादी के लिए क्षमता निर्माण और फ्रंटलाइन हस्तक्षेप कार्यक्रम और गोलपारा और कामरूप जिलों और अरुणाचल प्रदेश में नामसाई जिला और ऑंध्रप्रदेश में विशाखपत्तनम जिले में आदिवासी सशक्तीकरण को आदिवासी उपयोजना (टीएसपी) और विशेष घटक योजना (एससीपी) के तहत लिया गया था।

राष्ट्रीय महत्व के कार्यक्रम

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान के तीनों केंद्रों जैसे, आईआईएसआर मुख्यालय, चेलवूर, कोषिक्कोड, क्षेत्रीय स्टेशन अप्पंगला और प्रायोगिक प्रक्षेत्र, पेरुवण्णामुषि में 27 अक्तूबर 2020 से 2 नवंबर 2020 तक सतर्कता जागरूकता सप्ताह मनाया गया। सार्वजनिक जीवन में अखंडता, पारदर्शिता और जवाबदेही को बढ़ावा देने के लिए तथा आधारित भ्रष्टाचार को रोकने के लिए एक सतर्क समाज की आवश्यकता हेतु 'सतर्क भारत, समृद्ध भारत' विषय पर कार्यक्रम आयोजित किए गए थे।

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

Black pepper

- Around 3467 accessions are being maintained in the germplasm nursery at the ICAR-IISR, Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala.
- 18 genotypes were characterized for pericarp thickness, dry recovery and biochemical constituents such as piperine, oleoresin, protein, phenols, reducing sugars and starch content in pericarp.
- The PnLRR–RLP marker was derived during black pepper – *Phytophthora* interaction and 2-D barcodes were developed using the unique variability in the signal peptide and LRR domain.
- The KAAS-KEGG analysis identified 17 important secondary metabolite pathways from the berry transcriptome.
- Drip fertigation schedules for three varieties (IISR Thevam, Girimunda and Shakthi) were standardized for yield and quality.
- Package for enhancing sustainability of black pepper in coconut based cropping system through site specific nutrient management was standardized.
- Staining procedure for visualizing *Phytophthora* nuclei was standardized using SYBR green and propidium iodide dye.
- A multiplex PCR assay was developed for simultaneous detection of *Phytophthora*, *Pythium* and *Fusarium*.
- Green labelled insecticide, chlorantraniliprole was effective in controlling the pollu beetle (*Lanka ramakrishnai*) at 0.3 and 0.5 mL/L followed by flubendiamide and spinetoram.

Cardamom

- 622 accessions are being maintained in the field gene bank which consists of 423 accessions from Appangala, 102 accessions from Pampadumpara, 41 accessions from Mudigere and 56 accessions from Sakaleshapur.
- Six genotypes (IC 349537, IC 584058, GG×NKE-12, IC 584078, CL 668, HS 1, IC 584090) with one check (Appangala 1) were evaluated for drought tolerance.
- Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations.
- 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.

Ginger

- 668 accessions are being maintained in the field gene bank.
- A new variety, IISR Vajra a clonal selection (Acc. 247) with bold and plumpy rhizomes, less fibre (5.67%) and high yield potential (26.38 t/ha) was released.
- A new conservatory (Garden of Gingers) was established at ICAR-IISR, Kozhikode

- 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.
- The bacterial antagonists *Bacillus safensis* (IISR TB4) and *B. cereus* (IISRGB7 (3) showed higher suppression of soft rot pathogen, *Pythium myriotylum* and foliar pathogens, *Colletotrichum gloeosporioides* and *Exserohilum rostratum*.
- A protocol for priming rhizomes with *Trichoderma* spp. was developed to regulate the germination process, prevent the growth of dry rot pathogens during storage and to provide uniform tillering of seed rhizomes.
- Two isothermal assays, RT-LAMP and RT-RPA assays were developed and validated for the quick detection of GCFaV-1 and GCFaV-2.

Turmeric

- Around 1404 accessions are being maintained in the field gene bank and the germplasm conservatory was enriched with three new *Curcuma longa* and five *Curcuma* sp. from Andaman Islands.
- 155 accessions, eight varieties and four GIs (Erode turmeric, Sangli turmeric, Waigon turmeric and Kandhmalhaldi) were characterized for different quality parameters and their curcumin content varied from 0.6 to 5.2%.
- Twenty TFs belonging to the classes bHLH, WD 40, NAC, WRKY and bZIP that showed differential expression with respect to curcumin were identified through comparative transcriptome analysis.
- Evaluation of different management systems indicated that organic system (100%) recorded maximum yield (34.78 t/ha) followed by integrated system (50%+50%) (31.8 t/ha). Among the twelve varieties, Suguna recorded highest yield (40.8 t/ha) followed by Pragati (38.6 t/ha).
- 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 MILMA.
- Spraying of low risk insecticides *viz*., chlorantraniliprole, flubendiamide and spinosad at fortnightly intervals rather than spraying at monthly intervals is more effective in controlling the shoot borer.
- An entomopathogenic fungus was isolated from *Conogethes punctiferalis* and identified as *Metarhizium pingshaense* based on morphological characteristics and molecular studies.
- Effect of cold storage of rhizomes on lesion nematodes indicated that nematode infested rhizomes stored in a cold storage (4-8˚C) for 35 days resulted in 100% mortality of nematodes compared to room temperature.

Vanilla

- 65 accessions of *Vanilla planifolia*, seven *Vanilla spp*. from Andaman, one each of *V. pilifera, V. aphylla, V. tahitensis* and *V. wightiana,* two species from Wayanad, one

species from Assam and three species from Little Andamans were added to the conservatory.

Tree spices

- A high yielding monoecious line with long fruits, a monoecious accession which bears fruits in clusters and a high yielding female accession of nutmeg were collected from Sirsi, Karnataka.
- Developed a package for enhancing sustainability of nutmeg in coconut based cropping system through site specific nutrient management.
- Four accessions of cinnamon and two wild species were collected from Andaman and Nicobar Islands. *Cinnamomum walaiwarense* and *C. chemungianum* were collected from Agasthyamala Biosphere Reserve, Kerala.
- Clove accession with bold flower bud from Kattippara, Kerala, a wild species of *Syzygium* from Agasthyamala Biosphere Reserve and five wild species from Andaman and Nicobar Islands were collected and conserved.
- Six species of *Garcinia* from Andaman and Nicobar Islands, five species of *Garcinia* and a wild accession of *G. gummi-gutta* from Agasthyamala Biosphere Reserve, two high yielding accessions of *G. gummi-gutta* from Thrissur and Nilambur, a high yielding accession of *G. indica* with red fruits and two accessions with yellow fruits from Sirsi were collected and conserved.
- GC-MS analysis showed that eugenol, myrcene, chavicol and limonene were the volatile constituents in leaves, berries and fruit stalk of *Pimenta racemose*.

General

- ICAR-IISR is the nodal DUS testing centre for black pepper, ginger, turmeric and small cardamom and the centre completed DUS testing for 19 turmeric varieties and seven ginger varieties.
- The DNA Fingerprinting and Barcoding Facility optimized the DNA isolation and PCR protocols in cardamom, ajowain and nigella. Six polymorphic ISSR primers for fingerprinting varieties of black pepper were identified and shortlisted.
- The bacterial isolates *viz*., *B. safensis* (IISR TB4), *B. marisflavi* (IISR GB6), *B. cereus* (IISR GB7) efficiently solubilized 'P' from tricalcium phosphate (TCP) in liquid and in soil *per se*.
- The farming system model plot established with different component crops including spices along with a dairy unit generated employment of 415 man days/year with a profit of Rs 1.66 lakhs from one acre.
- Microrhizome of ginger varieties (IISR Mahima, IISR Varada) were subcultured and 2200 plantlets of ginger were raised in cultures and being hardened in protrays and poly bags under nursery. Five hundred hardened micro rhizomes were raised in grow bag conditions and 300-500 g fresh rhizome yield was realized from each clump in 11 months cycle.
- Rooted cuttings of black pepper (IISR Sreekara*)* inoculated with AMF showed significantly higher root length, shoot length and dry biomass when compared to

uninoculated control and it was more prominent in root biomass than aerial biomass at 30, 60 and 90, 120 and 150 days after inoculation.

- The nematode antagonistic fungus, *P. chlamydosporia* showed steady increase in colonization of black pepper roots from 7th day to 28th day post inoculation indicating the endophytic colonization ofthe fungus.
- The bacterial isolates *B. safensis*, *B. marisflavi* and *Pseudomonas aeruginosa* in liquid assay with insoluble substrate of P (Tricalcium phosphate) and Zn (ZnO) showed maximum organic acid production of 793, 317 and 347 µg/mL and 404, 269 and 566 µg/mL, respectively.
- The carbon equivalence (CE) of the used fertilizers is 156.6, 247.6 and 297.6 Gg in 2000, 2010 and 2019, respectively and of the pesticides used were 926.6, 936.7 and 584.4 Mg.
- The continuous decadal growth rate of output of spices till 2018-19 has been consistently above that of food grains and oilseed during the last three decades implying a better rate of technology uptake and resultant output growth.
- The wholesale prices for the period 1997 to 2018 indicated a clear decline in price instability after 2007 for major spices like chillies, black pepper, ginger and turmeric.
- Capacity building and frontline intervention programmes for tribal population in spices sector development in NE states and tribal empowerment in Golpara and Kamrup districts and in Arunachal Pradesh, Namsai district and Vishakapatanam district in Andhra Pradesh were taken up under Tribal sub plan (TSP) and Special Component Plan (SCP).

PROGRAMMES OF NATIONAL IMPORTANCE

- Vigilance Awareness Week was observed from 27 October 2020 to 02 November 2020 in all the three campuses of ICAR-IISR namely, IISR headquarters at Chelavoor, Kozhikode; Regional station at Appangala and Experimental Farm at Peruvannamuzhi. Programmes were organized to promote integrity, transparency and accountability in public life and the need for having a vigilant society to prevent corruption based on the theme “Vigilant India, Prosperous India”.
- Swachhta Hi Sewa programme was organized at ICAR-IISR, main campus, ICAR-IISR Experimental Farm, Krishi Vigyan Kendra, Peruvannamuzhi and ICAR-IISR Regional Station, Appangala from 11 September to 02 October 2020. Various programmes including cleaning the institute premises, laboratories, collection and segregation of plastic wastes, creating awareness among the general public, farmers and students about Hygienic life and Covid-19 were conducted.
- Swachhta Pakhwada 2020 was organized at ICAR-IISR, main campus, ICAR-IISR Experimental Farm, Krishi Vigyan Kendra, Peruvannamuzhi and ICAR-IISR Regional Station, Appangala from 16 to 31 December 2020.

INTRODUCTION

History

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

Location

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

Mandate

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

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

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

Organization

The Director is the administrative head of the institute. The Institute Management Committee, Research Advisory Committee and Institute Research Council assist the Director in matters relating to management and research activities of the institute. Research on various aspects of the mandate crops is conducted in three divisions, namely, Division of Crop Improvement and Biotechnology, Division of Crop Production

and Post Harvest Technology and Division of Crop Protection and a Social Sciences Section. The other facilities available at the institute include Agricultural Technology Information Centre,Agricultural Knowledge Management Unit,Bioinformatics Centre and Krishi Vigyan Kendra. The institute also functions as the headquarters for the All India Coordinated Research Project on Spices (AICRPS). The institute has also linkages with several universities, research institutes, and developmental agencies for collaborative research and developmental activities in spices.

Budget

The total budget of the institute was ₹ 2240.07 lakhs during the year. The institute earned total revenue of 76.52 lakhs through sale of planting materials, biocontrol agents, trainings, publications and consultancy services etc.

Staff

The institute has a sanctioned strength of 48 scientific, 35 technical, 24 administrative and 31 supporting staff, of which 36, 25, 12 and 6 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.

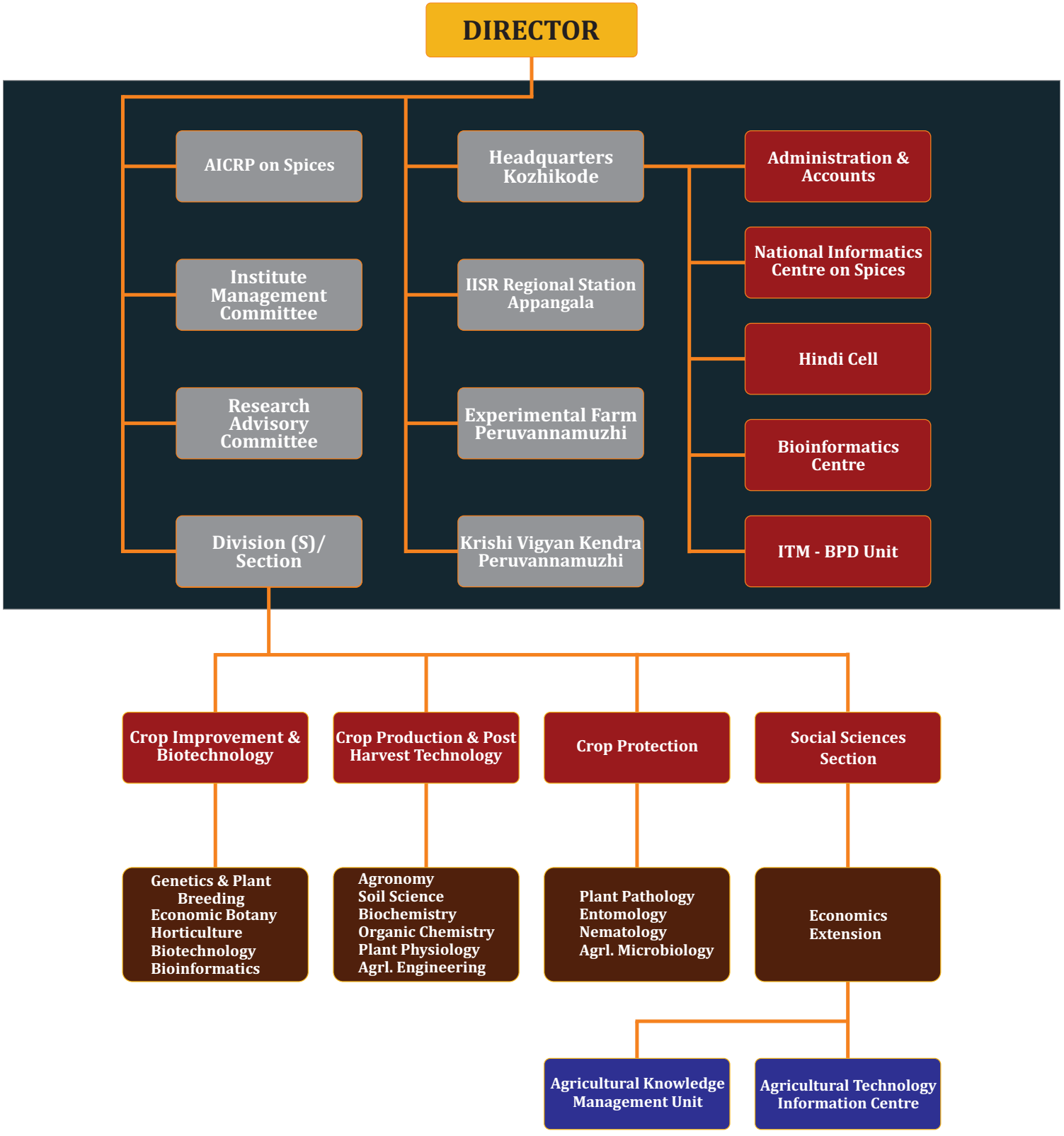
Staff position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientific	47+1	28	2	06	36	11+1
Technical	35	14	07	04	25	10
Administrative	24	11	0	01	12	12
Supporting	31	02	01	03	06	25
Total	137+1	55	10	14	79	58+1

Staff position of KVK

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientific	01		01		01	-
Technical	11	-	09	-	09	02
Administrative	02	-	01	-	01	01
Supporting	02	-	02	-	02	-
Total	16	-	13	-	13	03

ORGANIZATIONAL CHART



PAST ACHIEVEMENTS

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PAST ACHIEVEMENTS

Black pepper

Germplasm collections are being maintained at ICAR-IISR, Chelavoor; Experimental Farm, Peruvannamuzhi as well as in alternate sites (Appangala and Chettalli of Karnataka). About 3467 accessions are presently being maintained. Nine improved varieties such as Sreekara, Subhakara, Panchami, Pournami, PLD-2, IISR Thevam, IISR Girimunda, IISR Malabar Excel and IISR Shakthi have been released. Three accessions, INGR 8099- *P. thomsonii* (IC 398863) - for its unique character for sex change and INGR 8100- *P. nigrum* (IC 563950) – a novel spike variant with proliferating spikes, and IC-0619910, for its unique spike length were registered with NBPGR, New Delhi.

Microsatellites developed for *Piper* species were successfully used to detect polymorphism in black pepper cultivars. 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 *P. 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, hybrids, land races and farmers selection were characterized based on traits like spike length, number of mature berries/spike, dry seed weight, fresh seed weight and berry weight showed high positive correlation with spike weight.

The adoption of site-specific soil fertility management helped in increasing the productivity of black pepper besides enhancing soil quality. Soils from all the 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 with minimum deviations in black pepper. Irrigating pepper vines once in a fortnight from March to May months at the rate of 50L/vine enhanced yield substantially. Drip fertigation schedules for three black pepper varieties IISR Thevam, Girimunda and Shakthi have been standardized. Quality analysis of black pepper genotypes indicated that the total alkaloid content (mg/g) ranged from 16.7 (Panniyur 4) to 35.7 (Subhakara). Oleoresin was negatively correlated with bulk density (r= –0.49) but positively correlated with essential oil content (r=0.44) and piperine content (r= 0.71). 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 non-exclusively licensed.

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 *Phytophthor*a further revealed that isolates shared the characters of both *P. capsici* and *P. tropicalis*. A RNA virus, Cucumber mosaic virus (CMV) and a DNA virus, Piper yellow mottle virus (PYMoV) were found to be associated with stunted disease of black pepper. A method for simultaneous isolation of RNA and DNA from infected black pepper plants and multiplex PCR for simultaneous detection of CMV 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. A novel molecular assay based on recombinase polymerase amplification (RPA) was developed for the detection of *P. capsici* and *P. tropicalis* infecting black pepper.

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 *T. harzianum* and aerial spray with 1% Bordeaux mixture was 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 safe deposited in NAIMCC, NBAIM, Mau for future reference. 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 non-exclusively 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 EC50 and EC90 values ranged from 0.0002 to 14.4 ppm and 1.1-68.5 ppm, respectively. PCR based techniques were developed for identification of traded black pepper and to detect adulterants in commercial black pepper powder. The existence of fungicide sensitive or resistant isolates among the field populations of *C. gloeosporioides* infecting black pepper was noticed in Pollibetta and the isolate from this locality was tolerant to

recommended doses of Bordeaux mixture and carbendazim. Post-harvest technologies for drying, processing, storage and production of value-added product 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* (Is. No. 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.

Climate analogues sites were identified for cultivation of pepper in newer areas to reduce climate change effects on production. Impact studies on adoption of IISR varieties of black pepper in farmers' fields indicated that the mean yield for high yielding varieties was 1160 kg/ha with the adoption of scientific packages as compared to 620 kg/ha for traditional varieties. The estimated cost benefit ratio was 2.48. 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.

The facility for DNA fingerprinting and barcoding was established for undertaking fingerprinting services to facilitate varietal release from AICRPS centres. So far 25 varieties of spices have been fingerprinted and uniqueness was established for the new varieties in comparison with its closely related varieties.

Cardamom

Germplasm collections (622) 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 accessions. Meanwhile, four germplasm accessions bearing unique characters have been registered with NBPGR, New Delhi. The improved varieties such as Appangala-1, IISR Vijetha, IISR Avinash and Appangala-2 (hybrid) have been developed. Coupled with production technologies, these varieties resulted in increasing productivity of cardamom.

Molecular profiles were developed for 100 accessions of small cardamom germplasm using 25 ISSR markers for studying the genetic diversity. Molecular profiling of Indian cardamom revealed the existence of two genetically distinct clusters such as "Kerala cluster" and "Karnataka cluster' among the germplasm collections. Characterization of

export grade cardamoms from India, Sri Lanka and Guatemala based on physical, biochemical parameters and molecular techniques revealed the superiority of Indian produce. GC-MS study confirmed superiority of Indian cardamom over Guatemalan and Sri Lankan cardamom. High production technology has been standardized. Drip irrigation and sprinkler irrigation once in 12 days significantly improved yield attributing characters. Soil and water conservation measures have been standardized in cardamom based cropping system. Organic packages and GAP have been developed and standardized. Cardamom accessions APG 257, APG 414 and APG 434 were found to be promising for drought tolerance.

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

The survival of *C. gloeosporioides* infecting cardamom in infected plant part (leaves) was studied under laboratory, greenhouse and field conditions. A new bacterial wilt disease on small cardamom was noticed in Wayanad, Kerala. The causative organism was identified as *R. 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 significantly inhibit thrips, *Sciothrips cardamomi* and also promote plant growth. Field screening of 180 cardamom germplasm accessions for three years at Appangala resulted in identification of eight accessions resistant to cardamom thrips. Different morphological traits such as panicle type, persistence of bract and nature of adherence of leaf sheath were found to impart resistance against thrips. A novel soil pH based micronutrient mixture for enhancing growth, yield and quality of cardamom has been developed and non-exclusively licensed.

Ginger

Around 668 accessions are being maintained in field germplasm conservatory. Three varieties namely, IISR Varada, IISR Rejatha and IISR Mahima were released for their high yield and quality. 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. Identified three potential mutants through gamma ray irradiation which showed resistant reaction against bacterial wilt caused by *R. solanacearum*. A relationship between leaf P/Zn ratio and soil P/Zn ratio to rhizome yield has been established. Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations. The economic optimum in terms of profitable

response for money invested was found to be ₹ 3.75/bed for N, ₹ 1.30 /bed for P and ₹ 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 non-exclusively licensed.

Post-harvest technologies for processing and technologies for preparation of value added products were standardized. Comparison of essential oil constituents of fresh and dry rhizomes indicated that fresh rhizomes contained higher level of monoterpenes namely, Z-citral and E-citral whereas the dry rhizomes were predominated by the sesquiterpene hydrocarbons *viz.*, zingiberene, farnesene and sesquiphellandrene. Indian mango ginger, *Curcuma amada* was found to be free from bacterial wilt even under inoculated conditions. The species of *Pythium* causing rhizome rot of ginger in Kerala, Karnataka, Uttar Pradesh and Sikkim was identified as *P. myriotylum.*

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

Seed treatment and three rounds of foliar spraying with tebuconazole (0.1%) at 15 days' interval were 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.

The life cycle of shoot borer (*Conogethes punctiferalis*) was studied on six resistant and six susceptible accessions. The infectivity of EPNs strains IISR-EPN 01 to 08 was testedagainst 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 (0.3 mL/ litre of water) tested. The combination of chlorantraniliprole and

spinosad was also equally effective in managing the insect.The improved varieties and technologies developed on cropping system, nutrient and water requirement, pest and disease management and post-harvest processing techniques were disseminated to farmers and other agencies through publications, training programmes and demonstrations. Large scale multiplication and distribution of elite planting material were also undertaken.

Turmeric

The germplasm with over 1404 accessions is being conserved in the field gene bank. These have been characterized for yield, quality, and resistance to pests, diseases and drought. Seven high curcumin and high yielding varieties, Suvarna, Sudarsana, Suguna, IISR Prabha, IISR Prathibha, IISR Alleppey Supreme, IISR Kedaram and IISR Pragati 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. zedoaria* 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, de methoxy curcumin and bis de methoxy curcumin) could be separated from oleoresin by employing chromatographic techniques. Turmeric 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 unraveled and micro RNAs that showed differential expression with respect to curcumin in turmeric accessions with contrasting curcumin content have been identified.

Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations. The economic optimum in terms of profitable response for money invested was found to be ₹ 0.65/bed for N, ₹ 0.40/bed for P and ₹ 0.85/bed of $3m^2$ for K. Increase in curcumin content was recorded when sprayed with micro nutrients like Zn and B. The optimum spacing, nutrient and water requirement were standardized for different soils and 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 by Pragati (22.1 t/ha) followed by Kanthi (19.2 t/ha). Higher oil content was noticed in varieties Prathibha (6.0%), 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 non-exclusively licensed.

Basic data on distribution, bioecology, population dynamics of shoot borer (*C. punctiferalis*) and its natural enemies and crop loss due to shoot borer was generated. Lamda cyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer. The improved varieties and technologies were disseminated to farmers and other agencies through publications and demonstrations. The adoption of released varieties like IISR Prathiba in Andhra Pradesh, Karnataka and Tamil Nadu were studied. A novel soil pH based micronutrient mixtures for enhancing growth, yield and quality of turmeric, ginger, black pepper and cardamom were developed.

New generation insecticides such as spinosad, flubendiamide and chlorantraniliprole were effective in the management of turmeric shoot borer (*C. punctiferalis*) even at the lowest dose (0.3 mL/L of water) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect.

Tree spices

The germplasm of important tree spices like nutmeg, clove, cinnamon including cassia, garcinia and allspice are being conserved. IC Numbers for cinnamon, clove, nutmeg and allspice accessions were obtained from NBPGR, New Delhi. Cassia C1 (IC 370415) has been registered as INGR 05029 with NBPGR, New Delhi for its high oleoresin content (10.5%) besides a dwarf clove accession. The cassia elite line A1 (IC 370400) has been registered with NBPGR for high cinnamaldehyde content in bark oil (81.5%) and leaf oil (80.5%). Two high quality cinnamon varieties, Navashree and Nithyashree and a nutmeg variety, 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 *M. fragrans* rootstock with 90-100% success.

GC-MS study revealed the presence of two chemotypes in *Cinnamomum verum*. Drying and processing methods for cinnamon, nutmeg and mace have been developed. 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.

Vanilla

Vanilla germplasm are being maintained in the repository, which includes a flower colour variant collected from Andaman and Nicobar islands. Comparative anatomical analysis of different vanilla species was carried out. Interspecific hybridization was made between *Vanilla planifolia* and *V. aphylla*. Reciprocal crosses were conducted between *V. planifolia* and *V. tahitensis* (species reported as resistant to root rot disease) and high percent of fruit set was observed in both the crosses. Fifty interspecific hybrids each of *V. planifolia* x *V. tahitensis*, *V. tahitensis* x *V. planifolia* and selfed progenies of V. tahitensis were established ex vitro. Chromosome number analysis of two interspecific hybrids between *V. planifolia* and *V. tahitensis* showed 2n=30 in one (PT-5) and 2n=32 in other (PT-17).

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

Paprika

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

Awards

Besides numerous individual fellowships and awards to scientists, the institute has been awarded twice with the Sardar Patel Outstanding ICAR Institution Award (1999 & 2009) and recently our 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 are Rajbhasha Shield Award 2013, 2014 & 2015, Best official Language Magazine Award 2015 for *Masalon Ki Mehak*, ICAR Swachhta Pakhwada Award Second Prize 2018 etc. Institute received three patents for the designer micro-nutrient formulations developed for ginger and turmeric.

RESEARCH ACHIEVEMENTS 2020

RESEARCH ACHIEVEMENTS-2020

Black pepper

Genetic resources

Around 3467 accessions are being maintained at the germplasm nursery at the Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala. At present the field genebank at CHES, Chettalli, Karnataka holds 627 accessions. A unique black pepper accession with extra-long spike of 34.5 cm was collected from the estate of Tata Coffee, Madikeri, Karnataka. A joint exploration program conducted along with ICAR-NBPGR, Trichur, Kerala to Andaman and Nicobar Islands and nine accessions of *Piper* spp (*Piper pedicellosum*, *P. miniatum*, *P. wallichi*, *P. sarmentosum* and *P. betle*) were collected.

Characterization

Germplasm accessions (82 nos) collected from Karnataka, Kerala, Goa and Maharashtra were characterized for 17 quantitative and 12 qualitative traits. Wide range and high coefficient of variation (CV) was recorded for dry berry weight, fresh berry weight and number of spikes vine^{-1} whereas, lower CV was observed for berry size.

Breeding

Black pepper genotypes (18 nos) were characterized for pericarp thickness, dry recovery and biochemical constituents and grouped into thin and thick pericarp groups. The genotypes differed substantially for both pericarp thickness and dry recovery (%) (Fig 1). Berries of IISR Malabar Excel had the thickest pericarp, while the berries from Agali and Nedumchola had the thinnest pericarp. Dry recovery ranged from 26.30 to 43.24%.

Pericarp contained 0.38 to 0.66% and 1.60 to 4.35% of piperine and oleoresin, respectively. Piperine content in the pericarp was higher in the thick pericarp genotypes such as IISR Malabar Excel while oleoresin was high in Kalluvally. Protein content in pericarp varied from 5.5 to 18.3%. Higher percentage of protein was found in Nedumchola and IISR Malabar Excel. Phenols in pericarp ranged from 1.15 to 6.22%. Reducing sugars ranged from 2.74 to 9.90%, IISR Shakthi recorded the maximum followed by Narayakodi. In pericarp, starch varied from 11.76 to 28.52%. High starch in pericarp was found in Narayakodi and Chumala. Thin pericarp group comprised of eight genotypes, while thick pericarp genotypes comprised of 10 genotypes. Greater variability was observed for thick pericarp group with no outliers.

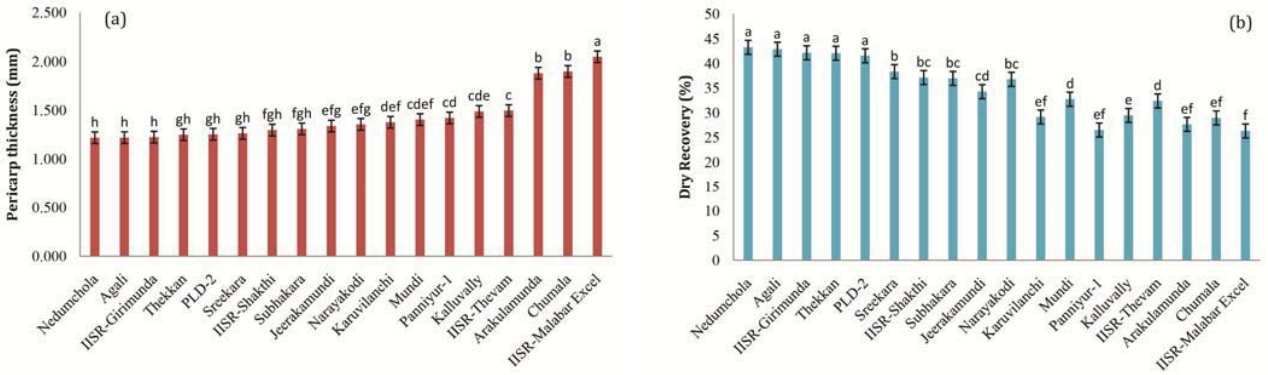


Fig.1 Comparision of (a) pericarp thickness (b) dry recovery (%) among 18 black pepper genotypes. Means followed by thesame letter within each variety are not significant different at $p < 0.05$.

Functional gene marker for genotyping

The PnLRR–RLP marker was derived from an abundant antimicrobial peptide formed during the black pepper – *Phytophthora* interaction.The precursor genes of rotundone, sesquiterpene compound responsible for the peppery aroma in black pepper was identified using berry transcriptome profiling.

Black pepper berry hybrid transcriptome assembly

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

Identification of genes for terpene synthesis pathways

The KAAS-KEGG analysis identified 17 important secondary metabolite pathways from the berry transcriptome. More than 50% of the unigenes were mapped to flavonoid, brassinosteroid, carotenoid, phenylpropanoid and terpenoid biosynthesis pathways. The percentage accumulation of the unigenes in phenyl propanoid (60.53%) and lysine biosynthesis (33.33%) suggested that these two pathways are the backbone pathways for piperine synthesis.

Development of fertigation schedule

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

Impact of rainfall on spike characters of black pepper

Spike intensity, spike length, number of filled berries and fruit set per cent were recorded in 29 locations in Kodagu, Hassan and Chikamagalur districts. Number of spikes per 0.5 m^2 ranged from 16.2 (Kushalnagar) to 61.8 (Shanivarsanthe) with a mean of 42.2. Spike length ranged from 10.8cm (Arbidacool estate, TATA Coffee,

Chikkamagaluru) to 15.22cm in Karadibetta estate, TATA Coffee with a mean of 13.28cm. Number of developed berries ranged from 31.8 (Hosathota, Suntikoppa) to 93.5 (Karadibetta) with a mean of 66.5. Number of unfilled berries ranged from 12.9 (Shanivarsanthe) to 33.8 (Arbidacool estate, Belagodu) with a mean of 23.2. Fruit set percent ranged from 38.6 (Hosathota, Suntikoppa) to 85.2 (Ubban, Sakleshpur) with a mean of 72.21.

Chemo-diversity

Quality analysis of berries from 35 black pepper genotypes wascompleted for essential oil, oleoresin, piperine, total soluble sugar, starch and total phenolics.The following are the genotypes that showed higher percentage of essential oil, oleoresin and piperine. The total phenolic content and starch content of genotypes ranged from 1.43- 7.89 mg GAE/g and 31.14 - 55.0% respectively. The genotypes Acc. 2436, Acc. 5762, Acc. 6619, Acc. 6622, Acc. 6649, Acc. 6714, Ac. 6730, Acc. 7272 and Acc. 7376 showed more than 50% starch content.

Package for enhancing sustainability of black pepper in coconut based cropping system through site specific nutrient management

For soil acidity amelioration: If the soil pH is < 6.0, apply 500 g dolomite lime + 500 g gypsum at the base during May-June at the onset of monsoon, every year. For soil pH > 6.0, this may be applied during alternate years.

***Nutrient management*:** Apply NPK fertilizers at the rates recommended based on soil test values: 150 g urea, 150 g factamfos and 420 g muriate of potash in two equal splits (rates based on NI of Kozhikode District). Apply foliar spray of IISR Black pepper micronutrient mixture-@ 5 g/ litre of water, twice, first during the flowering stage and second during the berry development stage.

***Health Management*:** Enrich 100 kg of FYM: Neem cake mixture (mixed in 9:1 proportion) with *Trichoderma asperellum* or *Pochonia chlamydosporia* formulation @ 1-2 kg/100 kg and apply enriched mixture @ 5-10 kg to the basin of black pepper vines at the onset of monsoon. Remove and destroy completely dried vines and drench the basins with copper oxy chloride (0.3%) with the onset of monsoon.

The yield was enhanced by 36.6% through adoption of the site specific nutrient management technology, thereby unlocking a part of the latent yield potential of the crop. It is estimated that the adoption of the technology across the crop growing regions of the state can enhance the crop output in the state by 15-20% in the medium term.

Foot Rot Disease

Phytophthora species identification and mating type analysis using PCR

A total of 148 *Phytophthora* isolates were subjected to PCR assay using species-specific primers. The species from different geographical regions were delineated as *P. tropicalis* (79), *P. capsici* (59), *P. meadii* (6), *P. nicotianae* (3) and *P. palmivora* (1) (Fig. 2a). In Kerala, both *P. capsici* and *P. tropicalis* were found in equal numbers, whereas *P. tropicalis* dominated in Karnataka over *P. capsici* (Fig. 2b). These isolates were also

screened for the mating type using PCAP1 and PCAP2 primers developed for *P. capsici*. A 508 bp band was observed in all the *P. capsici* isolates and no amplification was observed in *P. tropicalis*. The 508 bp band was sequenced and compared with the nucleotide sequences of FY2 (A_1) and TL1 (A_2) isolates by multiple sequence alignment using Clustal X software (Fig. 5). The nucleotide sequence shared >99% similarity with nucleotide sequence of the A_2 reference isolate.

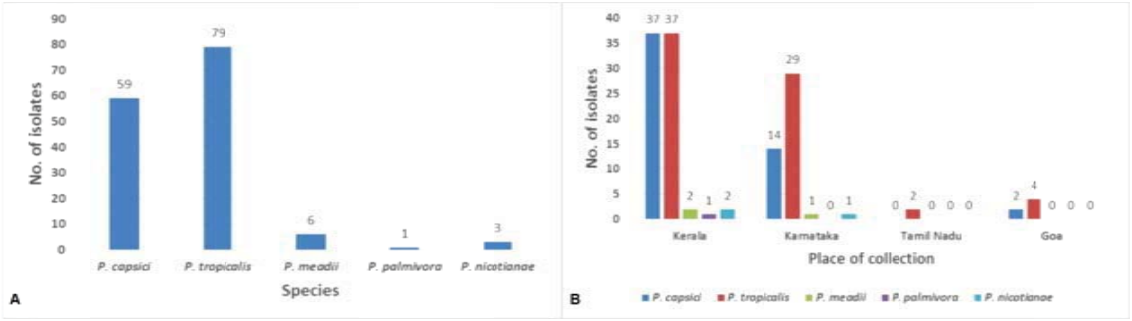


Fig. 2 Graphical representation showing (a) distribution of different *Phytophthora* species in black pepper (b) distribution of *Phytophthora* species in different black pepper growing states

Staining procedure for *Phytophthora* nuclei to ascertain ploidy level

Staining procedure for visualizing *Phytophthora* nuclei was standardized using SYBR green and propidium iodide dyes (Fig. 3). Propidium iodide based staining procedure was standardized to ascertain the ploidy level.

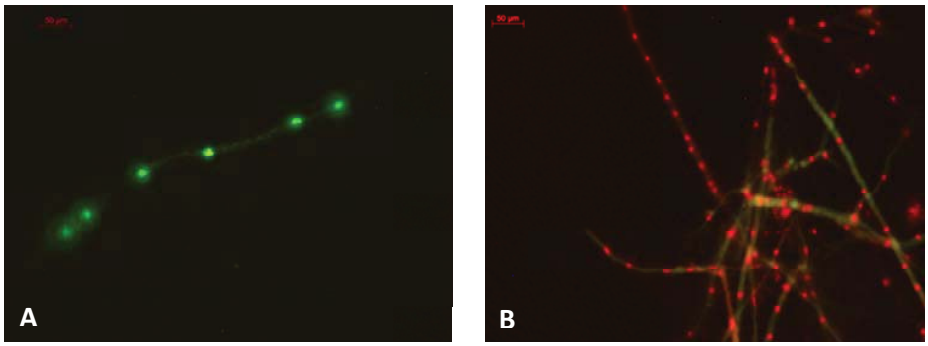


Fig. 3 *Phytophthora* mycelium stained using (a) SYBR green and (b) propidium iodide

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

A multiplex PCR assay was developed for simultaneous detection of *Phytophthora*, *Pythium* and *Fusarium* at genus level along with a plant internal control gene, 18s rRNA. The assay could successfully detect the pathogens both singly and in combinations and does not show any cross reaction with other fungal pathogens of black pepper (Fig. 4).

Electrotaxis and encystment based methods to isolate *Phytophthora* from soil

Based on the principle of electrotaxis, a method was developed for isolating *Phytophthora* from soil suspension using roots of cowpea. The encystment of zoospores was observed after 45 minutes and germination was observed after 2 hours on the root surface. The roots were subsequently inoculated on carrot agar medium and incubated

under room temperature from which the mycelia emerged 24 hours after incubation.In another method based on the principle of encystment, *Phytophthora* infecting black pepper was isolated from soil suspension using inert materials like cotton, thermocol and filter paper. The substrates were immersed for 3 to 5 hours in the soil suspension containing zoospores of *Phytophthora*. Subsequently on plating on carrot agar medium, thermocol and cotton resulted in 90% and 100% recovery after 3 and 5 hours immersion, respectively with the mycelial growth observed within 48 hours of incubation.

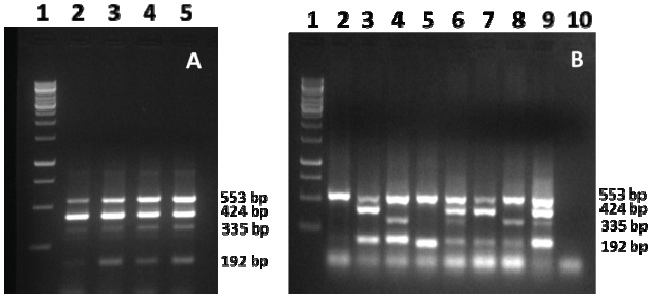


Fig. 4 Multiplex PCR assay detection (a) Lane 1. 1 Kb DNA ladder, Lane 2-5. Amplification of 18s rRNA region of black pepper (553 bp), ITS region of *Pythium* (424 bp), *Phytophthora* (335 bp) and *Fusarium* (192 bp) (b) Multiplex PCR detection of *Pythium*, *Phytophthora* and *Fusarium* from artificially inoculated root samples of black pepper

Cabin-sequestering method to salvage *Phytophthora* cultures contaminated with bacteria

Cabin-sequestering (CS) method was standardized to salvage the *Phytophthora* cultures contaminated with bacteria. The mycelial disc derived from bacterial contaminated plates of *Phytophthora* was inoculated on carrot agar medium adopting the cabin-sequestering method. After 2 days of incubation, the hyphae emerged along edges of the coverslip without bacterial contamination (Fig. 5).

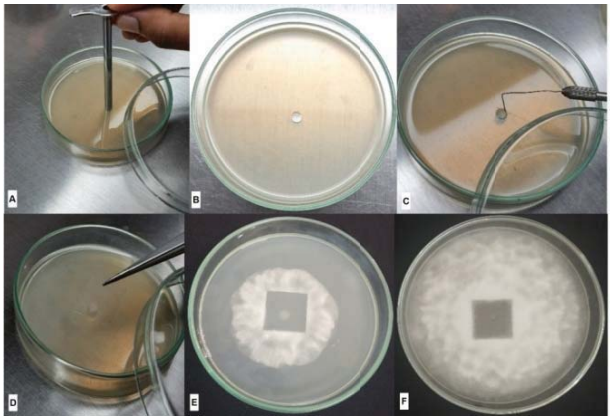


Fig. 5 Different stages in salvaging contaminated *Phytophthora* culture using cabin-sequestering method (a) punching with cork borer (b) carrot agar plate with the cabin (c) placing contaminated mycelial disk in the cabin (d) placing sterile coverslip over the cabin (e) hyphal growth along the edges of coverslip (f) pure culture obtained through CS method

New Disease

In black pepper, collar rot associated yellowing was noticed in Kerala and Tamil Nadu. Yellowing of the vines was generally manifested during post-monsoon season and aggravated during February to March. General decline in plant health and flaccidity of the leaves were the other associated symptoms. In the advanced stages, the entire vine exhibited yellowing leading to wilting. The symptoms manifested on collar region included, formation of necrotic regions beneath the bark (Fig. 6) which later extended both up and downwards leading to disintegration of affected tissues. Initial observations of the infected tissues revealed the association of *Fusarium* species. The isolates were morphologically characterized based on colony conidial and chlamydospore characteristics. Based on molecular analysis the pathogen was identified as *Fusarium solani*. Bordeaux mixture (1%), copper oxychloride (0.2%) and carbendazim (0.1%) were found promising compared to other fungicides under *in vitro* conditions.

Fig. 6 Manifestation of yellowing in black pepper under field conditions (A) yellowing (B) necrotic tissues of collar region

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

Asymptomatic rooted cuttings of Piper Yellow Mottle Virus (PYMoV) infected plants of 19 varieties were subjected to varying temperature and relative humidity (RH) in the polyhouse while another set of plants were maintained under the controlled condition at constant temperature and RH in the greenhouse. The average number of plants expressing symptoms in the polyhouse showed a gradual increase from 1% during 3rd standard meteorological week (SMW) (16th January) to 41% during 21st SMW (22nd May). Thereafter, there was a fall in the average number of plants expressing symptoms till the 53rd SMW (1st January). Based on the percentage of plants expressing symptoms, varieties such as Arka Coorg Excel, Panniyur 2 and Panniyur 6 were grouped into high symptom expression category (DI ranged from 0 to 100), varieties namely, Panniyur 1, Panniyur 3, Panniyur 4, Panniyur 5, Panniyur 7 and Panniyur 8, Vijay, PLD 2, IISR

Shakthi, Panchami, Subhakara, IISR Girimunda and Sreekara were grouped into medium symptom expression category (DI ranged from 0 to 59%) while varieties namely, IISR–Malabar Excel, Panniyur 9 and Pournami were grouped into low symptom expression category (DI ranged from 0 to 9). In contrast, only 0–2% of plants of different varieties kept under controlled condition expressed symptoms. Analysis of the data indicated a positive correlation of symptomatic plants with afternoon maximum temperature (T Max) and afternoon maximum relative humidity (RH Max).

Screening of low risk insecticides against root mealybug

Laboratory bioassays were conducted to screen low risk insecticides *viz*., diafenthiuron, flonicamid, buprofezin, chlorantraniliprole, flubendimide, spinetoram, spinosad and nimbecidineagainst root mealybug, *Planococcus* sp., infesting black pepper. Based on the studies, buprofezin (3 mL/L), diafenthiuron (1g/L), flonicamid (0.3g/L), spinetoram (1.5 ml/L) and spinosad (0.5 mL/L) were found to be effective under *in vitro* conditions

Screening of new generation insecticides against Pollu beetle

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

Plant parasitic nematodes

In vitro evaluation of new nematicides against *Radopholus similis*

Among the nematicides evaluated against *Radopholussimilis* under *in vitro* conditions, Fluopyram @ 0.75 mL/L and above caused more than 95% mortality compared to carbosulfan which caused 88% mortality.

Cardamom

Genetic resources

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

Breeding

Raising of open pollinated progenies from pre potent cardamom lines

Open pollinated progenies from pre potent lines were raised. 128 OP progenies of IC 584058; 22 OP progenies of IC 349537 (Clone 893); 20 OP progenies of Green Gold; 141 OP progenies of IC 349627 (Sampaje clone) and 33 OP progenies of Appangala 1 were field planted to evaluate for different traits *viz*., yield, moisture stress tolerance *etc*.

Screening of OP progenies for moisture stress tolerance

Open pollinated progenies seedlings of IC 584058 were evaluated for moisture stress tolerance. 2-3 leaf stage seedlings were raised in the Hoagland solution. After one month, seedlings were subjected to moisture stress using PEG (15%). After 37 days treatment the seedlings were subjected to 20% PEG. After transplanting, only two seedlings survived which were planted in field.

Evaluation of farmer's varieties of cardamom

Observations on morphological and yield parameters were recorded from CVT on farmers varieties consisting of nine farmer's varieties of small cardamom *viz*., Arjun, Wonder Cardamom, Panikulangara, Thiruthali, Elarajan, Pachakai, Pappaulu, Njallani, PNS Gopinath and a local check variety Appangala1. Yield contributing traits *viz*., number of bearing tillers, number of panicles and panicle length (cm) were found to be highest in Pappaulu followed by Thiruthali (Table 1). Highest yield was also recorded in the same varieties.

Table 1 Observations on morphological and yield contributing traits for the year 2020

Variety	Plant height (cm)	Number of tillers	No. of bearing tillers	No. of panicles	Panicle length (cm)
V1-Thiruthali	229.06	32.44	16.22	24.78	57.17
V2-Wonder cardamom	208.39	24.89	11.17	14.18	38.70
V3-Green Gold	202.33	25.22	10.00	13.17	45.39
V4-Panikulangara	204.89	35.89	11.44	15.00	42.78
V5-Appangala-1	193.22	30.44	9.56	12.50	38.39
V6-Elarajan	203.39	26.78	11.17	14.11	50.33
V7-Pappaulu	231.34	30.11	13.83	18.61	59.83
V8-Arjun	214.54	28.42	12.44	15.49	39.50
V9-Patchakai	197.00	25.67	10.75	16.42	50.92
V10-PNS Gopinath	199.67	22.01	6.92	8.49	39.50
CD	23.14	N/A	N/A	7.53	14.31
SE(m)	7.73	3.00	1.87	2.52	4.78
SE(d)	10.93	4.25	2.64	3.56	6.76
CV (%)	6.42	18.45	28.51	28.53	17.89

Evaluation of elite cardamom accessions for drought tolerance

Six genotypes (IC 349537, IC 584058, GG×NKE-12, IC 584078, CL 668, HS 1, IC 584090) with one check (Appangala 1) were evaluated for drought tolerance. Mositure stress was imposed in summer from February to April 2020 in stress block by withholding irrigation. The control block was irrigated by sprinkler (25mm) once in 12-15 days interval. Soil moisture, gas exchange parameters, growth and yield showed significant variation between control and stress treatments. Dry capsule yield (kg/ha) ranged from 314.58 (CL 668) to 542.3 (IC 584078) in control and in stress, it ranged from 159.7 (Appangala 1) to 231.5 (GGXNKE-12). Accession IC 584090 recorded 61.86% 8 mm bold

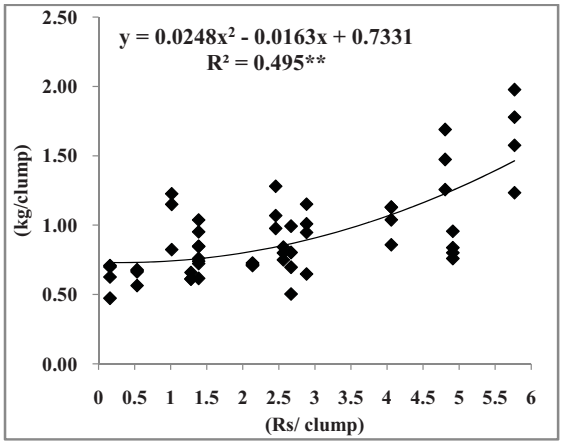
capsules followed IC 584058 (57.90%). In stress, accession IC 584090 recorded 48.25% 8 mm bold capsules. Essential oil ranged from 8.05% (IC 584078) to 8.97% (IC 584058) and under stress, it ranged from 8.37% (IC 584058) to 9.18% (IC 584078).

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

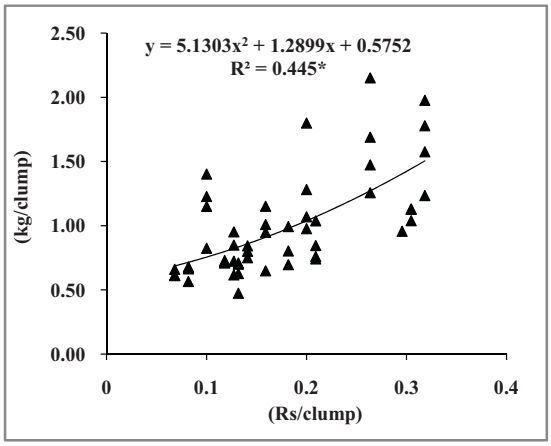
The genotypes (Appangala 1, PV-1, ICRI-2, FGB-34, PV-2 and Green Gold) selected from three ecotypes (*Malabar, Mysore and Vazhukka*) during 2018-2019. Green Gold registered more dry capsule yield (673.8 kg/ha) followed by Appangala-1 (576.4 kg/ha). Physiological attributes like photosynthetic rate, stomatal conductance, epicuticular wax and total chlorophyll content were higher for Green Gold closely followed by Appangala-1. Both Appangala-1 and Green Gold reported higher concentration of 1, 8-cineole accordingly 43.9% and 40.8%. Other genotypes PV-1 and ICRI-2 had higher quantity of α-terpinyl acetate (41.6% and 40.3% respectively). Volatile oil of PV-2 and FGB-34 possessed higher proportion of α-terpinyl acetate (37.9% and 37.9% respectively) and linalool (11.1% and 7.1%, correspondingly). The results of the study highlight Green Gold as physiologically superior and high yielding genotype, and PV-2 as a better quality genotype due to its pleasant sweet aroma.

Economic optimum for fertilizers

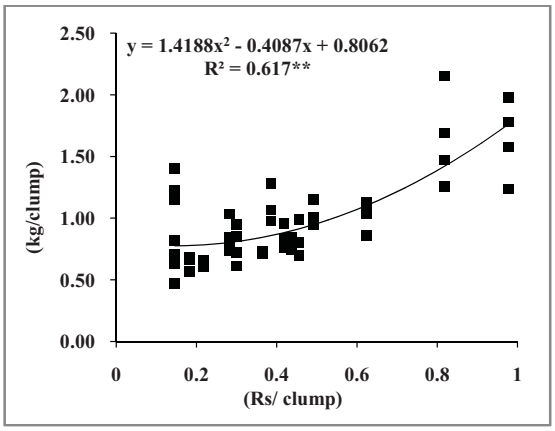
Targeted yield equations for predicting nutrient requirements for fixed yield targets in soils with varying fertility levels were standardized with minimum deviations in cardamom (Fig. 7). The economic optimum in terms of profitable response for money invested was found to be up to ₹ 3.61/clump for N, ₹ 9.6/clump for P and ₹ 15.4/clump for K in cardamom. It implies that an economic response can be expected up to fertilizer dosage of 340 kg N, 230 kg P_2O_5 and 540 kg K_2O per ha for a population of 1100 plants per ha.



Nitrogen



Phosphorus



Potassium

Fig.7 Response curves for cost of NPK vs Yield (kg/clump) for working economic optimum

Viral diseases

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

Previous studies have shown the association of a novel virus namely, cardamom vein clearing virus (CdVCV) (genus: *Nucleorhabdovirus*) with vein clearing disease of cardamom. 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 infecting cardamom. Detection limits of both assays were determined and compared with conventional RT-PCR and SYBR Green-based real-time RT-PCR. RT-LAMP was found 10000 times additional sensitive than RT-PCR and one-tenth that of real-time RT-PCR. RT-RPA was found 1000 times additional sensitive than RT-PCR and one-hundredth that of real-time RT-PCR (Fig. 8). Both assays were specific, rapid, and sensitive for detecting CdVCV. Compared to real-time RT-PCR, these assays are economical and can be employed in large scale screening of cardamom plants against CdVCV for the selection of virus-free plants.

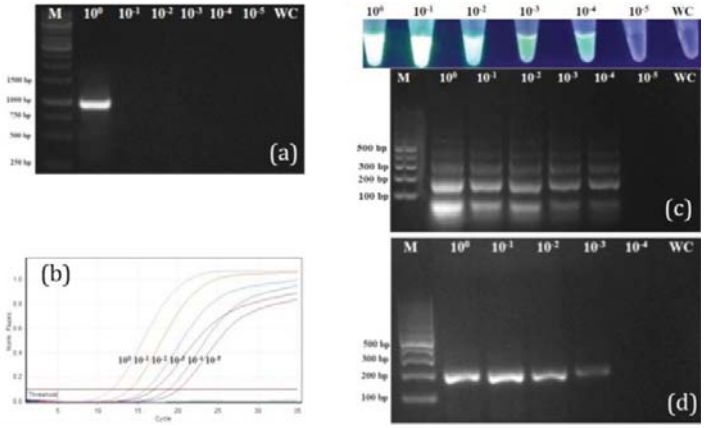


Fig. 8 Comparison of the sensitivity of detection of cardamom vein clearing virus (CdVCV) by (a) reverse transcriptase-polymerase chain reaction (RT-PCR), (b) SYBR Green-based real-time RT-PCR, (c) reverse transcriptase-loop mediated isothermal amplification (RT-LAMP) and (d) reverse transcriptase-

recombinase polymerase amplification (RT-RPA). Lanes 10^{0}, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} show different dilutions of the original extracts of total RNA (cDNA in case of RT-RPA); Lane M shows molecular marker. Lane WC indicates water control.

Ginger

Genetic resources

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

Fig.9 View of conservatory-Garden of Gingers

Characterization

Quality characterization

Quality characterization of 10 exotic accessions was carried out. Among the genotypes Acc. 869 (2.44%), recorded the highest essential oil content followed by Acc. 393 (2.42%) followed by Acc. 833 and Acc. 873 (2.10%). Acc. 869, Acc. 874, Acc. 873 and Acc. 393 recorded higher oleoresin content of 5.88%, 5.63%, 5.34% and 5.28%, respectively. The exotic genotypes such as, Acc. 607, Acc. 736 and Acc. 393 recorded the less crude fibre content (<5.0%), whereas, Acc. 869 recorded the higher crude fibre content of 7.85%. The principal compound identified in essential oil was α- Zingiberene and it was highest in Acc. 393 (30.49%) followed by Maran (30.32%).

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

Molecular characterization

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

Breeding

Variety released

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

Polyploid breeding

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

Differential expression of potential microRNAs in bacterial wilt resistant and susceptible gingers

The assembled mRNAs (transcriptome data from ginger *R. solanacearum* interactions) were utilized to generate miRNA targets and miRNAs. Considering the alignment results, we located a total of 2926 potential miRNA targets out of which 1551 were upregulated and 1419 were downregulated in ginger. In case of mango ginger, out of 2145 potential miRNA targets, 1506 were upregulated and 1594 were downregulated. In the resistance interactions with mango ginger, 1068 unique target genes were upregulated when compared to control. Gene Ontology (GO) analysis of differentially expressed target genes showed highest enrichment in response to cold, chloroplast and ATP binding in biological, cellular and molecular functions respectively. Nine target genes and their corresponding miRNAs were experimentally validated, which shows significant difference in expression with ginger-*R. solanacearum* interactions (Fig. 10).

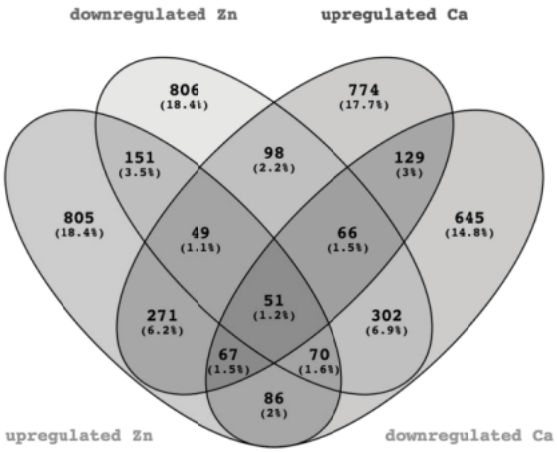


Fig. 10 Venn diagram of differentially expressed target genes in response to bacterial wilt in two ginger species (ginger: Zn and mango ginger: Ca)

Bacterial wilt disease management

Among the various treatments to manage soft rot and wilt diseases under non-solarized field conditions, the highest percentage of plant survival and lowest disease incidence (rot/wilt) were noticed with calcium chloride (3.0%) followed by Bacillich (powder formulation)and *Methylobacterium komagate*.

The process of biofilm formation in *R. pseudosolanacearum* (Peruvannamuzhi isolate) was investigated under *in vitro* conditions using acridine orange dye and employing fluorescent microscopy. The biofilm formation was visualized after 2 h of incubation period and subsequently the extracellular polymeric compounds accumulated surrounding the congregation of bacterial cells leading to the formation of biofilm (Fig. 11).

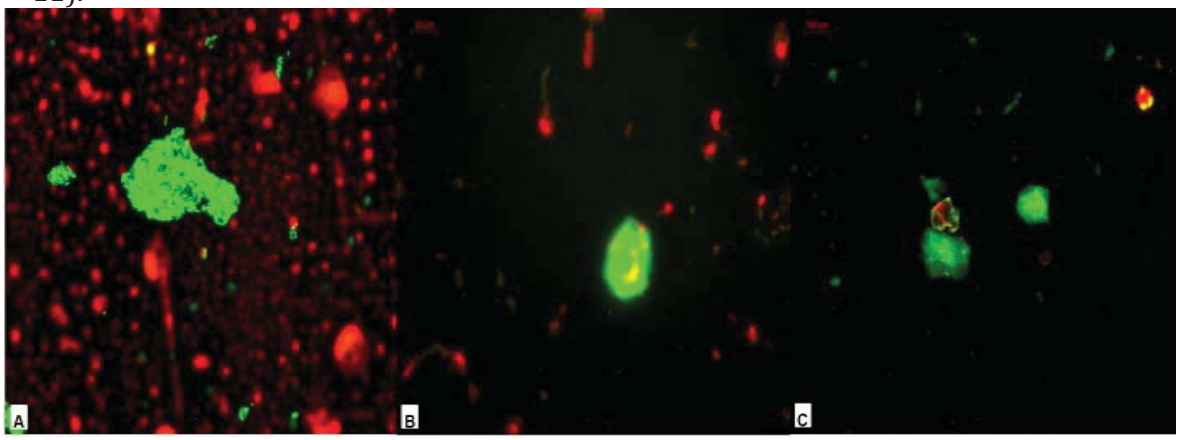


Fig. 11 Different stages in biofilm formation (a) after 2 hours (b) after 6 hours (c) after 8 hours

Soft rot disease management

Evaluation of efficient bacterial antagonists

Under glasshouse conditions, the most efficient bacterial antagonists *Bacillus safensis* (IISR TB4) and *B. cereus* (IISRGB7 (3)) were evaluated against the soft rot pathogen, *Pythium myriotylum and* foliar pathogens, *Colletotrichum gloeosporioides* and *Exserohilum rostratum* of ginger. The results indicated significantly higher sprouting in treatments with PGPR treatments compared to the chemical method (Table 2). Both the PGPR exhibited significant ($P < 0.05$) suppression of all the three pathogens compared to the chemical method. In case of *P. myriotylum*, the PDI was 92.45 in the control and 53.04 in the treatment with metalaxyl-mancozeb, which decreased significantly to 12.05 (*B. safensis* alone), 14.22 (*B. safensis* + *B. cereus*) and 21.30 (*B. cereus* alone). Likewise, in case of foliar diseases also the PDI was lower in PGPR treatments than in chemical method and control.

Table 2 Effect of bacterial antagonists on sprouting, disease incidence and yield of ginger in the green house

	Sprouting (%)	Rhizome yield (g pot^{-1})	Percent disease index		
			Yellowing of tillers	Soft rot/rhizome rot	Foliar disease incidence
T1	91.10 (76.19)^{ab}	286.8^{a}	8.25 (15.02)^{c}	14.22 (20.22)^{c}	10.22 (16.84)^{b}
T2	86.66 (70.76)^{ab}	248.4^{b}	10.44 (18.82)^{c}	21.30 (27.31)^{c}	12.84 (20.86)^{b}
T3	93.32 (77.93)^{a}	297.0^{a}	7.66 (12.63)^{c}	12.05 (18.52)^{c}	9.04 (15.84)^{b}
T4	79.99 (63.90)^{bc}	153.6^{c}	31.85 (34.27)^{b}	53.04 (46.78)^{b}	37.04 (37.39)^{a}
T5	68.89 (56.29)^{c}	131.2^{d}	95.78 (82.25)^{a}	92.45 (77.27)^{a}	36.16 (36.93)^{a}

Figures in parentheses are Arc Sine transformed values

T1- IISR TB4- rhizome treatment, spraying and drenching 30, 60 and 90 DAP; **T2** - IISR GB7 (3)- rhizome treatment, spraying and drenching 30, 60 and 90 DAP; **T3** - Combined application of IISR GB7 (3) & IISR TB4- rhizome treatment, spraying and drenching 30, 60 and 90 DAP ; **T4**- Fungicide metalaxyl- mancozeb (0.125%) as rhizome treatment; **T5**- Untreated rhizomes (Control)

A novel process for priming rhizomes and tubers using *Trichoderma asperellum*

A robust protocol was developed to manage fungal pathogens, to shorten the germination time of rhizomes, to improve the vigour of buds and to provide uniform tillering by priming seed rhizomes and tubers with the biocontrol fungi, *T. asperellum* (Fig. 12). Further, the priming process will help to regulate the germination process, prevents the growth of dry rot pathogens during storage and also provides protection from fungal pathogens during the initial stages of the crop.

Fig. 12 Ginger rhizomes primed with the biocontrol fungi, *T. asperellum* A: activated buds B: shoots produced from activated buds

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

Our previous studies have shown the association of two novel viruses namely, ginger chlorotic fleck-associated virus 1 (GCFaV-1) (Family: *Tombusviridae*) and ginger chlorotic fleck-associated virus 2 (GCFaV-2) (Family: *Closteroviridae*) with chlorotic fleck disease of ginger. The development of diagnostics would aid in the identification of virus-free plants and to locate sources of resistance against viruses in the germplasm accessions. Two isothermal assays, RT-LAMP and RT-RPA assays were developed and validated for the quick detection of GCFaV-1 and GCFaV-2 (Fig. 13). Based on the cost-effectiveness and duration, RT-LAMP and RT-RPA assays can be suggested for the rapid detection of both viruses.

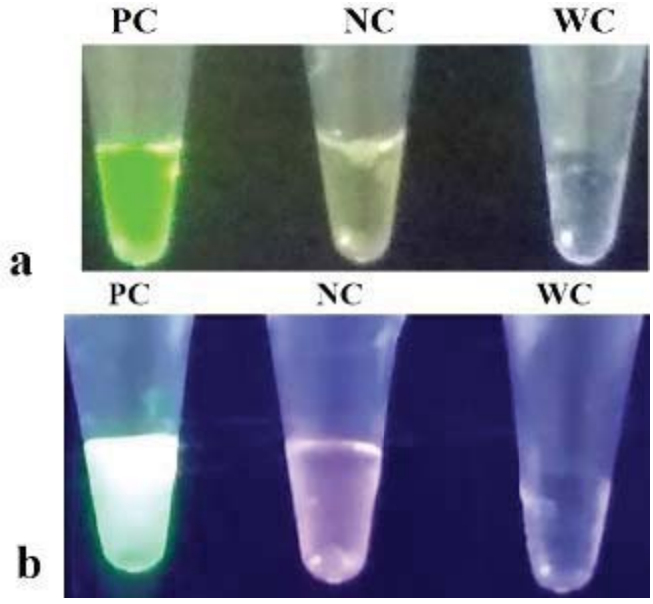


Fig. 13 Visual detection of reverse transcription loop-mediated isothermal amplification (RT-LAMP) products under UV light (a) ginger chlorotic fleck-associated virus 1(GCFaV-1), (b) ginger chlorotic fleck-associated virus 2 (GCFaV-2). PC, infected ginger (positive control); NC, healthy ginger (negative control); WC, water control.

Turmeric

Genetic resources

Around 1404 accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with three *Curcuma longa* and five *Curcuma* sp. from Andaman Islands.

Characterization

Characterization of 200 accessions was carried out based on different morphological traits. A total of 12 quantitative and 10 qualitative characters were recorded for each accession.

A total of 155 accessions, eight varieties and four GIs (Erode turmeric, Sangli turmeric, Waigon turmeric and Kandhmalhaldi) were characterized for different quality parameters. The curcumin content varied from 0.6 to 5.2%. Investigation of detailed curcuminoid profile revealed three groups, genotypes with equal quantity of BDMC and DMC, BDMC greater than DMC and DMC greater than BDMC.

Breeding

Maintenance of seedling progenies, hybrids and inbreds of turmeric

First generation seedlings (204), mother genotypes (20), second generation seedlings (432), third generation seedlings (47), first generation inbreds (839 Nos), second generation inbreds (11), third generation inbreds (402), fourth generation inbreds (367) and inter-varietal hybrids (36 Nos) were maintained. 117 F_2 hybrids of H1 (36), H2 (81), and nine open-pollinated progenies of high curcumin line SLP 389/1 were also maintained. Additionally, intercross hybrids (29), back cross hybrids (7), OP progenies of two inter-varietal hybrids (30) and 60 somaclones were also maintained.

Evaluation of promising seedlings and hybrids of turmeric

Replicated trial involving three hybrids and four seedlings were laid out at Chelavoor and three hybrids and three seedlings were planted at Peruvannamuzhi.At Chelavoor, SLP 359/2, SLP 65/12 and SLP 389/1-OP-4 recorded average yield above 12 kg per bed. Based on the trials SLP 359/1, SLP 65/12, Hybrid-1 and Hybrid-2 were submitted to AICRP for multi- location testing.

Chromosome number analysis of seedlings, hybrids and inbreds of turmeric

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

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

25 transcription factors (TFs) belonging to the classes bHLH, WD 40, NAC, WRKY and bZIP that showed differential expression with respect to curcumin were identified

through comparative transcriptome analysis (Fig. 14). Three TFs including two bHLH and one WD40, that showed maximum comparative fold change and negative correlation with curcumin content were validated through qRT-PCR analysis. The results of comparative transcriptome and qRT-PCR analyses were in congruence indicating their putative role as negative regulators.

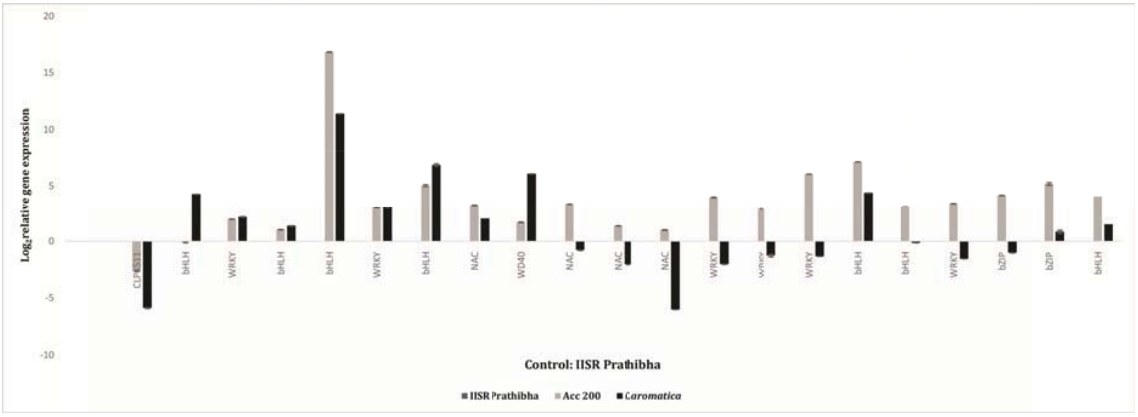


Fig. 14 Expression profiling of twenty TFs genes in germplasm accession with high, low and very low curcumin content.

Evaluation of different management systems

Soil samples were collected 120 days after planting of turmeric from different management systems and analyzed for nutrients**.** The OC, N, P, Ca, Mg, Mn and Zn contents were significantly higher under organic management system.Among management systems, organic system (100%) recorded maximum yield (34.78 t/ha) followed by integrated system (50%+50%) (31.8 t/ha). Among the varieties, Suguna recorded highest yield (40.8 t/ha) followed by IISR Pragati (38.6 t/ha) (Fig. 15).

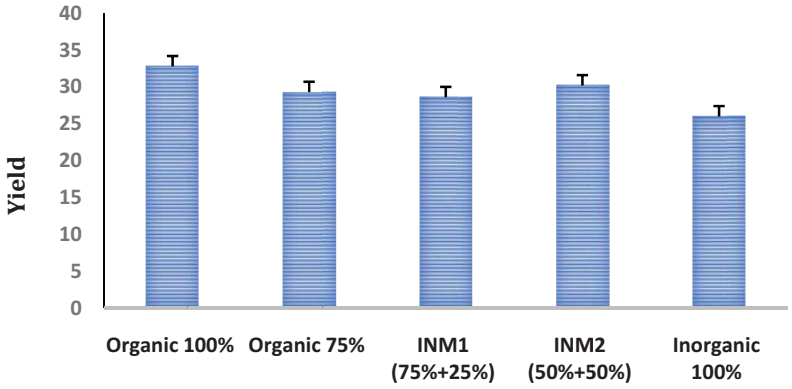


Fig. 15 Yield level of turmeric under different management systems.

Varietal response to organic farming

Twelve varieties were grown under 100% organic management systems. Among these, Suguna recorded maximum yield (48 t/ha), followed by Pragati (44.5 t/ha). Regarding essential oil content, Pragati and Prathibha were on par (5.8%). Maximum oleoresin content was recorded by Prabha (14.90%) followed by Pragati (14.55%). Maximum curcumin content was recorded by Pragati (6.28%), followed by Prabha (6.08%) (Fig. 16 a & b).

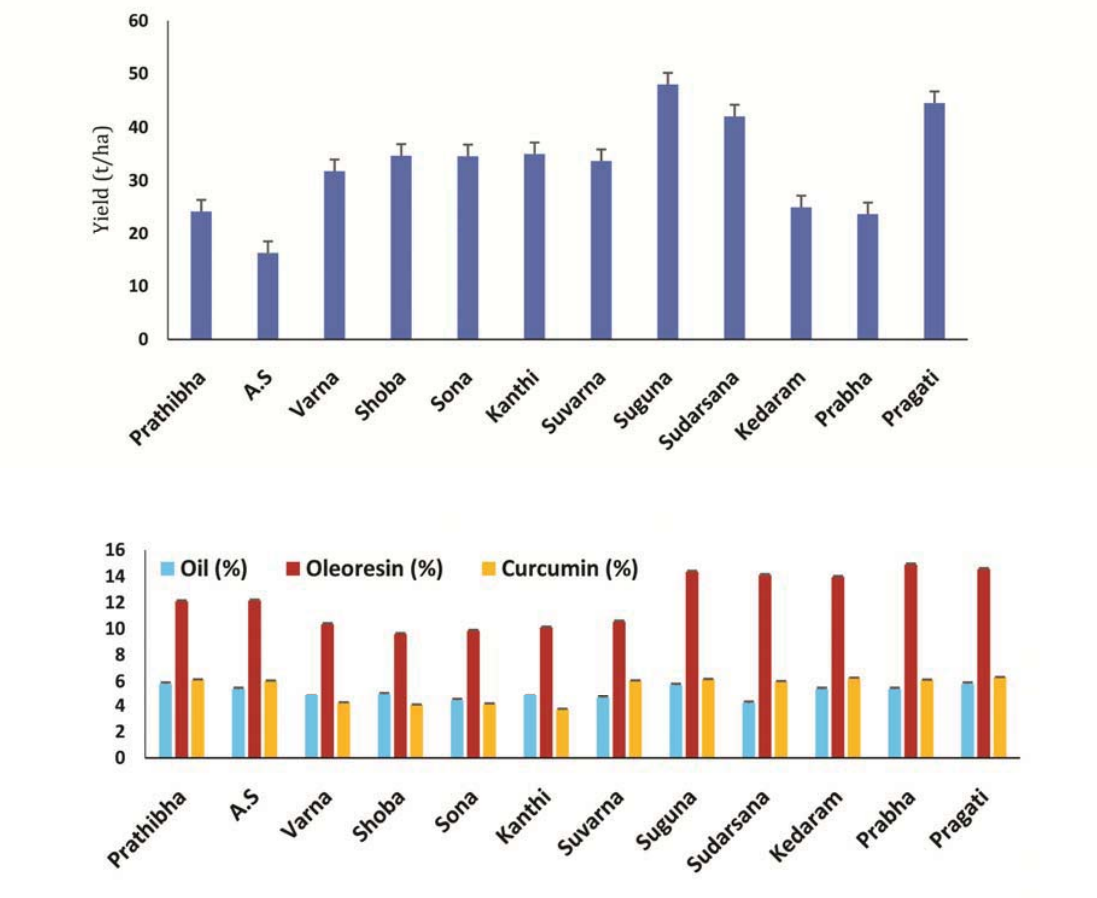


Fig. 16 Varietal response to yield (a) and quality (b) under organic management system.

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

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

Functional product development of spices through value addition

ICAR-IISR has developed two separate technologies for turmeric milk preparation; one as ready to serve sterilized flavoured turmeric milk and the other one as turmeric milk instant mix powder. A third product using the liquid spice extract of turmeric, ginger and *Piper chaba* was used for the preparation of Ayur butter milk.The lab scale technologies developed at ICAR-IISR was further fine tuned by carrying out industrial trial at processing plant of Malabar Regional Co-operative Milk Producers' Union Ltd. (MRCMPU), Kozhikode. The technology was then commercialized to MILMA, and the products have been launched as "MILMA Golden Milk", "MILMA Golden Milk Mix" and "MILMA Ayur Butter Milk" (Fig. 17).

Fig. 17 Golden Milk technology with spice adjuvants

Insect pests

Spray schedule optimization of new generation insecticides against shoot borer

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

Entomopathogenic fungus infecting *Conogethes punctiferalis*

An entomopathogenic fungus was isolated from *C. punctiferalis* and identified as *Metarhizium pingshaense* Q.T. Chen & H.L. Guo (Ascomycota: Hypocreales) based on morphological characteristics and molecular studies. Bioassay studies with purified conidial suspension proved that the isolate was highly virulent to *C. punctiferalis*, causing more than 86% mortality to fifth instar larvae at 1×10^8 spores/mL, under

laboratory conditions. The median lethal concentration (LC_{50}) of the fungus against late instar larvae was 9.1 × 10^5 conidia/mL and the median survival time (MST) of late instar larvae tested at the doses of 1 × 10^8 and 1 × 10^7 conidia/mL were 4.7 and 6.4 days, respectively. The optimal temperature for fungal growth and sporulation was found to be 25 ± 1 °C. This is the first report of *M. pingshaense* naturally infecting *C. punctiferalis* (Fig. 18 a & b).

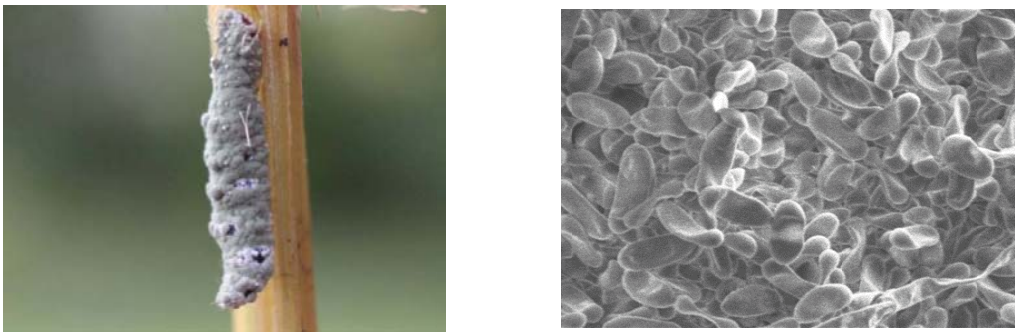


Fig. 18 (a) Sporulated cadaver of *C. punctiferalis* infected by *M. pingshaense* (b) Close up of chains of *M. pingshaense* conidia on the cuticle surface

Plant parasitic nematodes

Culturing of lesion nematodes

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

Effect of cold storage of turmeric rhizomes on lesion nematodes

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

Root knot nematode incidence on turmeric

High incidence (150 nematodes/200 cc soil, 16 nematodes/10 g root, root knot index 3, average no. of eggs 202.3/egg mass) of root knot nematodes was observed in Chelavoor Farm of IISR. The main symptoms of nematode infestation were yellowing of leaves, stunting in patches, weak shoots, drying of leaf margins and tips.

Vanilla

A total of 65 accessions of *Vanilla planifolia*, seven *Vanilla spp*. from Andaman, one each of V. *pilifera, V. aphylla, V. tahitensis* and *V. wightiana,* two species from Wayanad, one species from Assam and three species from Little Andamans were added to the conservatory (Fig. 19).

Fig.19 Vanilla germplasm conservation under protected condition

Characterization

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

Quality profiling

Quality profiling of *V. planifolia* showed vanillin in the range of 0.57 to 1.99% whereas p-hydroxybenzoicacid, p- hydroxybenzaldehyde and vanillic acid in the range of 0.0003 to 0.0127%, 0.017 to 0.036% and 0.055 to 0.093% respectively.

In planta biochemical activity in bioformulation treated vanilla plants

Activities of peroxidase, polyphenol oxidase, catalase and superoxide dismutase were measured in vanilla leaves challenge inoculated with *Fusarium oxsyporum* f.sp. *vanilla* and treated with bioformulations of *B. amyloliquefaciens* and *Chaetomium globosum*. Increased activity of all the enzymes was noted till fourth day in plants treated with the bioformulations compared to chemical treated (0.25% copper oxychloride) and untreated control plants.

Tree spices

Nutmeg

A high yielding monoecious line with long fruits, another monoecious accession which bears fruits in clusters (Fig. 20) and a high yielding female accession of nutmeg were collected from Sirsi, Karnataka. Yield observations of nutmeg germplasm were recorded and accessions 505, 511, 530,572, 616 and 625 were found to be promising.

Fig. 20 Monoecious nutmeg accession with cluster bearing

Recommended package for enhancing sustainability of nutmeg in coconut based cropping system through site specific nutrient management (SSNM)

For soil acidity amelioration: If the soil pH is < 6.0, apply 1.0 kg dolomite lime + 1.0 kg gypsum along the drip line/ canopy periphery during May-June at the onset of monsoon, every year. For the soil pH > 6.0, this may be applied during alternate years.

***Nutrient management*:** Apply NPK fertilizers at the rates recommended based on soil test values: 800 g Urea, 500 g Factamfos and 1.50 kg MOP in two equal splits. Apply foliar spray of IISR nutmeg micronutrient mixture - @ 5 g/ L water, 2-3 sprays at flowering and flower development stages at monthly intervals.

***Health Management*:** Enrich 100 kg of FYM: neem cake mixture (mixed in 9:1 proportion) with *T. asperellum* @ 1-2 kg formulation per 100 kg and apply @ 20-25 kg of enriched mixture per tree during the onset of monsoon. Cut and remove the dried or infected branches (due to thread blight infection) and spray Bordeaux mixture (1%) on leaves at the onset of monsoon (May-June) and repeat the spray one month after first application.

The yield increase was up to 22% in the treated plots in the experimental condition for nut and mace yield. A yield increaseof 10-25% in nut and mace from farmer's demonstration plots were observed as compared to the farmers practice.

Economic evaluation

Table. 3 Economic evaluation of SSNM for nutmeg in coconut based cropping system

Particulars	Value
Cost of inputs in SSNM	₹ 50665 per hectare
Incremental output - Nut	159.3 kg/ha
Incremental output - Mace	70.8 kg/ha
Average additional income	₹ 52955/ha
Incremental Benefit Cost Ratio (IBCR)	2.1

Cinnamon

Four accessions of cinnamon and two wild species were collected from Andaman and Nicobar Islands. *Cinnamomum walaiwarense* (Fig. 21) and *C. chemungianum* were collected from Agasthyamala Biosphere Reserve, Kerala.

Fig. 21 *Cinnamomum walaiwarense* collected from Agasthyamala Biosphere Reserve

Clove

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

Garcinia

Garcinia andamanica (Fig. 22a), *G. dulcis*, *G. cowa*, *G. kydia*, *G. dhanikhariensis* and *G. speciosa* were collected from Andaman and Nicobar Islands. *Garcinia imberti, G. rubro-echinata* (Fig. 22b), *G. travancorica, G. gamblei* and *G. morella* were collected from Agasthyamala Biosphere Reserve. Two high yielding accessions of G. *gummi-gutta* were collected from Thrissur and Nilambur. A wild accession of *G. gummi-gutta* was collected from Agasthyamala Biosphere Reserve. A high yielding accession of *G. indica* with red fruits and two accessions with yellow fruits were collected from Sirsi.

Fig. 22a *Garcinia andamanica* collected from Andaman Islands

Fig. 22b *Garcinia rubro-echinata* collected from Agasthyamala Biosphere Reserve

Allspice

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

High Value compounds/ Pharmaceutical profiling

Essential oil profile of *Pimenta racemosa*

The volatile constituents of samples of *P. racemosa* collected from Wayanad were analyzed using GC-MS. Eugenol, Myrcene, Chavicol and Limonene are found to be the major constituents (Table. 4). The eugenol content was found to be the highest in fruit stalk (57%), followed by leaves (52.3%) and berries (39.9%). Other distinguishing volatiles among different parts are myrcene, limonene, trans-ocimene and chavicol.

Table 4. Major volatile constituents of berries, leaves and fruit stalk of *P.racemosa* collected from Wayanad

Volatile components	Relative Area Percentage			
	RT	Berries	Leaves	Fruit Stalk
Sabinene	4.71	0.2	ND	ND
Myrcene	5.90	22.2	15.8	11.6
Limonene	6.78	7.0	5.3	4.7
β-Phellandrene	6.99	1.2	0.7	0.7
Trans-ocimene	8.38	2.6	0.4	3.9
1-Octen-3-ol	14.22	0.7	1.2	0.7
α-Copaene	15.15	1.0	0.5	0.8
n-Decanal	15.40	0.2	0.1	0.1
Linalool	16.88	1.2	1.2	0.9
β-Caryophyllene	18.03	1.6	0.5	0.7
Germacrene D	21.34	4.0	0.0	0.1
δ -Cadinene	22.90	1.9	1.4	2.5
Eugenol	35.62	39.9	52.3	57.0
Chavicol	40.41	8.2	13.5	8.9

GENERAL

DUS facility

ICAR-IISR is the nodal DUS testing centre for black pepper, ginger, turmeric and small cardamom and also the co-nodal centre for nutmeg. Major activity of DUS centre includes maintenance of example varieties and multiplication of ginger and turmeric provided by farmers for DUS testing. DUS testing was completed for 19 turmeric varieties which include 14 farmers' varieties and four varieties of common knowledge and one new variety. DUS testing completed for seven ginger varieties which include four farmers' varieties and three varieties of common knowledge. Onsite preliminary observation of four black pepper and six small cardamom varieties were undertaken and corresponding reference verities were identified. At present two ginger and four turmeric farmer varieties are under DUS testing.

Other Events

- An awareness programme on Protection of Plant Varieties & Farmers' Rights act was organized at Madikeri on 26 February 2020. The programme was inaugurated by Dr. T.H. Gowda, Deputy Registrar, PPV&FRA, UAHS, Shivamogga.
- An extension folder on PPV&FR Act was prepared in Kannada
- On-site evaluation of black pepper farmer variety "Sigandini" in Karnataka.

DNA Fingerprinting and Barcoding

The DNA Fingerprinting and Barcoding Facility was established at ICAR-IISR for undertaking fingerprinting services for facilitating varietal release for various AICRPS centres. DNA isolation and PCR protocols were optimized in Cardamom, Ajwain and Nigella. Polymorphic ISSR markers for distinguishing candidate varieties from check in the above crops were identified. Six polymorphic ISSR primers for fingerprinting varieties of black pepper and unique markers identified for 10 black pepper varieties were identified and shortlisted.

Establishment of farming system model with spices as component crops

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

Production of nucleus planting materials of improved varieties

About 80000 rooted cuttings of improved varieties of black pepper were multiplied from Main Campus, Kozhikode and Regional Station, Appangala and distributed to farmers. Improved varieties of ginger 200 beds and 900 beds improved turmeric varieties were planted and maintained for seed productionat main campus and Experimental Farm, Peruvannamuzhi. The cardamom suckers 10000 were multiplied

and distributed from Regional station, Appangala. Four thousand seedlings of cinnamon varieties and 2500 grafts of nutmeg were produced for distribution to farmers. Farmers participatory seed production of ginger (IISR Varada) is being taken up by signing an MOU at two farmer's plots (Mr. Baiju Sebastian, Thamarasery and Mr. Cheriyan, Pulpally) (Fig. 23).

Microrhizome of ginger varieties (IISR Mahima & IISR Varada) were subcultured and 2200 plantlets of ginger were raised in cultures and hardened in pro-trays and poly bags under nursery. Five hundred hardened micro rhizomes were raised in grow bag conditions and 300-500 g fresh rhizome yield was realized from each clump in 11 months cycle (Fig. 24 a & b). Those rhizomes were again being used as seed rhizomes for next production season.

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

Fig. 23 Participatory seed production of ginger at Farmers field (Mr. Cheriyan, Pulpally & Mr. Baiju, Thamarasery)

Fig. 24 a Ginger rhizome yield from microrhizome, **b** Ginger plants hardened from micro rhizomes

Value chain incubation facility for processing of spices

The facility was inaugurated by Hon'ble Agricultural Minister, Govt. of Kerala on 01 July 2020. At present the facility is used for the commercial production of ginger and nutmeg based value added products**.** Out of the trained participants one group namely Al-Dina Foods, have started using this facility for the production of various value added products

Plant beneficial rhizosphere microorganisms (PBRMs)

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

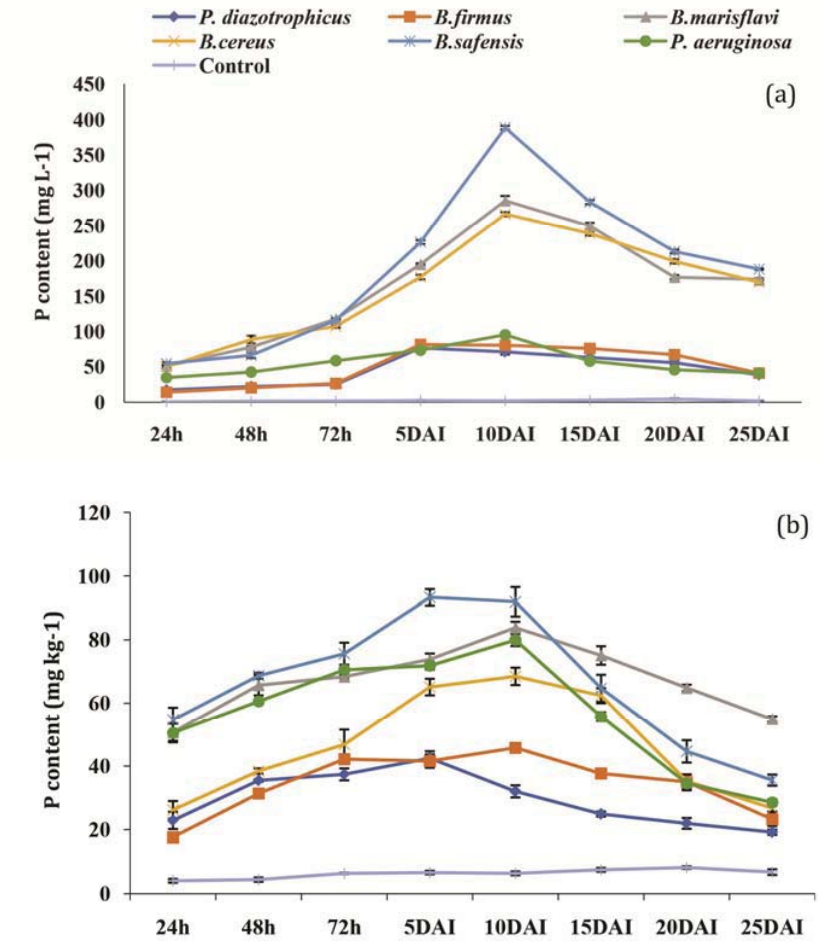


Fig. 25 Phosphorus (P) content in (a) liquid medium spiked with TCP (b) soil spiked with TCP at different days of incubation

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

Single node cuttings of black pepper (var. Sreekara*)* were grown in the presence and absence of AMF, *Rhizophagus* sp., for 150 days under polyhouse (Fig. 26). The inoculum of AM fungus, prepared with vermiculite as the carrier, contained 100 propagules of per gram of the inoculum in the form of spores, hyphae, and mycorrhizal roots. Rooted cuttings inoculated with AMF had significantly higher root length, shoot length and dry biomass when compared to uninoculated control which was more prominent in root biomass than aerial biomass at 30, 60 and 90, 120 and 150 days after AM inoculation (Table 5).

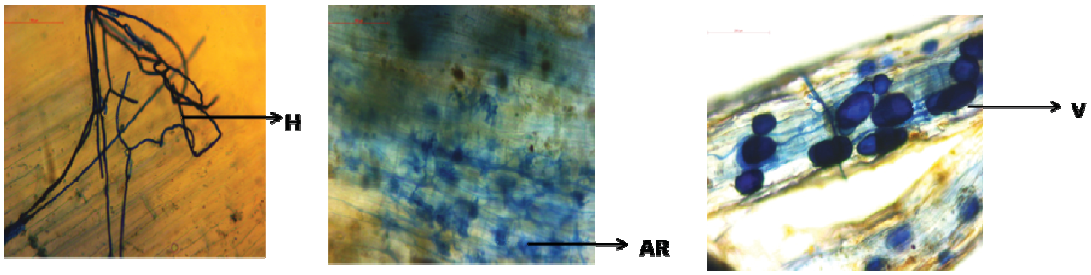


Fig. 26 AM root colonization showing hyphae (H), arbuscules (AR) and vesicles (V) in black pepper roots

Table 5 Influence of AMF on the growth and colonization of black pepper cuttings

Treatment (A)	DAI (B)	Shoot length (cm)	Root length (cm)	No of leaves	Dry biomass (g)
+AM	0	15	28	3	5.3
	30	50	30	8	7.8
	60	85	38	12	9.2
	90	155	41	15	10.3
	120	208	43	34	12.4
	150	235	32	39	14.3
	Mean	124.6	35.3	18.5	9.88
-AM	0	16	11	4	5.7
	30	58.3	23	8	7.2
	60	71.3	26.6	13	8.6
	90	150	27	16	9.2
	120	190	30	30	10.5
	150	219	34	34	10.6
	Mean	117.4	25.6	17.5	8.66
*p<0.05	Treatment (A)	NS	2.60	NS	0.75
	DAI (B)	17.42	4.50	2.68	1.31
	A x B	24.64	6.37	NS	NS

DAI-Days after inoculation, NS-Non significant

Root colonization by *Pochonia chlamydosporia* in black pepper

A greenhouse study was conducted to assess the root colonizing ability of nematode antagonistic fungus, *P. chlamydosporia*. Rooted cuttings of black pepper (var. Sreekara) raised in soilless medium were inoculated with the fungus and root samples were drawn at 3, 7, 14, 21 & 28 days after inoculation. Very high population of *P. chlamydopsoria* (2.8 – 3.0 $\log_{10}$ CFU/g of root) was observed 7 and 14 days after inoculation. For examining the endophytic colonization by *P. chlamydosporia*, roots collected at various intervals were used. There was steady increase in colonization from 7th day to 28th day post inoculation indicating the endophytic colonization of *P. chlamydosporia* in black pepper roots.

Real-time PCR estimation of endophytic colonization by *P. chlamydopsoria*

The endophytic colonization of *P. chlamydopsoria* was further confirmed through RT-PCR assay. *P. chlamydosporia* DNA was detected in roots at intervals of 7, 14, 21 and 28 dpi. Ct values in root samples ranged from 33.37 to 32.7 at 21 and 28 dpi which were interpolated using the standard curve as 0.8 ng to 1.8 ng at 21 and 28 dpi, respectively (Fig. 27).

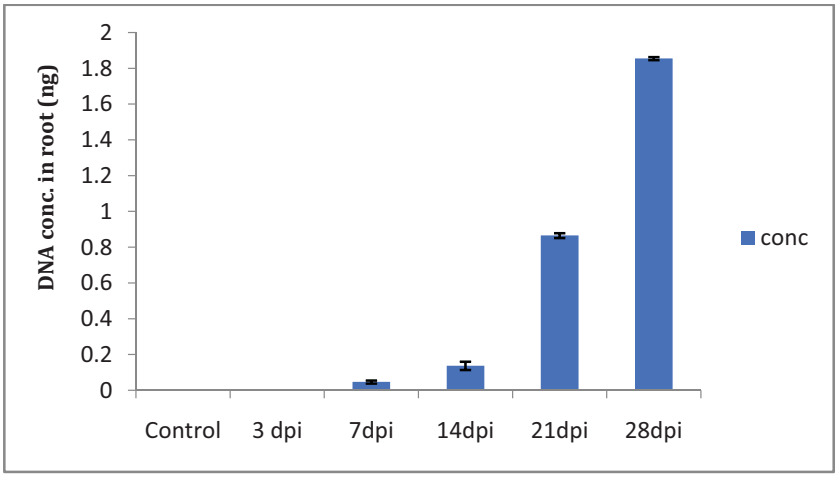


Fig. 27 Real-time PCR assay to study the endophytic colonization of *P. chlamydosporia* in black pepper roots at different intervals after inoculation

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

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

produced 486, 386, 508 ppm and 404, 269 and 566 ppm organic acids, respectively (Fig. 28 a & b).

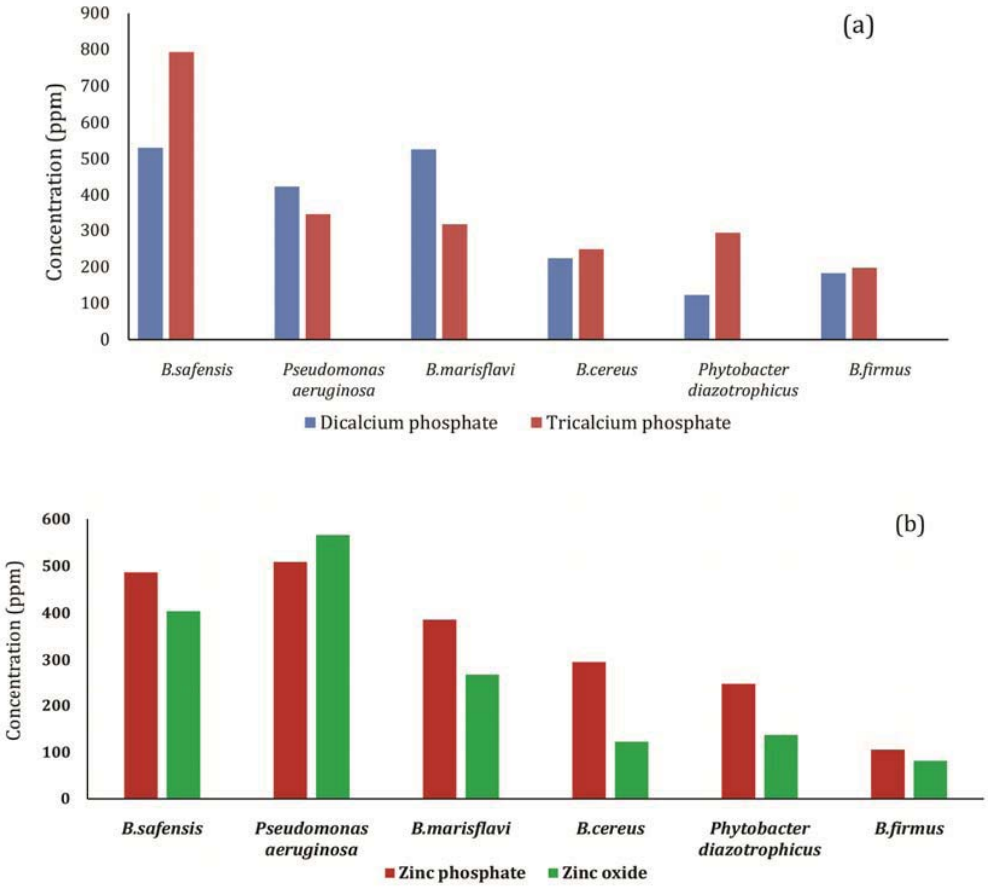


Fig.28 Organic acid production by six bacterial isolates during P and Zn solubilization (a) Insoluble P substrates (b) Insoluble Zn substrates

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

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

ECONOMICS & IMPACT ASSESSMENT

Infrastructure and export issues in spice industry

A study on the major issues requiring policy intervention and detailed attention in spice industry was conducted. One of the major requirements for the country to consolidate its position as the global leader in spices would involve critical changes in the production environment to suit the global market preference. The focus on food safety,

reduction in use of pesticides, adoption of sustainable and good agricultural practices (GAP) is key components of this change. Some other issues identified were:

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

Analysis of output performance in spices

One of the prime focus area of public funded research programmes were development of high yielding varieties to replace extant local varieties. Across the crops, more than 150 varieties developed by public funded research has been released. The public funded varieties cover more than 80% of the total area under spice crops. Continuous genetic advancement has played a significant role in maintaining the output growth in spices, at a rate higher than that of food grains and oilseeds taken together. The continuous decadal growth rate of output of spices till 2018-19 has been consistently above that of food grains and oilseed during the last three decades implying a better rate of technology uptake and resultant output growth (Fig. 29).

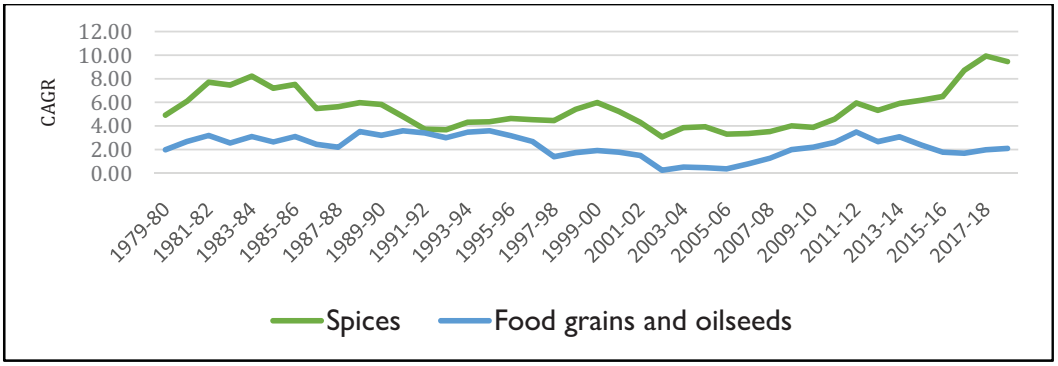


Fig. 29 Output performance of spices sector

Tribal Sub Plan (TSP) and Special Component Plan (SCP)

- Demonstration trial conducted on turmeric promotion programmes during two seasons in Paderu indicated that average yield for local cultivars were 3 MT of dry turmeric and 8 MT for Roma variety and a higher dry recovery of 22-24%.
- An area of 1,483 ha. of turmeric involving 1050 farmers organized under two FPO's was brought under organic cultivation adopting the technologies developed by ICAR-IISR.

- Training and stakeholder workshops were carried out in Golpara and Kamrup in Assam and Namsai in Arunchal Pradesh for 500 and 300 beneficiaries, respectively.
- The scheme integration of black pepper in ongoing "My Government Assam Clean & Green Village Campaign" was initiated for the vertical and horizontal expansion of black pepper sector in Assam (Fig. 30).
- The linkage of black pepper growers of the State with technology, training and trade was established to enhance the income of small and marginal farmers by organizing them into Pepper Production Cluster (PPC).
- Around 30 black pepper nurseries were set up in 33 districts for making available quality planting material to farmers.
- In Arunchal Pradesh, an FPO Namsai Organic Spices producer company (with 500 farmers) jointly with spices board, cultivated two varieties Rajendra sonia and Megha turmeric covering an area over 300 acres. The 100 tonnes of seeds during second season harvest was exchanged with the Department of Horticulture.

Fig. 30 Honourable Chief Minister of Assam with ICAR - IISR Scientists

ATIC AND EXTENSION SERVICES

- ATIC provided advisory and scientific services including sale of technology and products to various stake holders and there was perceptible shift from personal visits to virtual mode of contacts and use of digital platforms for availing the services offered.
- ATIC leveraged the increased use and familiarity with virtual platforms to reach out to wider stakeholder community across the country especially during the nationwide lock down period.
- Visitor management system software has been developed and implemented at the ATIC for efficient and easy handling of visitor stakeholders.
- About 16 on-demand training programmes for the state departments and other organisations on production and processing technologies were organized.
- Two Educational Training Programmes were organised for RAWE students of College of Agriculture Padakkad and Vellanikkara, Kerala Agriculture University , Thrissur.
- The institute joined hands with the Farm Information Bureau, Government of Kerala, to produce a series of radio programmes under the tile title "*Sugandha Keralam*" which were broadcasted during the popular farm programme called the "*Njattuvela*". The programmes were aired through seven radio stations at various times ensuring wider dissemination of information.
- The institute designed short instructional videos on diverse aspects of spice farming for easy dissemination of technology through social media platforms. The videos are available in public domain and are widely shared among the farming community.
- The institute provided technical support and expert services for video productions on its mandate spice crops for DD KisanChannel. A total of 8 programmes were broadcasted during the year through the programme titled "Masala India" through the national DD Kisan Channel.
- The revenue generation through the sale of planting material of spice crops, bio-inputs and micronutrients and other products from ATIC was 28.2 lakhs during 2020.

Table 6 Revenue generation from ATIC in 2020

ITEMS	AMOUNT(₹)
Planting material (NHM)	573220.00
Planting material (General farm)	154840.00
Farm produce	538279.00
Diagnostic services	122500.00
Biocapsules	584510.00
Bio inputs - others	217650.00
Micronutrients	308000.00
Others	170866.00
Total	2820515.00

ICAR-ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

The XXXI Workshop of ICAR-All India Coordinated Research Project on Spices (AICRPS) was conducted during 29-30 September 2020 at ICAR- Indian Institute of Spices Research, Kozhikode through virtual platform. The workshop was inaugurated by Dr. R. Chandra Babu, Hon'ble Vice Chancellor, Kerala Agricultural University, Thrissur on 29 September 2020.Dr. A. K. Singh, Deputy Director General (Horticultural Science), Indian Council of Agricultural Research, New Delhi presided over the function.

During the inaugural session the "Best AICRPS Centre Award 2019-20" was presented to AICRPS centre at IGKV, Raipur (Raigarh), Chhattisgarh. Ten booklets/pamphlets on spices production technologies in English and local languages from different AICRPS centres were released during the workshop.

During the workshop, a technology for the management of insect pest of large cardamom using Spinosad (45 SC @ 0.3 ml/L) or neem based oil (Azadirachtin 0.15% EC) 1500 ppm @ 3 ml/L) was recommended. Four varieties were recommended for release during XXXI AICRPS workshop (Table 7 & Fig 30).

Table 7 Varieties recommended for release during XXXI AICRPS workshop

Crop	Name of the variety	Developer	Recommended for	Salient features
Ginger	Acc. 247 (IISR Vajra)	ICAR- IISR, Kozhikode	Kerala, Karnataka, Odisha and West Bengal	Plumpy and bold rhizomes with high essential oil (2.15%), 7.26% oleoresin, 5.67% crude fibre and 20.7% dry recovery. Owing to its high zingiberene content (29.83%) it has a desirable flavor
Turmeric	Lam Turmeric1(LTS-2)	Dr. Y.S.R. Horticultural University	Andhra Pradesh, Telangana and Tamil Nadu	Provides dark lemon yellow colour powder suitable for masala industry, high yield (40-42 t/ha) and high dry recovery.
Turmeric	Rajendra Haldi 1	Dr. Rajendra Prasad Central Agricultural University, Dholi, Bihar	Bihar, Odisha and Andhra Pradesh	Has dwarf stature, matures early and is high yielding (55-64 t/ha). It has high curcumin (6.08%), 7% essential oil and 13.32% oleoresin content.
Fenugreek	HM 257	Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana	Haryana, Bihar, Rajasthan, Chhattisgarh and Gujarat	High yielder (20-22 q/ha) with field resistance todowny mildew and powdery mildew.

IISR Vajra

Lam turmeric 1 (LTS-2)

Rajendra Haldi 1

HM 257

Fig. 30 Varieties recommended for release during XXXI AICRPS workshop

Advisories given

- Crop advisories to the farmers for various spice crops were prepared by AICRPS and uploaded in the website. Planting material availability of spices at different regions were compiled and uploaded in AICRPS website.
- 852 advisories were given through newspaper in various local languages by different AICRPS centres
- Advisory to the farmers through whatsapp group (4489) and phone calls (5500) in local language
- Farmers' advisory was also broadcasted by AIR, Raigarh and AICRPS centre, Pottangi uploaded advisory on dry ginger production in You tube

KRISHI VIGYAN KENDRA

- The KVK imparted regular training programmes in agriculture and allied fields for the farmers, farm women, rural youth and extension functionaries. The Kendra conducted 75 on-campus and online mode trainings benefitting 12673 participants. Online trainings were organized on "cultivation of spices, vegetables, mushroom, ornamental fishes" and pest and disease management, which benefited more than 12000 persons during the COVID period.

- Sponsored trainings were organized on garment making, friends of Coconutand dairy entrepreneur (sponsor- ASCI), mechanized coconut climbing (Sponsor-Coconut Development Board, Cochin) and Nursery management (sponsor - MANAGE, Hyderabad – ASCI).

- Two training programmes on basics of plant propagation, propagation techniques were conducted for school students. One month long Rural Agricultural Work Experience (RAWE) programme was organised for B.S.c (Agriculture) students from Dr B.R. Ambedkar University, Agra.

- Five OFTs on "Yard long bean varieties, Strawberry varieties, management of aphids in cow pea, shedding placenta treatment in cows and water quality management for fish culture in 21 farmer fields were organized. Nutrigarden establishment demonstration for farm women is also implemented in Naduvannur and Kottur Grama Panchayats of Kozhikode district.

- The Kendra organized webinar on Nutrient management in spices during Kerala Farmer's Day (17th August) with expert class on 'Soil nutrients, deficiency symptoms and fertilizer management in spices Dr. V. Srinivasan, Principal Scientist, ICAR-IISR.

- National Farmers' Day was celebrated at KVK on 23 Dec, 2020 and a seminar on 'Bush pepper and vegetable grafting' was organized.

- Live - web casting of Global potato conclave inaugural by Hon'ble PM on 28 January; World Environment Day seminar on Oyster mushroom cultivation on 5th June; World Yoga day on 26 June; World Soil day workshop on Soil health management on 05 December were organized effectively as mass awareness programmes. Krishi Vigyan Kendra organized soil nutrient analysis camp, distribution of soil health cards and awareness creation programs for farmers on balanced fertilizer usage and soil health management.

Fig. 31 Activities of Krishi Vigyan Kendra, Peruvannamuzhi

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

- ITM-BPD unit commercialized 11 technologies during the year 2020 (Table 1). An amount of ₹ 27.65 lakhs were earned through technology commercialization and royalty payments from licensees.
- The institute entered in to a MoA withMalabar Regional Co-Operative Milk Producers' Union Ltd., (MRCMPU Ltd) on 11 November 2020 for collaboration in research and development of novel technologies related to health and wellness and its production as well as sales and for hand holding young startups and entrepreneurs for commercial production and marketing.
- A patent application was filed for the invention "An antimicrobial composition for coating rhizomes and tubers and a process for its preparation" on 08-10-2020.
- National Biodiversity Authority approval was obtained for two of the patent filed inventions 'A novel granular formulation of a beneficial fungus (*Lecanicillium psalliotae*) with multifarious plant growth promoting, immune boosting traits for cardamom and the process thereof and' A novel granular process for mass multiplication of *Pochonia chlamydosporia'*.
- The ITM-BPD unit facilitated one consultancy visit, two contract researches, and Phytophthora culture sharing with other ICAR institutes
- Ministry of Micro, Small & Medium Enterprises (MSME) recognised ICAR-IISR as Host Institute (HI) to setup/establish Business lncubator (BI). ITM-BPD unit organized a sensitization programme on a new scheme of MSME, Government of India 'Ideas for new India for supporting MSMEs through incubators' for Research scholars of the institute on 11 February 2020
- ICAR-IISR celebrated the foundation day on 01 July and organized various activities to promote farming in spices by awarding the eminent farmers of spices. During this occasion, Mr. Paulson Cyriac, M/s Nirappel Nursery, Thrissur, licensee of nutmeg varieties IISR Keralashree and IISR Viswashree and Mr. Mathew Kozhuvanal, Kozhikode, a determined clove farmer were honored with awards.
- Sixteen startups/ entrepreneurs were enrolled as incubates during the year 2020 under the BPD unit of ICAR-IISR for marketing of spices, development of spice based food products, marketing of agrinputs for spice cultivation and marketing planting materials of various spices and other crops.
- ITM-BPD unit produced an immunity booster formulation of spices based on an age old traditional formulation *viz.,* "Kava" through the incubatee Mrs. Maya, Arun Agro food products Ltd. and supplied to staff of IISR. Around 130 packets of Kava were sent to ICAR-headquarters for distribution among staff and other beneficiaries.
- ITM-BPD unit developed and supported startups in development and marketing of spices, spice based products such as hand sanitizers, mask spray. 20 L of hand sanitizer developed M/s Corevalleys Herbal technologies Pvt Ltd, Kozhikode was handed over to Kerala State Road Transport Corporation, during foundation day of IISR.

- SPIISRY, the sales outlet of IISR managed by the BPD unit is acting as a link for farmers, startups, and people looking for good quality spices and other allied products. As part of providing market linkage to startups, the products from FPOs, registered farmers and startups, MILMA products from MRCMPU Ltd are marketed by startups through SPIISRY (Fig. 32 & 33).
- Krishidhan nursery managed by BPD unit acting as a point for production and distribution of qualityassured planting materials of spices,plantation crops, fruit crops, medicinal and ornamentals of joint liability groups, licensees, registered farmers to customers.
- ITM-BPD members attended various seminars/ webinars for promoting institute technology commercialization and entrepreneurship.
- Principal investigator, IPR delivered lectures various technologies of ICAR-IISR, technology commercialization aspects and agribusiness opportunities in spices sector to startups/ entrepreneurs/farmers as part of training programmes /seminars /webinars.

Table 8 Commercialization of technologies during 2020

Name of Technology/ Know-How	Name of Contracting Party	Revenue Earned (₹)
A novel method of encapsulating PGPR/microbes through biocapsules	Krishi Vikas Sahakari Samiti Ltd, Jaipur, Rajasthan	7,00.000
Nutmeg -IISR Keralashree	Mrs. Vijitha Polson Nirappel Nursery Pattikkad PO, Thrissur, Kerala	25,000/-
Turmeric –IISR Pragati	Mr.Mohammed Umar Akthar Adilabad,Telangana	1,00,000/-
Turmeric –IISR Prathibha	Mr. Abdul Nabeel P M/s Natura Nursery and Agro Products, Kozhikode, Kerala	50,000/-
A spice mix as adjuvant in milk and milk products	Malabar Regional Co-Operative Milk Producers' Union Ltd., (MRCMPU Ltd),Kozhikode	4,000,00/-
A micronutrient composition for black pepper and a process for its preparation	Horticulture Department Dakshina Kannada, Karnataka	3,00,000/-
A micronutrient composition for black pepper and a process for its preparation	Centre of Excellence for Precision Farming, Maddur, Karnataka	2.50,000/-
A micronutrient composition for ginger and a process for its preparation (for soil pH<7)	Centre of Excellence for Precision Farming, Maddur, Karnataka	2,00,000/-
A micronutrient composition for turmeric and a process for its preparation (for soil pH<7)	Centre of Excellence for Precision Farming, Maddur, Karnataka	2,00,000/-
A micronutrient composition for black pepper and a process for its preparation	Leaf Analysis Lab, Shivamogga, Karnataka	2,50,000/-
A micronutrient composition for ginger and a process for its preparation (for soil pH>7)	Leaf Analysis Lab, Shivamogga, Karnataka	2,00,000/-

Fig. 32 MoA execution between ICAR-IISR and Malabar Regional Co-Operative Milk Producers' Union Ltd., (MRCMPU Ltd), Kozhikode.

Fig. 33 Director, ICAR-IISR and Officials of MRCMPU Ltd handing over the dairy products and spice products to M/s Cropnrich Agri Pvt Ltd, Wayanad as part of the programme organized at SPIISRY for handholding startups by ICAR-IISR and MRCMPU Ltd.

AGRICULTURAL KNOWLEDGE MANAGEMENT UNIT (AKMU)

AKMU facilitates the IT and ICT related activities of the institute and ensures uninterrupted internet connectivity to all divisions/sections and VPN connectivity to IISR Regional station, IISR Experimental Farm and Krishi Vigyan Kendra. AKMU is also taking care of network security aspects, developing websites and regular updating of websites of the institute, AICRP on spices, SpicE-Library, and BPD. Displaying circulars and other materials in the website and intranet portal, maintenance of SpicE-mail, webserver etc., were also done. The repair and maintenance of computers and its accessories, video conferencing, audio visual support to various activities were also facilitated through AKMU. Apart from this AKMU assists in analyze and interpret geographical data using ArcGIS & DIVA GIS and statistical analysis of scientific data using SAS and other statistical software, developed a mobile applications ICAR-IISR Cardamom (Fig. 34), ATIC Visitor Management System (Fig. 35) and online applications for the selection of young professionals and senior research fellows

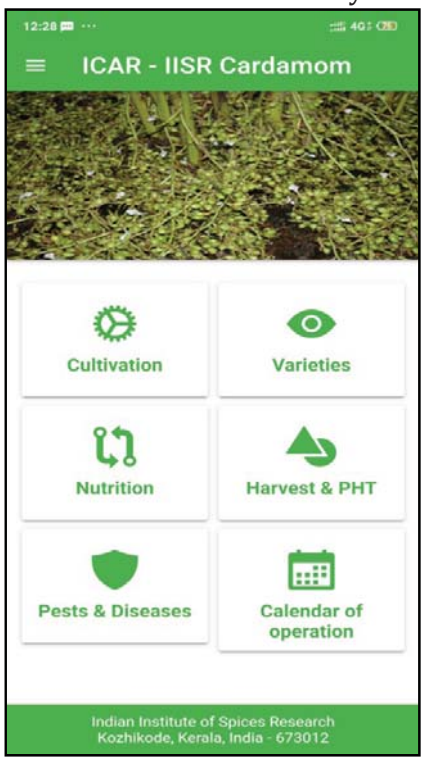


Fig. 34 ICAR-IISR Cardamom Mobile App (Android)

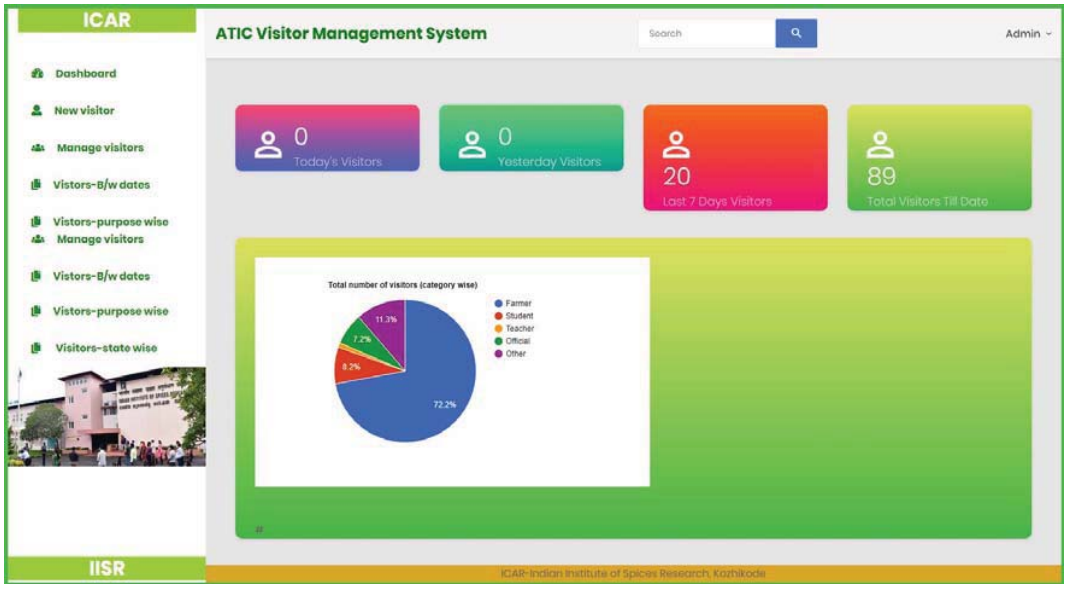


Fig.35 ATIC Visitor Management System

हिंदी अनुभाग

राजभाषा कार्यान्वयन समिति की बैठक

वर्ष 2020 में राजभाषा कार्यान्वयन समिति की दो बैठकें आयोजित की हैं। पहली बैठक 18 मार्च 2020 को डॉ. के. निर्मल बाबू, निदेशक, आईसीएआर-आईआईएसआर एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति की अध्यक्षता में संपन्न हुई। दूसरी बैठक 13 अक्तूबर 2020 को डॉ. संतोष जे. ईपन, निदेशक आईसीएआर-आईआईएसआर एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति की अध्यक्षता में संपन्न हुई। बैठक में निदेशक महोदय ने संस्थान की राजभाषा कार्यान्वयन की समीक्षा के और नये दिशानिर्देश भी प्रस्तुत की।

हिन्दी कार्यशाला

राजभाषा को लोकप्रिय करने के लिए आईसीएआर-आईआईएसआर, कोषिक्कोड में दो हिंदी कार्यशालाएं ऑनलाइन मोड में आयोजित की गयी। पहली कार्यशाला दिनांक 24 सितंबर 2020 को आयोजित की जिसमें श्री. एम. अरविंदाक्षन, वरिष्ठ अनुवाद अधिकारी, कर्मचारी भविष्य निधि संगठन ने राजभाषा नीति एवं हिंदी टिप्पणी के बारे में ऑन लाइन कक्षा चला दी। इसमें 21 स्टाफ सदस्यों ने भाग लिया।

दूसरी कार्यशाला दिनांक 18 दिसंबर 2020 को आयोजित की। यह भी वेबएक्स प्लाटफोर्म पर थी। इसमें ई-ऑफीस के बारे में श्री, मनोज सिंह ने कक्षा चला दी और श्री सूरज विश्वकर्मा ने प्रतिभागियों की शंका का समाधान दिया।

हिन्दी पखवाडा 2020

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में 14 सितंबर से 1 अक्तूबर 2020 तक हिंदी पखवाडा मनाया गया। देश के वर्तमान कोविड-19 महामारी के व्यापन के कारण संस्थान में हिंदी पखवाडा ऑन लाइन तरीके से आयोजित की। इस अवसर पर संस्थान के निदेशक डॉ. संतोष जे. ईपन का हिंदी दिवस से संबंधित संदेश तथा श्री नरेंद्र सिंह तोमर, कृषि एवं किसान कल्याण, ग्रामीण विकास और पंचायती राज मंत्री, भारत सरकार, नई दिल्ली के हिंदी दिवस का संदेश सभी

अधिकारियों एवं कर्मचारियों को ई-मेल भेज दिया। हिंदी दिवस के अवसर पर डॉ. त्रिलोचन महापात्र, महानिदेशक, भारतीय कृषि अनुसंधान परिषद की अपील की वीडियो संस्थान के रिसप्शन की टीवी में प्रदर्शित की।

हिंदी पखवाडा के अवसर पर विभिन्न हिंदी प्रतियोगिताओं जैसे हिंदी अनुशीर्षक लेखन, हिंदी गीत, हिंदी कविता पाठ, हिंदी सार लेखन, हिंदी टिप्पणी एवं मसौदा लेखन, हिंदी सुलेख आदि का आयोजन किया था। हिंदी पखवाडा के अवसर पर दिनांक 24 सितंबर 2020 को एक ऑन लाइन हिंदी कार्यशाला आयोजित की।

दिनांक 1 अक्तूबर 2020 को हिंदी पखवाडा का समापन समारोह ऑन लाइन तरीके से आयोजित किया। इस समारोह में डॉ सुस्मिता भट्टाचार्या, उपनिदेशक, क्षेत्रीय कार्यन्वयन कार्यालय (दक्षिण-पश्चिम) मुख्य अतिथि थी। इस समारोह में विभिन्न प्रतियोगिताओं के विजेताओं की घोषणा की। इसके अलावा संस्थान में हिंदी में मौलिक रूप से अधिकतम शब्दों का प्रयोग करने के लिए श्रीमती सी. के. बीना, निदेशक का निजी सचिव को हिंदी टिप्पणी एवं मसौदा लेखन पुरस्कार तथा विभिन्न हिंदी कार्यों के द्वारा राजभाषा का प्रोत्साहन करने के लिए डॉ. सी. के. तंकमणी, अध्यक्ष, फसल उत्पादन एवं फसलोत्तर प्रौद्योगिकी को राजभाषा प्रोत्साहन पुरस्कार मुख्य अतिथि के वरचुअल उपस्थिति में डा. जे. रमा, निदेशक के द्वारा वितरण किया गया।

नराकास गतिविधियां

सुश्री एन. प्रसन्नकुमारी, वरिष्ठ तकनीकी अधिकारी ने 23 सितंबर 2020 को आयोजित नगर राजभाषा कार्यान्वयन समिति की ऑन लाइन अर्धवार्षिक बैठक में भाग ली।

संस्थान के दो स्टाफ सदस्यों ने हिंदी गीत प्रतियोगिता और हिंदी अनुशीर्षक लेखन प्रतियोगिता में भाग ली।

प्रकाशन

वर्ष 2019-20 में निम्न लिखित हिंदी प्रकाशनों को प्रकाशित किया।

- अदरक में जीवाणुक म्लानी का एकीकृत प्रबंधन।
- मसाला फसलों की रोपण सामग्रियों का उत्पादन।
- अखिल भारतीय समन्वित मसाला अनुसंधान परियोजना के वार्षिक प्रतिवेदन का कार्यकारी सारांश हिंदी में तैयार करके वार्षिक प्रतिवेदन में शामिल किया।
- आईआईएसआर वार्षिक प्रतिवेदन 2019 का कार्यकारी सारांश हिंदी में तैयार करके वार्षिक प्रतिवेदन में शामिल किया।

राजभाषा रिपोर्ट

संस्थान के राजभाषा कार्यान्वयन की तिमाही एवं वार्षिक रिपोर्ट तैयार करके भारतीय कृषि अनुसंधान परिषद, नई दिल्ली को भेज दिया। राजभाषा कार्यान्वयन का अर्धवार्षिक रिपोर्ट तैयार करके नगर राजभाषा कार्यान्वयन समिति को प्रस्तुत किया।

संस्थान की विभिन्न समितियों एवं सदस्यों की सूची हिंदी में तैयार करके वेवसाइट में अपलोड की गयी

प्रशिक्षण

संस्थान के छः अधिकारियों ने केन्दीय हिंदी प्रशिक्षण संस्थान द्वारा आयोजित पत्राचार पाठ्यक्रम का हिंदी प्रबोध पाठ्यक्रम में भाग लिया। इसमें तीन वैज्ञानिकों ने परीक्षा लिख दी।

सुश्री एन. प्रसन्नकुमारी, वरिष्ठ तकनीकी अधिकारी ने सिफनट, कोच्चि में नगर राजभाषा कार्यान्वयन समिति, कोच्चि द्वारा आयोजित दो दिवसीय (9-10 जनुवरी, 2020) राजभाषा संगोष्ठी में भाग ली।

सुश्री एन. प्रसन्नकुमारी, वरिष्ठ तकनीकी अधिकारी ने 6 फरवरी 2020 को होटल मरीना रसिडेंसी में आयोजित नगर राजभाषा कार्यान्वयन समिति की संयुक्त हिंदी समारोह के समापन समारोह में भाग लिया।

राजभाषा विभाग, नई दिल्ली द्वारा संचालित पत्राचार पाठ्यक्रम के प्रबोध परीक्षा दिनांक 26 नवंबर 2020 को संस्थान में आयोजित की।

LIBRARY

Library continued to provide the online and offline services and regularly. Updated databases related 'Faculty Profile','DSpice' (institutional repository)and 'KOHA' (online library catalogue). Subscribed 24 Indian and nine foreign journals in addition to journals accessible under Consortium of Electronic Resources in Agriculture (CeRA)

Library added 240 publications to stock. Library continued to exchange publications with various organizations as part of exchange programme. Participated in e-journal consortium document delivery service and requests from other partners were catered. Added 200 full text publications to 'DSpice' institutional repository.

All newly added publications were brought in to the 'KOHA' database and Cataloguing Classification data updated. Monthly issues of newspaper clipping service 'Agrititbits' were brought out. User awareness was done for the benefit of new patrons of library.

HUMAN RESOURCE DEVELOPMENT

ICAR-IISR has signed MoU with two institutions viz., University of Agricultural and Horticultural Sciences, Shivamoga, Karnataka and Dr. YSR Horticultural University, West Gothavari, Andhra Pradesh for research collaboration and exchange of students.

Table 9 Training and Capacity Building of IISR Employees

Participation of ICAR IISR staff members in training programmes			
Name	Training particulars	Duration	Institute
Scientifc staff			
Dr. Santhosh J Eapen Dr. D. Prasath Dr. K V. Saji Dr. A. Ishwara Bhat Dr. R. Dinesh Dr. N.K. Leela Dr. P. Rajeev Dr. E. Jayashree Dr. Sharon Aravind Dr. Praveena R. Dr. C. Sarathambal Dr. S. Aarthi Ms. Sivaranjani R.	E – office Awareness Training Programme	03 June 2020	ICAR-IISR, Kozhikode
Dr. R. Ramakrishnan Nair Dr. C.M. Senthil Kumar Dr. A. Jeevalatha Dr. C.K. Thankamani Dr. K. S. Krishnamurthy Dr. T.E. Sheeja Dr. Lijo Thomas Dr. M. Alagupalamuthirsolai Dr. C. Sellaperumal Dr. Anees K.	E – office Awareness Training Programme	08 June 2020	ICAR-IISR, Kozhikode
Dr. Anees.K. Dr. T.E. Sheeja	Fourteen days virtual workshop –cum-Training on Intellectual Property Risk in Agricultural Research and Education in India	12 September 2020	ICAR-IP&TM cell, New Delhi
Dr. T.E. Sheeja Dr. Anees K. Ms. Sivaranjani R.	Uncertainty of measurement and decision rule (Online)	17 October 2020	Quality council of India
Dr. Lijo Thomos	Market Research & Value Chain Management of Agricultur al (Online)	17-21November 2020	ICAR-NAARM, Hyderabad
Dr. Santhosh J Eapen Dr. V. Srinivasan Dr. D. Prasath Dr. C.M. Senthil Kumar Dr. Lijo Thomos Dr. Praveena R. Dr. C. Sarathambal	Virtual training on Introduction of new features GeM Portal	17 December 2020	ICAR-IISR, Kozhikode
Dr. R. Dinesh Dr. C.M. Senthil Kumar	Drone for Agriculture	16 December 2020 to 6 February 2021	Wageningen University and Research Netherland

Administrative staff			
Mr. R. N. Subramaniam Mr. P. Sundaram Mr. V.C. Sunil Mr. V.V. Sayed Muhammed Mr. Jayaprakash P.T. Ms. Beena C.K. Mr. Rahul P.K. Ms. Seema M. Ms. Rebeena N.	E - office Awareness Training Programme	3 June 2020	ICAR-IISR, Kozhikode
Mr. P. Sundaran Mr. V.V. Sayed Muhammed Mr. P. Muraleedaran Ms. Rebeena N. Mr. Neela Megha Shyamala Kanan Mr. Sunil V.C. Mr. Beena C.K.	Training on Introduction of new features GeM Portal	17 December 2020	ICAR-IISR, Kozhikode
Technical Staff			
Mr. Jayarajan K. Ms. Chandravally P.K. Mr. Sudhakaran A. Mr. Krishna Das Mr. Vijesh kumar I.P. Mr. O.G. Sivadas Ms. Shajina O. Mr. Binoy V.S. Mr. Prasana kumari N. Mr. Ramesh Kumar M.P. Mr. Reshmish A.R. Mr. Hareesh B.T Mr. T.C. Prasad Mr. Nikhil C.M. Mr. Sadasivan T.R. Mr. Vishnu B. Ms. Hridya K.S. Mr. Premachandran K.P.	E - office Awareness Training Programme	08 June 2020	ICAR-IISR, Kozhikode
Mr. K.Jayarajan Dr. E. Radha Mr. R. Bharathan	Virtual training on Introduction of new features GeM Portal	17 December 2020	ICAR-IISR, Kozhikode

Table 10 Seminar/Symposium/Conferences attended by employees

Participation of ICAR IISR staff members in Seminar/Symposium/Conferences			
Name	**Seminar/Symposium/conference/Workshop**	**Duration**	**Institute**
Dr. C.K. Thankamani Dr. M.S. Shivakumar Ms. Sivaranjani R.	National seminar on spices: Emerging trends productions, processing and marketing	21-22 January 2020	ICAR-CCRI Goa
Dr. M. Balaji Rajkumar	International seminar on Transboundary pest management	04-05 March 2020	TNAU, Coimbatore

Dr. Jeevalatha A. Dr. C. Sellaperumal Dr. C. Sarathambal	New trends in Agriculture, environmental and biological sciences for inclusive development (NTAEBSID-2020)	21-22 June 2020	Agro environmental development Society, Rampur, Uttar Pradesh
Dr. C. Sarathambal	E International conference on multidisciplinary approaches for plant disease management in achieving sustainability in agriculture	06-9 October 2020	University of Horticultural Sciences, Bagalkot
Ms. Sivaranjani R.	E Conference on plant specialized metabolism and metabolic engineering	14-16 October 2020	CSIR- Central Institute of Medicinal and Aromatic Plants, Lucknow
Dr. Sharon Aravind	E Conference on Advances and future outlook in biotechnology and crop improvement for sustainable productivity	24-27 November 2020	University of Horticultural Sciences, Bagalkote
Ms. Sona Charles	Virtual international conference on Bioinformatics 2020	25-29 November 2020	Apbionet
Dr. Biju C.N.	Indian Phytopathological Society (South Zone 2020) Virtual symposium on advances in crop health management	01-02 December 2020	ICAR -RS Wellington

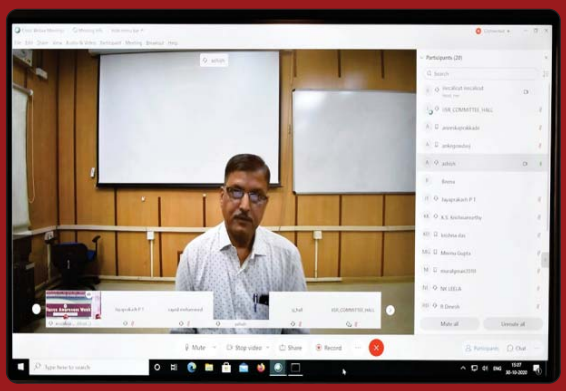
Table 11 PhD registrations

PhD registrations		
Name of the student	**Guide**	**Subject**
Ms. Aswathi A.P.	Dr. D. Prasath	Botany
Mrs. Saljuna K.P.	Dr. C.K. Thankamani	Botany
Ms. Megha Das	Dr. A. Ishwara Bhat	Botany
Ms. Karthika C.S.	Dr.C.N. Biju	Botany
Ms. Fathimath Zumaila	Dr. A. Jeevalatha	Botany

Table 12 PhD degree awarded

PhD degree awarded			
Student	**Topic**	**University**	**Guide**
Dr. Krishna P.B.	Characterization and development of molecular diagnostics for burrowing nematode infecting black epper	University of Calicut	Dr. S.J. Eapen

MAJOR EVENTS 2020



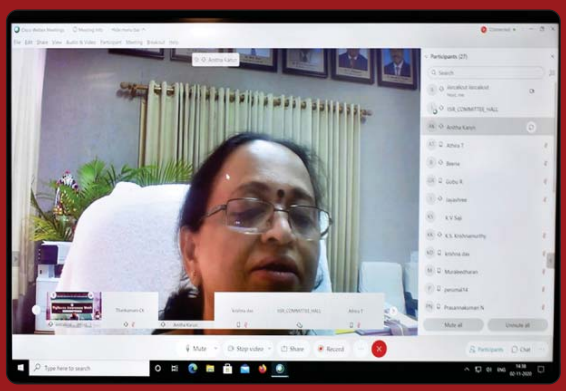


Fig.36 Vigilance awareness activities at ICAR IISR

MAJOR EVENTS 2020

Vigilance awareness week

Vigilance awareness week was observed from 27 October 2020 to 2 November 2020 in all the three campuses of ICAR-IISR namely, IISR head quarters at Chelavoor, Kozhikode; Regional station at Appangala and Experimental Farm at Peruvannamuzhi. The week started with the Integrity Pledge taken by all the staff members of the institute in their respective centres at 11.00 am on 27th October, in all the stations. Various programmes were organized to promote integrity, transparency and accountability in public life and also to bring in awareness of the harmful effects and gravity of corruption and the need for having a vigilant society to prevent corruption based on the theme "Vigilant India, Prosperous India"for this year.

Slogan writing competition both in Malayalam and English, and Essay writing competition in English and Malayalam for staff was conducted based on this year's team. As a part of Vigilance Awareness Week 2020, an online lecture on "Conduct Rules" at 3.00 pm on 30-10-2020 by Shri Ashish Roy, Ex Joint Director (Administration) and Registrar, ICAR-National Academy for Agricultural Research Management (ICAR-NAARM), Hyderabad was organized at the campus for the benefit of entire staff of the institute (Fig. 36).

The Valedictory Function of the VAW- 2020 was held on 2nd November at 2.30 pm in the institute. Dr. A. Ishwara Bhat, Vigilance Officer of the institute welcomed the gathering and gave a presentation on the various activities conducted during VAW-

2020 in all three campuses of the Institute. Dr. Santhosh J Eapen, Director of the institute gave the presidential address. Dr Anitha Karun, Director, ICAR-Central Plantation Crops Research Institute (ICAR-CPCRI), Kasaragod was the Chief Guest. All staff members including those from the Regional Station, Appangala and Experimental Farm, Peruvannamuzhi joined the programme onlne. Dr Anitha Karun spoke on the various measures taken to promote personal integrity and prevent corruption and also explained to the audience the various steps taken to help the public when they report corruption and how to report corruption without fear.Prizes were distributed to the winners during the Valedictory function. The programme came to an end with a Vote of thanks proposed by Mr.John George, Chief Technical Officer.

Swachhta activities

With the conclusion of two yearlong commemoration period of 150th birth anniversary of Mahatma Gandhi, ICAR-Indian Institute of Spices Research, Kozhikode organized a webinar on "Hygienic Life and COVID 19" by Dr. T. S. Anish, Associate Professor, Department of Community Medicine, Medical College, Thiruvananthapuram on 02 October 2020. The webinar discussed the importance of using mask and sanitizer as a measure to curb the spread of COVID 19. Many of the air-borne diseases have subsided with the use of mask; he said adding that even the cases of tuberculosis have come down with the use of mask. Dr. J. Rema Director-in-Charge presided over the function (Fig. 37).

Fig.37 Swachhta activities at ICAR IISR

Dr. C. K. Thankamani, Principal Scientist and Nodal Officer (Swacchta Committee) and Dr. C. N. Biju, Senior Scientist were present during the occasion. The staff members of the institute including Scientists, Technical, Administrative, Students, SRFs at headquarters, Regional Station, Appangala and Experimental Farm, Peruvannamuzhi attended the webinar. Planting saplings of Erythrina, nutmeg, avocado, citrus and black pepper was carried out at ICAR-IISR Regional Station Appangala. In addition to this plant saplings were distributed to poor families. At Experimental Farm, Peruvannamuzhi, saplings of various spices were planted in tree spice germplasm and cleaning was undertaken in the area adjacent tohi-tech polyhouse. The fortnightly Swachhta Pakhwada 2020 campaign at ICAR-IISR, Kozhikode was inaugurated by Dr. Santhosh J. Eapen, Director during which, the Swachhta pledge was administered followed by planting of nutmeg saplings in the farm.

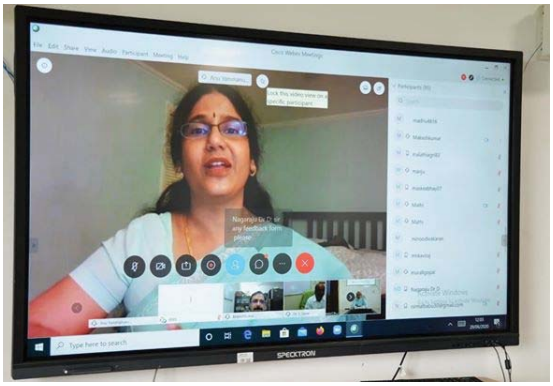
As a part of Swachhata fortnight celebration, scientists and technical staff of ICAR-IISR conducted crop surveillance and monitoring visit toKattippara, the village adopted by the Institute under *Mera Gaon Mera Gaurav* programme. The volunteers visited the farmer's plots including kitchen gardens, paddy lands, banana plantations and vegetable gardens in collaboration with the Krishi Bhavan, Kattippara which was coordinated by K. K. Muhammad Faisal (Agricultural Officer), Dr. K. V. Saji, Dr. C. M. Senthilkumar and Dr. C. N. Biju, Scientists, ICAR-IISR interacted with the farmers during the field visits.

Consultative online meeting for North East

A consultative online meeting on quality planting material production of ginger and turmeric in the NE region was jointly organized by the Mission Organic Value chain Development for NE Region (MOVCD-NER) and ICAR- IISR/ ICAR-AICRPS, Kozhikode on 16 October and 4 November 2020. Mission Organic Value Chain Development for North Eastern Region (MOVCD-NER), is a scheme launched by the Ministry of Agriculture and Farmer Welfare, covering all the eight states of the North East with an area of over 80,000 ha and 134 Farmer Producer Companies which aim at development of certified organic production in a value chain mode.

Fourth Dr.Y.R. Sarma Memorial Lecture

Prof. M S Reddy, Former Professor, Department of Entomology & Plant Pathology, Auburn University Auburn, United States and Founder Chairman of Asian PGPR Society delivered the fourth Dr.Y.R. Sarma Memorial Lecture on "Nano based microbial technologies for 21st century's sustainable spice cultivation" organized by ICAR - Indian Institute of Spices Research in association with Dr.Y.R. Sarma Memorial Trust. Prof. Reddy said that nanotechnology based microbial formulations are increasingly used across the globe to enhance the efficacy of microorganisms and to decrease human toxicity and adverse effects on environment. More than 400 participants from various parts of the world registered for the lecture. The programme was chaired by Dr. Santhosh J. Eapen, Director, ICAR-IISR. Dr.Anuradha Sarma proposed vote of thanks.



Constitution day celebration

ICAR-IISR observed the year long celebrations to mark the 70th anniversary of the Indian Constitution with different programmes. Mizoram Governor P S Sreedharan Pillai inaugurated the valedictory session of the Indian Constitution Day observance on November 26. Dr. A. K Singh, Deputy Director General (Horticulture) presided over theConstitution Day observance. Adv. Kumaran C.V., Principal of the Government Law College Kozhikode delivered technical lecture on"Change: An inherent part of a stable constitution?". A webinar was also organized on the new agriculture bills passed by the Central Government on October 9. Dr. L. R Aarathi, Special officer, WTO Cell of Department of Agriculture delivered the keynote address during the webinar.

RAC meeting

The first meeting of the IX Research Advisory Committee (RAC) was held at the ICAR-Indian Institute of Spices Research Kozhikode on September 17. Dr N K Krishna Kumar, chairman of RAC the former Deputy Director General of Horticulture headed the sessions. Dr. N.K. Krishna Kumar released 'Research Highlights 2019' during the online meeting. Dr. Santhosh J. Eapen, Director presented an overview of ICAR-IISR. RAC members including Dr. U.C. Srivastava, Dr. V.C. Mathur, Dr. Jitendra Kumar, Dr. V.G. Malathi and Dr. H. Bhatacharya and Dr. V.K. Pandey (ADG) presented their views and suggestions.

Foundation day

The 25th foundation of ICAR-Indian Institute of Spices Research, Kozhikode was celebrated with various programmes on 01st July 2020. The day-long celebrations were inaugurated by Dr. A. K. Singh, Deputy Director General (Hort. Sci.), ICAR, New Delhi. Dr. R. Ramakumar, Professor, Tata Institute of Social Sciences, Mumbai and Member of Kerala State Planning Board delivered a lecture on 'Global and Indian Challenges in Agriculture Sector in the Post Covid Scenario. Adv. V. S. Sunil Kumar, Hon'ble Minister for Agriculture, Govt. of Kerala, who was the chief guest in the afternoon session, inaugurated two new facilities- Spice Processing Facility and Pesticide Residue Analytical Laboratory, at the institute headquarters. On this occasion Mr. K.V. Noushad,

Agricultural Officer explained about the 'Subiksha Keralam' project of Kerala Government.

Summer care training programme

ICAR-IISR in association with Mission for Integrated Development of Horticulture (MIDH) organized an online training programme for spices farmers. The training was conducted to educate spices farmers on season specific cultivation methods and strategies. Two sessions were conducted as part of the training programme. Dr. Biju C N Senior Scientist, ICAR-IISR and Dr. K M Prakash, Subject Matter Specialist, KVK Peruvannamuzhi presented the lectures. Over 100 farmers from different parts of Kerala attended the online training programme.

Training for nutmeg farmers

A two-day online training programme on 'Sustainable production practices in nutmeg cultivation' was organized on 16 October and over 100 nutmeg farmers across Kerala participated in the program. The webinar was inaugurated by Dr.Femina, Deputy Director of the Directorate of Arecanut and Spices Development. Dr. Santhosh J Eapen, Director of ICAR-IISR chaired the session. Dr. V Srinivasan, Dr. Biju C N and Dr. E Jayasree of ICAR-IISR and Dr. Mini Raj N, Professor, Department of Plantation and Spice Crops, Kerala Agriculture University interacted with the farmers.

INSTITUTE MANAGEMENT COMMITTEE

1	Dr. Santhosh J Eapen Director, ICAR-IISR, Kozhikode, Kerala	Chairman
2	Director of Agriculture Department of Agriculture Development and Farmers Welfare, Vikas Bhavan, Trivandrum, Kerala	Member
3	Director (Horticulture) Chepauk, Chennai, Tamil Nadu	Member
4	Associate Director RARS, Pattambi, Kerala	Member
5	Sri. T.P. Jayachandran Master Narikkuni, Kozhikode	Member
6	Sri. Nanjundan Bhojan Chairman, Sathiyakaathi Global School, Kotagari	Member
7	Dr. T. Makeshkumar Principal Scientist ICAR-CTCRI, Trivandrum, Kerala	Member
8	Dr. K. Madhavi Reddy Principal Scientist ICAR-IIHR, Bengaluru, Karnataka	Membeer
9	Dr. A. IshwaraBhat Principal Scientist ICAR-IISR, Kozhikode, Kerala	Member
10	Dr. Vinayaka Hegde Head (Crop Protection) ICAR-CPCRI, Kasaragod, Kerala	Member
11	Dr. Vikramaditya Pandey ADG (HS)-II ICAR, New Delhi	Member
12	Mr. P. Krishna Kumaran Finance & Accounts Officer ICAR-CTCRI, Trivandrum, Kerala	Member
13	Administrative Officer ICAR-IISR, Kozhikode, Kerala	Member

RECOMMENDATIONS OF THE FIRST MEETING OF THE IX RAC

1. Andaman Islands & NE region should be the focus for trait-specific collection aimed at utilization. Avoiding duplicates, strengthening characterization using molecular methods/Barcoding of germplasm must be started. Crop-specific minimum descriptors need to be developed for spices. Core collection to be conserved in two places (ICAR IISR and NE). Cryo-conservation of pollen and tissue should be initiated at ICAR IISR.

2. Breeding priority(s) should be fixed for each spice crop & molecular breeding techniques e.g. MAS for introgression of desirable trait(s). Varietal release based on an index developed using summation of prioritized, weighted parameters etc. is needed. Improvement in Large Cardamom through collection, conservation, and trait-specific breeding must start.

3. Enhanced inputs use efficiency without compromising productivity and with due concern for food safety in production trials needs special attention. Standard Package of Practices for Protected and organic cultivation must be generated.

4. A research project on pesticide residue monitoring including aflatoxins, additives; need to be formulated on priority. Reorient and prioritize research on yield limiting pests including nematodes, with value added for ecological sustainability (ES) need to start. Epidemiology and comprehensive management of Chirke virus in large cardamom must be addressed on priority.

5. The ICAR-IISR should review the National and International scenario of spice trade and accordingly prepare a Policy paper on Spices to guide the Government on enhancement of exports and minimization of imports through scientific and technical background notes. Factors contributing to higher cost of production, issues relating to safety of market spices samples, global trends in spices need critical analysis to facilitate export competitiveness.

6. The megaprojects may be reoriented based on the research priorities set for the next five years.

RESEARCH PUBLICATIONS

1. Aarthi S, Suresh J, Leela N K & Prasath D (2020) Multi environment testing reveals genotype-environment interaction for curcuminoids in turmeric (*Curcuma longa* L.). Industrial Crops and Products 145: 112090.
2. Akshitha H J, Umesha K, Leela N K, Shivakumar M S & Prasath D (2020) Essential oil profiling of ginger (*Zingiber officinale* Rosc.) genotypes from India. Journal of Essential Oil Research, DOI: 10.1080/10412905.2020.1789000.
3. Alagupalamuthirsolai M, Ankegowda S J, Murugan M, Sivaranjani R, Balaji Rajkumar & Akshitha H J (2019) Influence of Light Intensity on Photosynthesis, Capsule Yield, Essential Oil and Insect Pest Incidence of Small Cardamom (*Elettaria cardamomum* (L.) Maton). Journal of Essential Oil Bearing Plants 22: 1172-1181.
4. Anandaraj M, Mathew S K, Eapen S J, Cissin J, Rosana O B & Bhai R S (2020) Morphological and molecular intervention in identifying *Phytophthora* spp. causing leaf and nut fall in nutmeg (*Myristica fragrans* Houtt.). European Journal of Plant Pathology 156: 373–386.
5. Ankita N, Johnson George K, Rahul S J, Soumya M, Angadi B, Iquebal A, Manju P, Umadevi P, Anil Rai & Dinesh Kumar (2020). Drought responsiveness in black pepper (*Piper nigrum* L.): Genes associated and development of a web-genomic resource. Physiologia Plantarum. https://doi.org/10.1111/ppl.13308.
6. Bhai R S, Ammu Raj, Vincy K & Eapen S J (2020) Elucidation of antibacterial effect of calcium chloride against *Ralstonia pseudosolanacearum* race 4 biovar 3 infecting ginger (*Zingiber officinale*Rosc.). Archives of Microbiology.doi: 10.1007/s00203-020-02052-1.
7. Bhat A I, Naveen KP, Pamitha N S & Pant R P (2020) Association of two novel viruses with chlorotic fleck disease of ginger. Annals of Applied Biology 177:232–242.
8. Bhat A I, Pamitha N S, Naveen K P & Biju C N (2020) Identification and characterization of cardamom vein clearing virus, a novel aphid-transmitted nucleorhabdovirus. European Journal of Plant Pathology 156:1053–1062.
9. Biju C N, Praveena R, Peeran M F, Sujatha A M & Ankegowda S J (2020) Occurrence of teleomorphic phase of *Colletotrichum gloeosporioides sensu lato*, the incitant of anthracnose of black pepper. Journal of Spices and Aromatic Crops 29: 48-58.
10. Devasahayam S, Jacob T K, Senthil Kumar C M & Balaji Rajkumar M (2020) Biorational strategies for the management of insect pests of spice crops. Journal of Spices and Aromatic Crops 29: 21–37.
11. Jacob T K, Senthil Kumar C M, Devasahayam S, D'Silva S, Senthil Kumar R, Biju C N, Praveena R, &Ankegowda S J (2020) Plant morphological traits associated with field resistance to cardamom thrips (*Sciothrips cardamomi*) in cardamom (*Elettaria cardamomum*). Annals of Applied Biology 177: 143–151.
12. Janakiram T, Nirmal Babu K, Homey Cheriyan, & Prasath D (2019) Indian regulatory system of spices varietal testing, release and notification: Issues and strategies. Indian Journal of Arecanut, Spices and medicinal plants 21: 13-22.

13. Joseph John K, Pradheep K, Jaisankar I, Asokan Nair R, Sharma T V R S, Krishnaraj M V, Zachariah T J, Muhammed Nissar V A,Latha M & Bhat K V (2020) 'Choijwal'(*Piper wallichii* (Miq.) Hand.-Mazz.): a wild pepper used as spice and medicine in Andaman Islands of India. Genetic Resources and Crop Evolution 67: 257-262.
14. Mohandas A & Bhat AI (2020) Recombinase polymerase amplification assay for the detection of piper yellow mottle virus infecting black pepper. Virus Disease 31:38-44.
15. Naveen K P & Bhat AI (2020) Reverse transcriptase loop-mediated isothermal amplification and reverse transcriptase recombinase amplification assays for rapid and sensitive detection of cardamom vein clearing virus. 3 Biotech 10: 250.
16. Naveen K P & Bhat AI (2020) Development of reverse transcription loop-mediated isothermal amplification (RT-LAMP) and reverse transcription recombinase polymerase amplification (RT-RPA) assays for the detection of two novel viruses infecting ginger. Journal of Virological Methods 282: 113884.
17. Prakash K M, Bhai R S, Jiji J, Saji K V, Sujatha V S & Santhosh Kumar A V (2019) Exploitation of resistant source of *Phytohpthora capscici* from genetic stocks of black pepper. International Journal of Current Microbiology and Applied Sciences. 8: 1487-1496.
18. Sarathambal C, Sivaranajni R & Rona Viswanathan (2020). Mechanism of antioxidant and antifungal properties of *Pimenta dioica* (L.) leaf essential oil on *Aspergillus flavus*. Journal of Food Science and Technology 1-10.
19. Shivakumar M S & Saji K V (2019) Association mapping and path coefficient analysis among yield attributes and berry yield in black pepper (*Piper nigrum* L.) Journal of Spices and Aromatic Crops 28:106-112.
20. Shivakumar M S, Saji K V, Anke Gowda S J & Sasikumar B (2019) Source of valuable genes for augmenting breeding in black pepper (*Piper nigrum* L.). International Journal of Chemical Studies 7: 2930-2932.
21. Sivaranjani R, Leela N K, Tejpal C S & Zachariah TJ (2020). Dietary supplementation of *Cinnamomum verum* J. Presl and *Curcuma longa* L. extract on growth performance, antioxidant and metabolic enzymes activities in experimental rats. Indian Journal of Experimental Biology, 58: 242-248.
22. Sivaranjini R, Johnson George K & Saji K V (2019) Evaluation of chemo diversity in major *Piper* spp. for three piperamides using validated RP-HPLC methods. Genetic Resources and Crop Evolution 66:1635-1641.
23. Sivaranjini R, Johnson George K & Saji K V (2019) Evaluation of chemo diversity in major *Piper* spp. for three piperamides using validated RP-HPLC methods. Genetic Resources and Crop Evolution 66:1635-1641.
24. Suraby E J, Prasath D, Nirmal Babu K & Anandaraj M (2020) Identification of resistance gene analogs involved in *Phytophthora capsici* recognition in black pepper (*Piper nigrum* L.). Journal of Plant Pathology 102: 1121–1131.
25. Thankamani C K, Prathusha K, Hamza S & Kandiannan K (2020). Enhancement of rooting and growth of bush pepper by jeevamrutham and tender coconut water. Journal of Plantation Crops 48: 142-146.

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. K.V. Saji, Dr. M.S. Shivakumar, Dr. Honnappa Asangi & Mr R. Gopu]
2. Gen. XIX (813): Conservation, characterization, evaluation and improvement of *Zingiber* and *Curcuma* sp. (2007-2023) [Dr. D. Prasath, Dr. Aarthi S & Dr. N. K. Leela]
3. Gen. XXXIII (813): Identification of core collection, characterization and maintenance of cardamom germplasm (2012- 2023) [Dr. Honnappa Asangi, Dr. Akshitha, H.J., Dr. Ankegowda, S. J., Dr. Mohammed Faisal Peeran & Dr. Balaji Rajkumar, M]
4. Gen. XXXVI (813): Genetic resources management in tree spices (2018-2023)[Mr. Muhammed Nissar V A, Dr. Rema J., & Dr. Honnappa Asangi]
5. Gen. XXXVII (813): Conservation of *Vanilla* spp. and their utilization in crop improvement (2018-2023) (Dr. Aarthi, S., Mr. Muhammed Nissar V. A., Dr. Mohammed Faisal Peeran & Ms. R. Sivaranjani)

Mega project II: Genomics assisted breeding for trait specific varieties in spices

6. Gen. XXXI (813): Breeding black pepper for high yield, quality and resistance to stresses (2012-2022) [Dr. M.S. Shiva Kumar, Dr. K. V. Saji, Dr. P. Umadevi & Dr. K.S. Krishnamurthy]
7. Gen. XXVI (813): Evolving high yielding and high quality nutmeg clones by selection (2007-2021) [Dr. J. Rema, Dr. K.V. Saji & Mr. V.A. Muhammed Nissar]
8. Gen. XXXV (813): Genetic improvement in turmeric through seedling selection and hybridization (2013-2022) [Dr. R. Ramakrishnan Nair, Dr. S. Aarthi & Mr R Gobu]
9. Gen. XXXVI (813): Evolving high yielding, biotic and abiotic stress resistant cardamom lines through selection and hybridization [Dr. H. J. Akshitha, Dr. S. J. Ankegowda, Dr. Balaji Rajkumar, M & Dr. M. S. Shivakumar]
10. Biotech. XIV (813): DNA fingerprinting and barcoding in spices (Dr. T.E. Sheeja & Dr. M.S. Shivakumar (2018 - 2023)
11. Biotech. XV (813): Identification & characterization of gene editing targets for *Ralstonia* resistance in ginger (2018-2021) (Dr P. Umadevi & Dr. A. Jeevalatha)
12. DBT- CIB VIII: Survey, identification and characterization of unique ginger and turmeric land races endemic to North Eastern Region of India (2018-2021) [Dr. D Prasath & Mr. VA Muhammed Nissar]
13. DBT-CIB IX: Quality enhancement of turmeric through comparative evaluation of genotypes for nutritional and quality profiles for sustainable turmeric production (2019-2023) [Dr. D. Prasath, Dr. N. K. Leela & Dr. Aarthi S.]
14. DUS project [Dr. K. V. Saji, Dr. D. Rema, Dr. D. Prasath & Dr. S. Aarthi]

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

15. Phy. X (813): Evaluation of black pepper and cardamom elite lines for yield and quality under moisture stress (2010–2023) [Dr. S.J. Ankegowda, Dr. K.S. Krishnamurthy, Dr. M. Alagupalamuthirsolai & Dr M.S. Shivakumar]
16. SSC VI (813): Nutrient cycling and soil C sequestering potential of spice crops under different management systems (2011-2021) [Dr. V. Srinivasan, Dr. R. Dinesh, Dr. S.J.

Ankegowda, Dr. A. Ishwara Bhat, Dr. C.N. Biju, Dr. K.S. Krishnamurthy & Dr. M. Alagupalamuthirsolai]

17. ICAR Mega Seed Project (Agr. XXXVII(813): Production of nucleus planting materials of improved varieties of spice crops (2006-2022) [Dr. V. Srinivasan, Dr. K. Kandiannan, Dr. S.J. Ankegowda, Dr. K.V. Saji, Dr. P Rajeev, Dr. TE Sheeja, , Dr. Sharon Aravind Dr. Ljio Thomas, Dr. & Honnappa Asangi]
18. AGR. XXXI (813). Development of fertigation schedule for better productivity in black pepper (2015-2023) [Dr. C.K. Thankamani, Dr. K. Kandiannan and Dr. M. Alagupalamuthirsolai]
19. Phy. XII (813): Physiological interventions for yield improvement in small cardamom (*Elettaria cardamomum* Maton) under weather extremities (2016-2021) [Dr. M. Alagupalamuthirsolai, Dr. S.J. Ankegowda, Dr. Sharon Aravind & Dr.M.Murugan)
20. Biochem. X (813): Study on spike abscission: Developing chemically induced method for harvesting black pepper (*Piper nigrum* L.) (2018-2022) [Dr. Anees K., & Dr. Biju C.N.]
21. Development of drought mitigating physiological strategies in black pepper (2020-2025) (Dr. M. Alagupalamuthirsolai & Dr. C. K. Thankamani)
22. Hort. VII (813): Evaluation of nutmeg for its suitability for high density planting (2011-2021) [Dr. J. Rema, Dr. Sharon Aravind & Dr. C.K. Thankamani]
23. ICAR-CPPHT-1: Network project on organic farming (2014-2025) [Dr. C.K. Thankamani, Dr. V. Srinivasan, Dr. R. Praveena, Dr. C. Sarathambal, Dr. S. Shanmughavel & Dr. B. Pradeep]
24. ICAR-CPPHT-2: Network on Organic Farming in Horticulture Crops (2014-20) (Dr. V. Srinivasan, Dr. K. Kandiannan, Dr. R. Dinesh, Dr. J. Rema, & Dr Honnappa Asangi)

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

25. ICAR-CPPHT-3: Network project on high value compounds and phyto-chemicals (2014-2021) (Dr. N.K. Leela, Ms. R. Sivaranjani & Dr. Santhosh J. Eapen)
26. Biochem. IX (813): Evaluation of chemo-diversity and microencapsulation of selected spices (2018-2023) (Ms. R. Sivaranjani)
27. CPPHT IX (813): Functional product development of spices through value addition and by-product utilization [Dr. E. Jayashree, Dr. Anees K & Dr. B. Dayakar Rao (ICAR-IIMR, Hyderabad)]

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

28. CPPHT VIII (813): Pesticide residue monitoring of major spices (Dr. Anees K., Dr. N. K. Leela, Dr. C. M. Senthil Kumar & Dr. Balaji Rajkumar)
29. DST-CPPHT-1: Aflatoxin management in spices: Development of novel preventive methods (Dr. Anees K., Dr. E Jayashree, Dr. C. Sarathambal, Dr. Muhammed Fahim Ansari)

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

30. ICAR-CP 1. ICAR-Consortium research project on borers in network mode (2014-2021) [Dr. C.M. Senthil Kumar &Dr. M. Balaji Rajkumar]
31. Integrated management of mealy bug (Pseudococcidae: Hemiptera) infesting black pepper (2019 – 2022) [Dr. M. Balaji Rajkumar & Dr. C. M. Senthil Kumar]

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

33. Path. XXIV (813): Surveillance, documentation and development of decision support system for pests and diseases of major spice crops (2016-2021) [Dr CN Biju, Dr. Santhosh J. Eapen, Dr. A. Ishwara Bhat, Dr. C. M. Senthil Kumar, Dr. Lijo Thomas, Dr. C. Sellaperumal, & Mr. K. Jayarajan]
34. Path. XXVII (813): Development of microbial biostimulants for growth promotion and disease resistance in major spices (2018-2021) [Dr. C. Sarathambal & Dr. A. Jeevalatha]
35. Path. XXVIII (813): Novel strategies for managing bacterial wilt and soft rot diseases of ginger (2018-2022) [Dr. C. N. Biju & Dr. Mohammed Faizal Peeran]
36. Path, XXIX (813): Strategic approaches for management of black pepper diseases (2019 – 2024) [Dr. Biju, C. N., Dr. A. Ishwara Bhat, Dr. Praveena, R., Dr. A. Jeevalatha, Dr. Mohammed Faisal Peeran, Dr. C. Sellaperumal, Dr. Santhosh J. Eapen]
37. Path. XXX (813): Development and formulation of Plant Beneficial Rhizosphere Microorganisms (PBRMs) for disease antagonism, soil nutrient solubilisation and plant growth promotion (2020-2024) [Dr. R. Praveena, Dr. R. Dinesh & Dr. C. Sarathambal]
38. DBT CP-VII: Characterization of episomal and endogenous pararetroviruses infecting black pepper (2018-2021) [Dr. A. Ishwara Bhat & Dr K.S. Krishnamurthy]

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

39. Ext. VI (813). Capacity building and front-line intervention programmes for (spice sector development in NE states and tribal empowerment (2014-23) (Dr. P. Rajeev & Dr. Lijo Thomas)
40. Eco. IV (813): Developing models for enhancing technology and policy impact in spices sector (2020-2025) (Dr. Lijo Thomas; Dr. P. Rajeev & Mr. K Jayarajan)

New externally funded project

1 . ICAR-NASF-1: Risk assessment of nanoparticle accumulation in soils: Effects of metal oxide nanoparticles on soil bacterial communities, soil microbial processes and evaluation of phytotoxicity using genomic approaches (Dr. R. Dinesh, Dr. V. Srinivasan, Dr. Sheeja TE, Dr. C. Sarathambal & Dr. V. Sajith)
2 . ICAR-CIB-3: Genomics-assisted identification of trait-specific markers for major biotic and abiotic stresses and development of core collections of black pepper (Dr. Santhosh J. Eapen, Dr. AI Bhat, Dr. KS Krishnamurthy, Dr. Sheeja TE, Dr. A. Jeevalatha, Dr. MS Shivakumar, Dr. UB Angadi & Dr. Sunil Kumar)

New project

3 . Development of off and on site detection techniques for major pathogens of spice crops. [Dr.A Jeevalatha, Dr. A. Ishwara Bhat, Dr. Biju, C. N and Dr. Mohammed Faisal Peeran]

STAFF LIST
ICAR-IISR, KOZHIKODE

SCIENTIFIC STAFF

1.	Dr. J Rema	Acting Director
2.	Dr. Santhosh J Eapen	Head in charge, Div. of Crop Protection
3.	Dr. C K Thankamani	Head in charge, Div. of Crop Production & PHT
4.	Dr. R Dinesh	Principal Scientist (Soil Science) & Head (General Adminstration)
5.	Dr. N K Leela	Principal Scientist (Org. Chemistry)
6.	Dr. R Ramakrishnan Nair	Principal Scientist (Genetics & Cytogenetics)
7.	Dr. K Kandiannan	Principal Scientist (Agronomy)
8.	Dr. K S Krishnamurthy	Principal Scientist (Plant Physiology)
9.	Dr. A Ishwara Bhat	Principal Scientist (Plant Pathology)
10.	Dr. K V Saji	Principal Scientist (Economic Botany)
11.	Dr. P Rajeev	Principal Scientist (Agricultural Extension)
12.	Dr. V Srinivasan	Principal Scientist (Soil Science)
13.	Dr. T E Sheeja	Principal Scientist (Biotechnology)
14.	Dr. E Jayashree	Principal Scientist (Agricultural Engineering)
15.	Dr. D Prasath	Principal Scientist (Horticulture)
16.	Dr. C M Senthil Kumar	Principal Scientist (Agricultural Entomology)
17.	Dr. Lijo Thomas	Senior Scientist (Agricultural Economics)
18.	Dr. C N Biju	Senior Scientist (Plant Pathology)
19.	Dr. R Praveena	Senior Scientist (Plant Pathology)
20.	Dr. Jeevalatha, A	Senior Scientist (Plant Pathology)
21.	Dr. C Sarathambal	Senior Scientist (Agricultural Microbiology)
22.	Dr. Anees K	Scientist (Plant Biochemistry)
23.	Dr. P Alagupalamuthirsolai	Scientist (Plant Physiology)
24.	Dr. C Sellaperumal	Scientist (Nematology)
25.	Dr. Sharon Aravind	Scientist (Spices Plantation Medicinal & Aromatic Plants)
26.	Dr. S Aarthi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
27.	Mr. V A Muhammed Nissar	Scientist (Spices Plantation Medicinal & Aromatic Plants)
28.	Ms. R Sivaranjani	Scientist (Plant Biochemistry)
29.	Mr. Gobu R	Scientist (Genetics & Plant Breeding)
30.	Ms. Sona Charles	Scientist (Agricultural Bioinformatics)

ADMINISTRATIVE STAFF

1.	Sri. T D S Prakash	Finance & Accounts Officer
2.	Ms. C K Beena	Private Secretary
3.	Mr. P. Muraleedharan	Assistant Administrative Officer
4.	Sri. P Sundaran	Assistant Administrative Officer
5.	Sri. Sunil .V.C	Assistant Administrative Officer
6.	Mr. Neela Megha Shyala Kannan	Personal Assistant
7.	Sri. V V Sayed Mohammed	Assistant
8.	Ms. M Seema	Upper Division Clerk
9.	Ms. Rebeena N	Upper Division Clerk
10.	Mr. P K Rahul	Lower Division Clerk

TECHNICAL

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

SUPPORTING STAFF

1.	Mr. M K Purushu	Skilled Support Staff
2.	Ms. C M Kamalam	Skilled Support Staff
3.	Mr. Abhi Balagopal	Skilled Support Staff

IISR EXPERIMENTAL FARM, PERUVANNAMUZHI

TECHNICAL STAFF

1.	Mr. E S Sujeesh	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

SUPPORTING STAFF

1.	Mrs. P N Kausalya	Skilled Support Staff
2.	Mr. Vijesh V	Skilled Support Staff

KVK, ICAR-IISR, PERUVANNAMUZHI

SCIENTIFIC STAFF

1.	Dr. P Ratha Krishnan	Programme Coordinator

TECHNICAL STAFF

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

ADMINISTRATIVE STAFF

1.	Mr. K Faisal	Stenographer Gr. III

SUPPORTING STAFF

1.	Mr. C Ravindran	Skilled Support Staff

ICAR- IISR REGIONAL STATION, APPANGALA

SCIENTIFIC STAFF

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

ADMINISTRATIVE STAFF

1.	Mr. P T Jayaprakash	Upper Division Clerk

TECHNICAL STAFF

1.	Sri. H C Rathish	Senior Technical Assistant
2.	Sri. H D Praveena	Senior Technical Assistant
3.	Sri. N Cholurappa	Senior Technician
4.	Sri Ranjith P.B	Technician

SUPPORTING STAFF

1.	Smt. B M Lalitha	Skilled Support Staff
2.	Sri. Marigowda	Skilled Support Staff
3.	Mr. Sachin K.P	Skilled Support Staff

WEATHER DATA

ICAR-IISR Chelavoor Kozhikode				
Month	**Temperature (°C)**		**Rainfall**	
	Maximum	**Minimum**	**Total rainfall (mm)**	**Rainy days**
January	32.9	22.7	0	0
February	33.5	23.0	0	0
March	34.4	25.1	0	0
April	35.2	25.5	24.6	3
May	34.6	25.7	86.6	5
June	31.3	23.6	1.2	0
July	30.3	23.7	359.4	17
August	30.1	23.8	447.4	20
September	30.5	23.6	560.2	21
October	31.6	23.3	164.4	8
November	33.2	23.8	68.8	5
December	32.1	23.4	41.4	4

ICAR-IISR Regional Station,Appangala, Madikeri				
Month	**Temperature (°C)**		**Rainfall**	
	Maximum	**Minimum**	**Total rainfall (mm)**	**Rainy days**
January	26.6	10.5	0	0
February	27.2	11.6	8	1
March	27.3	12.9	10.2	1
April	27.5	13.4	159.4	8
May	27.5	13.1	188.4	11
June	27.0	12.4	369	21
July	26.3	12.6	430.1	24
August	26.3	13.0	1258.7	25
September	26.2	12.5	539.7	27
October	26.6	12.9	180.4	13
November	26.4	11.1	42.3	3
December	24.7	11.3	28	1

ICAR-IISR KVK Peruvannamuzhi				
Month	Temperature (°C)		Rainfall	
	Maximum	Minimum	Total rainfall (mm)	Rainy days
January	34.3	21.6	0	0
February	35.8	21.9	0	0
March	37.1	23.7	0	0
April	34.3	21.6	75.8	8
May	34.5	24.8	511.4	20
June	31.0	23.5	942.6	27
July	34.5	24.8	902.6	26
August	29.9	23.5	945.4	21
September	30.5	23.6	933	22
October	22.2	13.0	275.2	12
November	34.4	22.5	80.4	8
December	33.8	21.9	99	8

AWARDS & RECOGNITIONS

ICAR-Fakhruddin Ali Ahmed award 2019 for Outstanding Research in Tribal Farming Systems – Drs. Rajeev P, Prasath D, Jayasree E

Best center award of All India Network Programme on Organic farming (AI-NPOF) during 2019-20 – Drs. Thankamani C K, Srinivasan V, Praveena R, Sarathambal C, Shanmugavel S.

Dr. D Prasath, Fellow, National Academy of Agricultural Sciences, New Delhi –2020.

Dr. A Jeevalatha, Chandra Prabha Singh Young Scientist award from Indian Potato Association, 2020.

Important days observed at ICAR-IISR, Kozhikode

Day	Date
National Science Day	28 February 2020
International Women's Day	08 March 2020
World Water Day	22 March 2020
World Earth Day	22 April 2020
World Environment Day	05 June 2020
Gareeb Kalyan Yogana	19 June 2020
International Yoga Day	21 June 2020
Institute Foundation Day	01 July 2020
World Coconut Day	02 September 2020
Swachhata Hi Sewa	11 September to 02 October 2020
Vigilance Awareness week	28 October to 02 November 2020
World Soil Day	05 December 2020
National Farmers Day	23 December 2020
PM Kisan Money Release Program	25 December 2020
Swachhata Pakhwada	16-31 December 2020

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