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वार्षिक प्रतिवेदन

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान

कोषिक्कोड

ICAR- Indian Institute of Spices Research

Kozhikode

वार्षिक प्रतिवेदन
Annual Report
2019

भाकृअनुप
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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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Front Cover Picture
High yielding Garcinia accession

Back Cover Pictures
SPIISRY - Farm gate sale counter
Cinnamon collection from Nicobar islands
High yielding Clove accession
Mealy bug infestation on Black pepper
High yielding & high oil Allspice accession
Root colonization by Mycorrhiza

PREFACE

It is a great honor to present the 2019 Annual Report of the ICAR - Indian Institute of Spices Research, Kozhikode, Kerala. We have envisioned that we will strive to enhance the productivity of spices to meet the growing demand and will make India the global leader in spices export. While we have been earnestly striving to realize this vision, our efforts have also perfectly aligned with the Government of India's vision to double farmer's income. We have been helping in realizing this vision by investing our intellectual and scientific resources in perfect sync with the ICAR's policy to herald a second evergreen revolution.

The spices economy of the country is vital to agricultural prosperity owing to its high value and the significant role played by the spice commodities in the agricultural export basket. Improving quality of life and supporting tribal and rural populations by harnessing technological innovations has been our forte and in doing so we have developed an array of spice varieties, spice production technologies and spice products, while concurrently fostering spicepreneurship. The latter has helped in transforming the dreams of startups into exciting new business ventures and as opposed to self-employment we have succeeded in rekindling the spirit of prospective entrepreneurs to quickly adapt to the changing business environs.

Our Tribal Sub-Plan has helped to ensure tribal welfare and in collaboration with AICRPS we are reaching out to the far flung regions of the North East, and other states of India. Supply of critical inputs and training programs on spices cultivation exclusively designed for the tribal areas has been the unique feature of our TSP. While our *Mera Gaon Mera Gaurav program* continues to promote the direct interface of scientists with the farmers, we are also focusing *on* programs to expeditiously improve the socio-economic status of aspirational districts. In our continuing quest to supply good quality spices and spice products to the consumers, our ITM-BPD unit has launched a new initiative christened SPIISRY, a farm-gate sale counter that displays and sells value added spice products. Besides signing an MOA with Kerala Start-up Mission (KSUM) for nurturing start-ups, we are now focussing on spice based product development owing to the increasing demand for sophisticated health and wellness products from spices. I am also happy to mention that we already have received three patents for our designer micro-nutrient formulations. The XXX Workshop of All India Coordinated Research Project on Spices was held at Tamil Nadu Agricultural University, Coimbatore. Three varieties one each in fennel, ajwain and nigella suitable for different growing regions were recommended for release during the workshop.

Be that as it may, inventions leading to incremental changes in productivity and quality will not suffice to meet the challenges of changing demographics, extreme weather harnessed by the ever changing climate, diminishing and degrading resources especially soil and water and the changing life style and income of the end users. Confronting these challenges would require fast tracking our entire research machinery through revolutionary and multidisciplinary approaches thereby doubling farmers' income. Therefore, we are continuing to focus on developing new varieties, crop production and protection technologies that are climate resilient but simultaneously ensure high productivity and conservation agriculture. We are also focusing on technologies that abet food safe spices to ensure nutritional security and public health. ICAR - IISR will continue to sustain and encourage startups and new licensees thereby nurturing the next generation of spice farmers, fuelling job growth and enhancing the economic health of the country.

We are excited about the prospects of our nation's spice based agricultural and food systems and am extremely thankful to the ICAR in supporting us in our quest for transformative spice research and extension. I wholeheartedly thank Dr. T. Mohapatra, Secretary, DARE and Director General, ICAR for his guidance and encouragement. I am also extremely grateful to Dr. A.K. Singh, Deputy Director General (Horticultural Science) and Dr. T. Janakiram, Assistant Director General (Hort-II) for their relentless support and motivation. Special thanks to the editors for their tireless efforts.

Kozhikode
March 2020

K. Nirmal Babu

OUR VISION

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

CONTENTS

कार्यकारी सारांश

काली मिर्च

- प्रायोगिक प्रक्षेत्र, पेरुवण्णामुषि में तीन हजार चार सौ छियासठ अक्सेशनों का अनुरक्षण किए जा रहे हैं। तीन सौ अक्सेशनों का एक नए खेत जीन बैंक की स्थापना की गई थी। मडिकेरी, करनाटक से अतिरिक्त लंबी स्पाइक (34.5 सेमी) के साथ एक अद्‌वितीय काली मिर्च अक्सेशन का संग्रह किया गया था।

- काली मिर्च के बयासी जर्मप्लाज्म अक्सेशनों को आईपीजीआरआई डिस्क्रिप्टेर्स का उपयोग करके 17 मात्रात्मक और 12 गुणात्मक लक्षणों के लिए विशेषता दी गई थी। जर्मप्लाज्म अक्सेशनों को बोल्ड बेरीज, फल सेटिंग, ड्राई रिकवरी, स्पाइक की लंबाई और उपज जैसे विशिष्ट लक्षणों के लिए आशाजनक पाया गया और उनका शॉर्टलिस्ट किया गया।

- उपज और उपज की विशेषताओं के लिए आनुवंशिक परिवर्तनशीलता और सहसंबंधों का अनुमान नौ काली मिर्च के जीनोटाइप में लगाया गया जिसमें पांच संकर, दो खुले परागण वाले पूर्वज और दो आईआईएसआर विमोचित प्रजातियां शामिल हैं। जीनोटाइप HP 2173 (HP1117× Thommannkodi), OPKM, HP 780, HP 1411 और HP 820 आर्थिक रूप से महत्वपूर्ण गुणों के लिए आशाजनक पाए गए।

- काली मिर्च के अठारह जीनोटाइप जिसमें किस्में / संकर और लैंड रेस / किसान चयन शामिल हैं, जो स्पाइक की लंबाई, परिपक्व बेरी / स्पाइक, सूखे बीज वजन, ताजा बीज वजन और बेरी वजन जैसे लक्षणों के आधार पर स्पाइक के वजन के साथ उच्च सकारात्मक सहसंबंध दिखाते हैं। स्कॉट-नॉट परीक्षण के आधार पर जीनोटाइप के समूहीकरण ने अधिकतम लक्षणों के लिए जीनोटाइप को विपरीत करते हुए पन्नियूर - 1 और नेदुमचोला का पता लगाया।

- एआईसीआरपीएस केंद्रों से किस्मों को विमोचित करने हेतु फिंगरप्रिंटिंग सेवाओं के लिए डीएनए फिंगरप्रिंटिंग और बारकोडिंग की सुविधा स्थापित की गई थी। अब तक मसालों की 25 किस्में फिंगरप्रिंट की जा चुकी हैं और नई किस्मों के लिए इसकी निकट संबंधी / समानता वाली किस्मों की तुलना में विशिष्टता स्थापित की गई है।

- *पी. नाइग्रम* और *पी. लोंगम* के बेरी हाइब्रिड ट्रांसक्रिप्टोम से नवीन यौगिकों के प्रमुख जीनों की पहचान की गई।

- *पी. नाइग्रम* और *पी. कोलुब्रिनम* ट्रांसस्क्रिप्टोम में एएमपी संकेत के साथ कुल 111 और 127 ट्रान्स्क्रिप्ट्स की पहचान की गई थी। फाइट एएमपी और सीएएमपी आर3 के साथ नोट में क्रमशः *पाइपर नाइग्रम* और *पी. कोलुब्रिनम* पी में 48 और 37 संभावित एएमपी दर्शाए गए हैं।

- तीन काली मिर्च किस्मों जैसे IISR थेवम, गिरिमुंडा और शक्ति के लिए ड्रिप फरटिगेशन शेड्यूल को मानकीकृत किया गया है।

- काली मिर्च में सूखा सहिष्णुता प्रदान करने के लिए एंटी ट्रान्स्पिरन्ट्स जैसे काओलिन 2.0%, काओलिन 2.0% + 0.5% एमओपी, चूना 1.5% और चूना 1.5% + 0.5% एमओपी का परीक्षण किया गया। 1.5% चूना छिड़काव करने से पत्ती के निम्न तापमान के साथ उच्च प्रकाश संश्लेषक दर को दर्शाता है।

- विभिन्न एस्टेटों में 50 बागानों में स्पाइकिंग तीव्रता और बेरी सेटिंग दर्ज की गई। स्पाइक की तीव्रता प्रति 0.5 वर्ग मीटर चंदवा क्षेत्र से 20.2 औसत से 12.2-25.4 के बीच होती है। बेरी सेट का अंतर 69.32% के औसत से 59.24-76.07% तक था।

- काली मिर्च के 25 जीनोटाइप के गुणवत्ता विश्लेषण ने संकेत दिया कि कुल क्षारीय सामग्री (मिली ग्राम / ग्राम) 16.7 (पनियूर 4) से 35.7 (सुभकरा) तक थी। ओलिओरसिन को थोक घनत्व (r=-0.49) के साथ नकारात्मक रूप से संबद्ध किया गया था, लेकिन एसनशियल तेल सामग्री (r=0.44) और पाइपरिन सामग्री (r= 0.71) के साथ सकारात्मक रूप से सहसंबद्ध था।

- काली मिर्च की खेती में डिटैचमेंट फोर्स (DF) के अध्ययन ने संकेत दिया कि पकने के साथ DF को काफी कम किया गया था और यह कल्टिवरों से भिन्न था। क्रमशः अगाली और चुमला में स्पाइक के पकने के कारण DF में लगभग 88.0% और 40.0% की कमी देखी गई।

- पुनर्संयोजन पोलीमरेज़ प्रवर्धन (RPA) पर आधारित एक नवीन आणविक परख *पी. कैप्सिसी* और *पी. ट्रॉपिकलिस* संक्रमित काली मिर्च का पता लगाने के लिए विकसित किया गया था। यह परख पीसीआर की तुलना में 10 गुना अधिक संवेदनशील और मजबूत थी।

- *फाइटोफ्थोरा* के दो आइसोलेट्स जैसे *पी. कैप्सिसी* (05-06) और *पी. ट्रॉपिकलिस* (98-93) का उपयोग करके एरियल इनोक्यूलेशन तकनीक द्वारा पैंतालीस जर्मप्लाज्म एक्सेशनों की जांच की गई। छः अक्सेशनों (अक्से. 5764, 6787, 7243, 7319, 7218

और 7344) में <5mg/100mg, <10mg के कुल फिनोल्स एवं चालकता <300 माइक्रो सिमेन्स की पाली फिनोल्स के साथ 0-5 मि मी आकार के स्टेम घाव दिखाया गया।

- *पी. कैप्सीसी* के प्रति *लीकानिसिलियम प्सालियोटे* की विरोधी गतिविधि पर अध्ययन ने संकेत दिया कि ग्रीनहाउस स्थितियों के तहत *एल. प्सालियोटे* का प्रयोग करने पर *पी. कैप्सीसी* संक्रमित काली मिर्च पौधों की बचाव देख ली। खेत में, चार साल के बेलों में *एल. प्सालियोटे* के साथ इलाज करने पर पीलापन में 50% की कमी हुई।

- *इनविट्रो* स्थितियों में *स्ट्रेप्टोमाइज़स एल्बुलस* और *ट्राइकोडर्मा हार्ज़ियानम* ने काली मिर्च में संक्रमित *पाइथियम डेलियेन्स* डेलियेन्स का 100% निषेध दिखाया। ग्रीनहाउस स्थितियों और खेत मूल्यांकन के तहत *इन प्लान्टा* मूल्यांकन में *टी.हर्ज़ियानम* और *एस. अल्बुलुस* उपचारित बेल के पीलेपन की तीव्रता में क्रमशः 75.2% और 74.4% की कमी दर्शायी।

- काली मिर्च में संक्रमित पाइपर येलो मोटिल वायरस (PYMoV) का पता लगाने के लिए *रीकॉम्बिनेज़ पोलीमरेज़ प्रवर्धन* (RPA) और रिवर्स ट्रांसक्रिप्शन (RT) RPA परख विकसित करके अनुकूलतम बना दी। अध्ययन से पता चला कि PYMoV संक्रमित काली मिर्च का पता लगाने के लिए RPA और RT-RPA को सफलतापूर्वक PCR के विकल्प के रूप में अपनाया जा सकता है।

- केरल और कर्नाटक के काली मिर्च उगाने वाले विभिन्न इलाकों में मीलीबग प्रजातियां फेरिसिया, आईसरिया और प्लानोकोकस स्पीसीस को नरम प्ररोह, बेरी, कॉलर क्षेत्र और काली मिर्च की जड़ प्रणाली से जुड़े पाए गए।

इलायची

- राष्ट्रीय सक्रिय जर्मप्लाज्म साइट (एनएजीएस) में कुल 622 इलायची जर्मप्लाज्म अक्सेशनों को बनाए जा रहे हैं, जिनमें अपंगला से 423 अक्सेशन, पाम्पाडुमपारा से 102 अक्सेशन; मुडिगेरे से 41 अक्सेशन और सकलेशपुर से 56 अक्सेशन शामिल हैं।

- नौ संकर प्रजातियों जैसे Njallani ग्रीन गोल्ड प्रजाति के साथ बोल्ड × आईसी 547219, (जीजी × बोल्ड) × अप्पंगला 1 और (जीजी × एनकेई 19) × आईआईएसआर क्षेत्रीय सेटेशन अपंगला से बोल्ड, आईसीआरआई, मैलाडुम्पारा से एमएचसी -1 और एमएचसी -2, आईसीआरआई क्षेत्रीय स्टेशन सकलेशपुर से एसएचसी -1 और एसएचसी-2 और पाम्पाडुमपारा से PH-13 और PH-14 के साथ आईआईएसआर

क्षेत्रीय सेटेशन, अपंगला में विभिन्न कृषि संबंधी लक्षणों के लिए सीवीटी परीक्षण का मूल्यांकन किया जा रहा है।

- आईसीएआर-आईएएसआरआई के सहयोग से एक छोटी इलायची - मोज़ेक वायरस इंटरएक्टिव ट्रांसक्रिपटॉम डेटाबेस (SCMVTDb) विकसित की गई।

- आणविक अध्ययनों के आधार पर, इलायची के वेयिन क्लियरिंग वाइरस (CdVCV) को जीनस में एक नई वायरस प्रजाति, न्यूक्लियोरहब्डोवाइरस के रूप में पाया गया।

- अपांगला में तीन साल के लिए 180 इलायची जर्मप्लाज्म अक्सेशनों के खेत मूल्यांकन के फलस्वरूप आठ अक्सेशनों को इलायची थ्रिप्स के प्रतिरोधी पहचान हुई। विभिन्न प्रकार के रूपात्मक लक्षण जैसे पनिकिल प्रकार, परसिस्टन्स ओफ ब्राक्ट एन्ड नेचर ओफ अडहरन्स ओफ लीफ शेथ को थ्रिप्स के खिलाफ प्रतिरोध प्रदान करते पाया गया।

अदरक

- फील्ड जीन बैंक में छः सौ अड़सठ अदरक अक्सेशनों का उपयोग किया जा रहा है, जिसे बाद में 12 अदरक के साथ समृद्ध किया गया था जिसमें नागालैंड से पांच लाल अदरक शामिल थे।

- प्रमुख गुणवत्ता मापदंडों के लिए एक सौ पांच अदरक जर्मप्लाज्म अक्सेशनों का चरित्रांकन किया गया। अधिकतम एसनशियल तेल अक्सेशन 282 और 396 में दर्ज किया गया। क्रूड फाइबर की मात्रा में 3.2 से 8.6% तक अंतर थी।

- उत्तर पूर्व भारत के विभिन्न स्थानों से एकत्र किए गए कुल 40 अक्सेशनों को 34 एसएसआर प्राइमरों का उपयोग करके जीनोटाइप किए गए थे और उनमें से 10 में जीनोटाइप के अद्वितीय बहुरूपी बैंड दिखाए गए थे।

- एआईसीआरपीएस के तहत भारत भर के पांच स्थानों पर वर्ष 2015-2018 के दौरान विभिन्न अदरक अक्सेशनों के यील्ड परीक्षण आयोजित किये। समन्वित वैराइटी परीक्षण से पता चला कि अधिकतम उपज (जमा) एसजी 2604 में दर्ज की गई और उसके बाद अक्सेशन 247 में थी।

- पाइथियम स्पीसीस और रालस्टोनिया सोलनसीरम के खिलाफ पहचान किये अदरक म्यूटेंट का मूल्यांकन समन्वित प्रजाति परीक्षण के तहत किया जा रहा है।

- अदरक के अर्क को पेट्रोलियम ईथर, मीथनॉल और पानी का क्रमिक रूप से उपयोग करके तैयार किया गया था। उनमें से, पेट्रोलियम ईथर अर्क में सबसे अधिक एंटीऑक्सिडेंट और एंटीडायबिटिक गतिविधि देखी गई। 6- शोगोल ने उच्च एंटीऑक्सीडेंट गतिविधि दिखाई, जबकि 6- जिंजरोल ने उच्च एंटीडायबिटिक गतिविधि का प्रदर्शन किया।

- म्लानी के एकीकृत प्रबंधन के लिए भौतिक (मृदा सौरिकीकरण), रसायन (कैल्शियम क्लोराइड -3% के साथ मिट्टी का शोधन) और जैविक (अदरक एपोप्लास्टिक जीवाणु - बेसिलस लीकेनिफॉर्मिस) विधियों को एकीकृत करके नई तकनीकी विकसित की गई। बायोएजेंट के निर्माण को 'बेसिलिक' के रूप में लॉन्च किया गया।

- सोडियम और पोटेशियम सिलिकेट और सोडियम मेटा सिलिकेट के ठोस और तरल रूपों के साथ *इन विट्रो* अध्ययन में *एम. फेसियोलिना* पर दिखाया गया है कि सिलिकेट्स ने कवक के मायसेलियल विकास को प्रतिबंधित किया है।

- अदरक को संक्रमित करने वाले पर्ण रोगजनकों के रूपात्मक और आणविक लक्षण वर्णन के परिणामस्वरूप *एक्सेरोहिलम रोस्ट्राटम, कोलेट्रोट्राइकम ग्लोयियोस्पोरियोयिड्स, सी. कैप्सीसी, बोट्रियोडिप्लोडियास्प* की पहचान की गयी। रूपवैज्ञानिक आधार पर आणविक उपकरणों का उपयोग करके *ट्राइकोडेरमा* स्पीसीस के पांच स्ट्रेन और पादप वृद्धि बढाने वाले ग्यारह जीवाणुओं को वियुक्त करके चरित्रांकन किया गया।

- कवक रोगजनकों के खिलाफ परीक्षण किए गए 18 पीजीपीआर वियुक्तियों में IISR GB1, IISR GB2, IISR GB7(3) और IISR TB4 ने *पाइथियम माइरियोटिलम, फाइटोफ्थोरा कैप्सीसि, एक्सेरोहिलम रोस्ट्राटम* और *मेक्रोफोमिना फैसियोलिना* के खिलाफ इन विट्रो स्थितियों के तहत अधिकतम प्रतिपक्षी गतिविधि दिखाई गई है। ग्रीनहाउस स्थितियों के तहत, जीवाणु वियुक्तियों जैसे IISR GB7(3) (*बेसिलस* स्पीसीस।) और IISR TB4 (*बेसिलस सर्फेसिस*) का उपचार किया गया था जिसमें मृदु गदलन का कोई लक्षण विकसित नहीं हुआ था।

- बीज उपचार और 15 दिनों के अंतराल पर टेबुकोनाज़ोल (0.1%) के साथ पत्तों पर तीन राउंड छिड़काव अदरक के पत्ते संबंधी रोगों के प्रबंधन में प्रभावी पाए गए। आम तौर पर, टेबुकोनाज़ोल (0.1%) के साथ पहला छिड़काव और उसके बाद 15 दिनों के अन्तराल पर कार्बेन्डाज़िम + मैंन्कोज़ेब (0.2%) का छिड़काव भी समान रूप से प्रभावी पाया गया।

- अदरक के क्लोरोटिक फ्लेक रोग से जुड़े दो वायरस की पहचान अदरक क्लोरोइक फ्लेक से संबंधित टोंबुसविरिडे वाइरस (जीसीएफएटीवी) और अदरक क्लोरोइक फ्लेक से संबंधित एम्पेलोवाइरस (जीसीएफएएवी) और जीसीएफएटीवी के पूर्ण जीनोम और जीसीएफएएवी के आंशिक जीनोम का क्लोन, अनुक्रमण और विश्लेषण किया गया।

- खेत के अध्ययनों से संकेत मिलता है कि स्पिनोसैड, फ्लुबेंडियमाइड और क्लोरैन्थ्रानिलिप्रोल, सबसे कम खुराक (0.3 एमएल / लीटर पानी) के परीक्षण के बाद भी अदरक शूट बोरर (कोनोगीथस पंक्टिफरालिस) के प्रबंधन में प्रभावी थे। क्लोरेंट्रानिलिप्रोल और स्पिनोसैड का संयोजन भी कीट के प्रबंधन में समान रूप से प्रभावी था।

हल्दी

- खेत जीन बैंक में एक हजार चार सौ चार *कुरकुमा* अक्सेशनों का संरक्षण किया जा रहा हैं। जर्मप्लाज्म कंजर्वेटरी को नागालैंड से एकत्र किये चार हल्दी अक्सेशनों के साथ समृद्ध किया गया।

- 165 हल्दी के अक्सेशनों का रूपात्मक वर्णन किया गया और प्रत्येक हल्दी अक्सेशन के लिए 12 मात्रात्मक और 10 गुणात्मक चरित्र अंकित किए गए।

- अतिरिक्त-लंबी और बोल्ड हल्दी लाइनों की पहचान करने के लिए, सेलम लोकल (तमिलनाडु के इरोड और सेलम जिले) के 12 अक्सेशनों और मिदुकुर (आंध्र प्रदेश) के चार अक्सेशनों को रूपात्मक चरित्रों के लिए चरित्रांकित की गई।

- हल्दी के पहली पीढ़ी के बीजपौधे (204), मातृ जीनोटाइप (20), दूसरी पीढ़ी के बीजपौधे (432), तीसरी पीढ़ी के बीजपौधे (47) पहली पीढ़ी के इनब्रेड्स (839), दूसरी पीढ़ी के इनब्रेड्स (11), तीसरी पीढ़ी के इनब्रेड्स (402), चौथी पीढ़ी की इनब्रेड्स (367) और अंतर-प्रजातीय संकर (36) को बनाए रखा जा रहा है। स्थिरता पर आधारित पराग प्रजनन क्षमता 138/11/1 के 10 तीसरी पीढ़ी के इनब्रेड्स में परीक्षण किया गया था। पांच इनब्रेड्स ने 90.0% से ऊपर पराग प्रजनन दिखाया। उभरते प्ररोह के रंग में अंतर 24 दूसरी पीढ़ी के ओपी संतानों में भी देखा गया था।

- प्रबंधन प्रणालियों में, जैविक प्रणाली (75.0%) ने अधिकतम उपज (13.9 t / ha) दर्ज की, जो कि एकीकृत प्रणाली (75.0% + 25.0%) के बराबर (13.8 t / ha) थी। अधिकतम तेल सामग्री (5.3%) कार्बनिक 100.0% और कार्बनिक 75.0% प्रबंधन प्रणाली द्वारा दर्ज की गई थी।

- 100% कार्बनिक प्रबंधन के तहत 12 हल्दी किस्मों का मूल्यांकन किया गया था, जिसमें महत्वपूर्ण उपज प्रगति (22.1 टी / हेक्टेयर) में अंकित की गयी जिसके बाद कांति (19.2 टी / हेक्टेयर) द्वारा काफी अधिक उपज दर्ज की गई थी। उच्च तेल सामग्री प्रतिभा (6.0%) और आलप्पी सुप्रीम (5.9%) किस्मों में देखी गई और सबसे कम तेल सामग्री सुवर्णा में देखी गई।

- 100°C पर गर्म हवा ओवन द्वारा ठीक कटी हुई हल्दी को सुखाने के लिए 10 घंटे का न्यूनतम सुखाने का समय दर्ज किया गया था और बिना कटे हुए हल्दी के सूरज सुखाने के लिए 165 घंटे (6.88 दिन) का अधिकतम समय दर्ज किया गया था।

- कुरकुमिन की जैव उपलब्धता बढाने के लिए सोनिकेशन आधारित प्रोटोकॉल का उपयोग करके नैनो-कुरकुमिन को तैयार किया गया था। इस प्रकार विकसित नैनो-कुरकुमिन में घुलनशीलता दोनों तरह पानी के साथ-साथ और वरजिन नारियल तेल में 2.5 गुना वृद्धि हुई थी और इसे कुरकुमिन के संभावित जैव-उपलब्ध संयोजन के रूप में इस्तेमाल किया जा सकता है।

- हॉटस्पॉट क्षेत्रों का सर्वेक्षण करने पर सूचित किया कि कोयंबटूर जिले (TN) में तण्णीरपंथल क्षेत्र (3.2 / ग्राम मिट्टी) में तथा इरोड जिले (तमिलनाडु) में गोबीचेट्टिपलायम (4.7 ग्रा। मिट्टी) में घाव निमोटोड, *प्रेटिलेंकस* स्पीसीस की वृद्धि हुई है।

- *प्रटिलेंकस* स्पीसीस के खिलाफ विरोधी बैक्टीरिया की *इन विट्रो* स्क्रीनिंग में, प्स्यूडोमोनस पुटिडा BP25 (92.7%) के साथ अधिकतम मृत्यु दर दिखाई दी, इसके बाद अल्कलीजेन्सफेकालिस आईआईएसआर859 (68.7%), बेसिलस मेगाटेरियम बीपी17 (58.1%) और बेसिलस लीकेनिफॉर्मिस जीपी107 (10%) (10%) है।

- नई पीढ़ी के कीटनाशक जैसे कि स्पिनोसैड, *फ्लूबेंडियामिडे* और क्लोरेंट्रानिलिप्रोल हल्दी शूट बोरर (*कॉनोगीथस पंक्टिफेरालिस*) के प्रबंधन में प्रभावी थे यहां तक कि सबसे कम खुराक (0.3 मि. लि. / लीटर पानी) का परीक्षण किया गया। क्लोरेंट्रानिलिप्रोल और स्पिनोसैड का संयोजन भी कीट प्रबंधन में समान रूप से प्रभावी था।

वेनिला

- वेनिला (अंदमान से 65 *वेनिलाप्लानिफोलिया*, 7 *वेनिला* स्पी., वयनाड से 2 *वेनिला* स्पीसी. और *वी. पीलिफेरा, वी. अफिल्ला, वी. तहितेन्सिस* और *वी. वाइटियाना* के एक

एक) की कुल 78 अक्सेशनों को संरक्षित स्थितियों के तहत जर्मप्लाज़म संरक्षणशाला में संरक्षित किया जा रहा है।

- एक संशोधित आरपी-एचपीएलसी विधि को वेनिला अर्थात, वेनिलिन, पी-हाइड्रॉक्सीबेन्जोइक एसिड, पी-हाइड्रॉक्सीबेन्जाल्डेहाइड और वेनिलिक एसिड के प्रमुख स्वाद यौगिकों के एकसाथ पता लगाने और मात्रीकरण के लिए मानकीकृत किया गया।

- स्वस्थ वेनिला पौधों से वियुक्त *कैटोमियम* को आईटीएस क्षेत्र के अनुक्रमण द्वारा चरित्रांकित की गयी। BLAST का उपयोग कर होमोलॉजी की खोज में *सी. ग्लोबोसम* के साथ 98-100 प्रतिशत पहचान दिखाया गया। पी. मियादी के प्रति जांच की गयी वियुक्तियों में एफवीआरपी 4 ने 40% प्रतिरोध के साथ एफवीआरईपी 2 और एफवीएलईपी 7 के बाद नियंत्रण पर अधिकतम प्रतिरोध (56%) अंकित किया।

- बयोकंट्रोल एजेंटों (*बेसिलस एमिलोलिक्विफेसिंस* और *सी.ग्लोबोसम*) का खेत मूल्यांकन ने संकेत दिया कि *बी. एमिलोलिक्विफेसिंस* की मिट्टी और पर्ण प्रयोग ने रोग आपतन को 10% कम कर दिया।

वृक्ष मसाले

- केरल के पालक्काड़ और वायनाड जिलों से *सिनामोमुम गंबली, सी. नियोलिप्सियम* और *सी. माक्रोकार्पुम* को एकत्र किया गया। दालचीनी के 10 अकसेशनों के छाल नमूनों में एसनशियल तेल सामग्री का विश्लेषण किया गया था और तेल सामग्री में 1.2–3.0% अंतर था।

- एक व्यापक स्पाइसकॉम डाटाबेस को विकसित किया गया था जो मसालों में लगभग 650 फाइटोकेमिकल्स का पूर्ण अवलोकन प्रदान करता है और वनस्पति नाम, रासायनिक घटक, अंतर्राष्ट्रीय रासायनिक पहचानकर्ता, भौतिक रासायनिक गुण, औषधीय गतिविधि और उनसे संबंधित प्रासंगिक साहित्य के आधार पर डेटा को पुनः प्राप्त करने में सक्षम बनाता है।

- निकोबार द्वीप समूह से एकत्र लौंग *सिज़िजियम क्लाविफ्लोरम* का एक वन्य जाति को आईसीएआर-एनबीपीजीआर, त्रिशूर से प्राप्त किया और उसे जर्मप्लाज्म में जोड़ा गया था। तीन स्थानों से एकत्र लौंग के नमूनों की एसनशियल तेल सामग्री में 10.0-19.33% अंतर है।

- वयनाड जिले से *गार्सिनिया मोरेला* और *जी. टलबोटी* को एकत्र किया गया, दो विदेशी प्रजातियों, *जी. एट्रोविरिडिस* और *जी. मैक्रोफिल्ला*को वायनाड में किसानों के खेत से एकत्र किया गया और एक अन्य विदेशी प्रजाति, *जी. मङ्गनो* को बेंगलुरु, कर्नाटक से एकत्र किया गया।

- उच्च उपज और सूखी वसूली के साथ पेरुवण्णामुषि में *जी. गम्मिगट्टा* पेड़ों की श्रेष्ठ प्रकारों की पहचान की गई। ताजा फलों का वजन 29.09 से 141.00 ग्राम तक, सूखे फल का सूखा फल रिकवरी 5.13 से लेकर 14.5% तक और सूखा छिलका प्रति पेड़ 0.5 से 30 किलोग्राम तक भिन्न होता है।

- वायनाड, केरल में किसानों के खेत से रिकॉर्ड किए गए श्रेष्ठ आलस्पाइस पेड़ों के *इन सिटु* आंकड़ों में, प्रति वर्ष प्रति पेड सूखे फल की पैदावार में 5.0 से 27.3 किलोग्राम तक भिन्नता है और सूखा वसूली 25.5% से 32.3% तक होती है।

- विभिन्न सॉल्वैंट्स में आलस्पाइस बेरी के अर्क के एंटीऑक्सिडेंट और एंटीडायबिटिक क्षमता का निर्धारण किया गया था। हेक्सेन एक्सट्रैक्ट ने अधिकतम एंटीडायबिटिक क्षमता दिखाई। मीथनॉल अर्क में क्लोरोफॉर्म अर्क और फ्लेवोनोइड्स में कुल फिनोल अधिकतम थे।

- सेक्स क्रोमोसोम विशिष्ट आरएपीडी मार्करों का मूल्यांकन जायफल के नर, मादा और मोनोशियस पौधों में किया गया। NM1 D5 प्राइमर ने महिला को नर और मोनोशियस से अलग किया। महिला ने खुद को नर और मोनोशियस से भेदभाव करने के लिए दो अलग-अलग विशिष्ट पैटर्न दिखाए।

- साइट विशिष्ट पोषक तत्वों और सूक्ष्मपोषणों ने जायफल की गहराई और उपज में मिट्टी की उर्वरता के साथ-साथ संशोधन (चूना और चूना + डोलोमाइट @ 1.0 किलोग्राम प्रत्येक) का उपयोग किया। साइट विशिष्ट मिट्टी की उर्वरता आधारित पोषक तत्व प्रबंधन के साथ-साथ जायफल में पूरक सूक्ष्मपोषण का छिड़काव करने पर जायफल के नट और जावित्री की पैदावार 25% तक बढ़ गयी।

- जायफल की गिरावट की बीमारी का अध्ययन केरल के पेरुवण्णामुषि, अंकमाली, कक्काड़मपोयिल और पालक्काड़ क्षेत्रों में किया गया। रूपात्मक और आणविक अध्ययनों के आधार पर, रोगग्रस्त नमूनों से पृथक कवक की पहचान लासियोडिप्लोडियाथेब्रोमा के रूप में की गई थी।

आर्थिकी

- काली मिर्च, इलायची, अदरक और हल्दी जैसे प्रमुख मसालों के लिए प्रति व्यक्ति अनुमानित मांग दर क्रमशः 148.0 ग्राम, 53.0 ग्राम, 1.22 किलोग्राम और 1.63 किलोग्राम है। इस वृद्धि के साथ, स्थानीय और वैश्विक मांग को पूरा करने के लिए उत्पादन का स्तर वर्तमान स्तरों से 2.7–5.7 गुना तक बढ़ने का अनुमान है।

- इस सदी के अंत से वैश्विक दालचीनी की मांग 4.1% की सीएजीआर से बढ़ रही है। इस अवधि के दौरान दालचीनी का क्षेत्र लगभग दोगुना हो गया है।

डीयुएस परीक्षण सुविधा

- 4 काली मिर्च और 6 छोटी इलायची किस्मों के ऑन-साइट परीक्षण के लिए प्रारंभिक अवलोकन पूरा कर लिया गया। काली मिर्च, छोटी इलायची, अदरक और हल्दी की किस्मों को संबंधित केंद्रों पर बनाए रखा गया था।

- DUS परीक्षण 19 हल्दी किस्मों के लिए पूरा किया गया, जिसमें 14 किसानों की किस्में और सामान्य ज्ञान की 4 किस्में और एक विस्तृत किस्म शामिल हैं। साथ ही, 7 अदरक किस्मों के लिए DUS परीक्षण पूरा किया गया, जिसमें 4 किसानों की किस्में और 3 सामान्य ज्ञान की किस्में शामिल थीं।

जैवसुचना केंद्र

- अदरक *रालस्टोनिया* उपभेदों, रेस 4 / बायोवायर 3 में एक विस्तृत *इन-सिलिको* विश्लेषण किया गया, जो कि उपभेदों की रोगजनकता में बेहतर जानकारी प्राप्त करने और होस्ट-अनुकूलित बहुरूपताओं का पूर्वानुमान करने के लिए किया गया।

- दो पौधों से जुड़े *पी. एरुगिनोसा* उपभेदों के लिए उत्पन्न पूरे जीनोम डेटा की तुलना अन्य नैदानिक और पर्यावरणीय आइसोलेट्स के साथ की गई थी ताकि उनके विषाणु के लिए जिम्मेदार जीन का पता लगाया जा सके।

- आर्थिक रूप से महत्वपूर्ण फसलों में जीवाणु म्लानी का कारक *रालस्टोनिया सोलानसीरम* पर एक डेटाबेस का विकास हुआ था। डेटाबेस http://192.168.1.14/ralstoniadb/ पर खुले रूप से सुलभ है।

सामान्य

- दो बहुत ही होनहार ज़िंक सोलुबिलाइसिंग जीवाणु को उनकी घुलनशील दक्षता के लिए पृथक किया, चरित्रांकित एवं परीक्षण किया गया। दो वियुक्तियां, IISR GB7 (3) (बेसिलस स्पी.) और IISR TB4 (बेसिलस सफेन्सिस) में तरल और मिट्टी दोनों में स्पष्ट रूप से उच्च Zn घुलनशील दक्षता है।

- मसालों, चारा और सब्जियों के संयोजन के साथ एक मॉडल कृषि प्रणाली स्थापित की गयी।

- AMfungi के बड़े पैमाने पर गुणन के लिए सब्स्ट्रेट्स के मानकीकरण का प्रयास किया गया। मक्के की तुलना में, वर्मीकम्पोस्ट संशोधन के तहत नेपियर घास में जड़ उपनिवेश (80%) की वृद्धि बहुत अधिक थी।

- विभिन्न एआईसीआरपीएस केंद्रों की प्रजातियों के विमोचन की सुविधा हेतु फिंगरप्रिंटिंग सेवाओं के लिए डीएनए फिंगरप्रिंटिंग और बारकोडिंग की सुविधा स्थापित की गई थी। काली मिर्च, अदरक, हल्दी, धनिया, मेथी, सौंफ, अजवाइन सहित मसालों की अब तक 25 किस्मों की फिंगरप्रिंटिंग की जा चुकी हैं और नई किस्मों के लिए इसकी निकट संबंधी / जैसी दिखने वाली किस्मों की तुलना में विशिष्टता स्थापित की गई थी।

- आईटीएम-बीपीडी इकाई ने उपभोक्ताओं को अच्छी गुणवत्ता वाले मसाले और संबद्ध उत्पादों की आपूर्ति के लिए अपनी निरंतर खोज में 'SPIISRY' नाम से एक नई पहल शुरू की। यूनिट ने स्वास्थ्य और कल्याण के लिए मसाला आधारित उत्पादों की एक सरणी भी लॉन्च की।

राष्ट्रीय महत्व के कार्यक्रम

- आईसीएआर-आईआईएसआर,मुख्य परिसर, आईसीएआर-आईआईएसआर प्रायोगिक फार्म, कृषि विज्ञान केंद्र, पेरुवण्णामुषी और आईसीएआर-आईआईएसआर क्षेत्रीय स्टेशन, अप्पंगला में 11 सितंबर से 02 अक्टूबर तक स्वच्छता ही सेवा कार्यक्रम का आयोजन किया गया। संस्थान के परिसर एवं प्रयोगशालाओं की सफाई, प्लास्टिक कचरे के संग्रह एवं पृथक्करण, प्लास्टिक के दुष्प्रभावों के बारे में आम जनता, किसानों और छात्रों के बीच जागरूकता पैदा करना आदि सहित विभिन्न कार्यक्रमों का संचालन किया गया।

- आईसीएआर-आईआईएसआर, मुख्य परिसर, आईसीएआर-आईआईएसआर प्रायोगिक फार्म, कृषि विज्ञान केंद्र, पेरुवण्णामुषि और आईसीएआर-आईआईएसआर क्षेत्रीय स्टेशन,

अप्पंगला में 16 से 31 दिसंबर तक स्वच्छ पखवाड़ा 2019 का आयोजन किया गया। मैरा गांवों मेरा गौरव के तहत गोद लिए गए गांवों में स्वच्छता और स्वच्छता अभियान, प्लास्टिक के कारण प्रदूषण पर सार्वजनिक परिसरों की सफाई और स्वच्छता कार्यक्रम का आयोजन छात्रों एवं आम जनता के लिए किया गया।

- जैविक कचरे के पुनर्चक्रण को सर्वोच्च प्राथमिकता दी जाती है और परिसर में एकल उपयोग प्लास्टिक पर प्रतिबंध सख्ती से लागू किया गया था।

- आईसीएआर-आईआईएसआर के तीनों परिसरों अर्थात, आईआईएसआर मुख्यालय (कोषिक्कोड), क्षेत्रीय स्टेशन (अपंगला) और प्रायोगिक फार्म (पेरुवण्णामुषि) के अलावा केवीके, पेरुवण्णामुषि में 28 अक्टूबर 2019 से 02 नवंबर 2019 तक सतर्कता जागरूकता सप्ताह मनाया गया।

- नियमित गतिविधियों के लिए सौर ऊर्जा का उपयोग कर विद्युत ऊर्जा के आंशिक प्रतिस्थापन का पालन किया जा रहा है।

- मृदा परीक्षण आधारित उर्वरक सिफारिश को कंबल की सिफारिश की बजाय सलाह की जा रही है और सभी फसलों को विशिष्ट पोषक तत्वों की सिफारिश के साथ मृदा स्वास्थ्य कार्ड जारी किए गए हैं।

EXECUTIVE SUMMARY

ANNUAL
REPORT
2019

BLACK PEPPER

- Three thousand four hundred and sixty six accessions are being maintained at the Experimental farm, Peruvannamuzhi. A new field gene bank was established consisting of 300 accessions. An unique accession with extra-long spike (34.5 cm) was collected from Madikeri, Karnataka.

- Eighty two germplasm accessions were characterized for 17 quantitative and 12 qualitative traits using IPGRI descriptors.

- Genetic variability and correlations for yield and yield attributes were estimated in nine genotypes comprising of five hybrids, two open pollinated progenies and two IISR released varieties. Genotypes HP 2173 (HP1117 × Thommannkodi), OPKM, HP 780, HP 1411 and HP 820 were found promising for economically important characters.

- Eighteen genotypes consisting of varieties/hybrids and land races/farmers selection were characterized based on traits like spike length, number of mature berries/spike, dry seed weight, fresh seed weight and berry weight and these traits showed high positive correlation with spike weight.

- 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/resembling varieties.

- Major genes encoding novel compounds were identified from berry hybrid transcriptomes of *P. nigrum* and *P. longum*.

- A total of 111 & 127 transcripts with AMP signature in *P. nigrum* and *P. colubrinum* transcriptome were identified. Annotation with PhytAMP and CAMP R3 showed 48 & 37 potential AMPs in *Piper nigrum* & *P. colubrinum* respectively.

- Drip fertigation schedules for three varieties IISR Thevam, IISR Girimunda and IISR Shakthi have been standardized.

- 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.

- Spiking intensity and berry setting were recorded in 50 plantations in different estates. Spike intensity ranged from 12.2–25.4 per 0.5 square meter canopy area with mean of 20.2. Berry set ranged from 59.24–76.07% with a mean of 69.32%.

- Quality analysis of 25 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).

- Detachment force (DF) study in black pepper cultivars indicated that DF was reduced significantly with ripening and it varied among cultivars. About 88.0% and 40.0% reduction in DF was observed due to ripening of spike in Agali and Chumala, respectively.

- A novel molecular assay based on recombinase polymerase amplification (RPA) was developed for the detection of *P. capsici* and *P. tropicalis* infecting black pepper. The assay was 10 times more sensitive and robust than PCR.

- Forty-five germplasm accessions were screened using two isolates of *Phytophthora viz. P. capsici* (05-06) and *P. tropicalis* (98-93) by aerial inoculation technique. Six accessions (Acc. 5764, 6787, 7243, 7319, 7218 and 7344) showed stem lesion in the range of 0-5mm size with total phenols <5 mg/100 mg, poly phenols <10 mg and conductivity <300 µS.

- Studies on the antagonistic activity of *Lecanicillium psalliotae* against *P. capsici* indicated that black pepper plants challenged with *P. capsici* recovered well after the application of *L. psalliotae* under greenhouse conditions. Under field conditions, there was 50.0% reduction in yellowing symptoms in four year old vines treated with *L. psalliotae*.

- Under *in vitro* conditions, *Streptomyces albulus* and *Trichoderma harzianum* showed 100% inhibition of *Pythium deliense* infecting black pepper. *In planta* evaluation under greenhouse conditions and field evaluation showed reduction in the intensity of yellowing in *T. harzianum* and *S. albulus* treated vines to an extent of 75.2% and 74.4%, respectively.

- Recombinase polymerase amplification (RPA) and reverse transcription (RT) RPA assays were developed and optimized for the detection of piper yellow mottle virus (PYMoV) infecting black pepper.

- Mealybug species belonging to *Ferrisia*, *Icerya* and *Planococcus* spp. were found associated with young shoots, berries, collar region and root system of black pepper in different growing tracts of Kerala and Karnataka.

CARDAMOM

- A total of 622 germplasm accessions are being maintained at National Active Germplasm Site (NAGS), which consists of 423 accessions from Appangala; 102 accessions from Pampadumpara; 41 accessions from Mudigere and 56 from Sakleshpur.

- A CVT trial with nine hybrids *viz.,* Bold × IC 547219, (GG × Bold) ×Appangala 1 and (GG × NKE 19) × Bold from IISR RS, Appangala, MHC-1 & MHC-2 from ICRI, Myladumpara, SHC-1 & SHC-2 from ICRI RS, Sakleshpur and PH-13 & PH-14 from Pampadumpara along with variety *Njallani* green gold is being evaluated in IISR RS, Appangala for different agronomical traits.

- A small cardamom - mosaic virus interactive transcriptome database (SCMVTDb) was developed in collaboration with ICAR-IASRI.

- Based on molecular studies, *cardamom vein clearing virus* (CdVCV) was found to be a new virus species in the genus, *Nucleorhabdovirus*.

- Field screening of 180 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.

GINGER

- Six hundred and sixty eight accessions are being maintained in the field gene bank, which was further enriched with 12 accessions which included five red collections from Nagaland.

- One hundred and five accessions were characterized for major quality parameters. Maximum essential oil was recorded in Acc. 282 and Acc. 396. The crude fibre content ranged from 3.2 to 8.6%.

- A total of 40 accessions collected from different locations of North East India were genotyped using 34 SSR primers and 10 of them showed unique polymorphic bands within the genotypes.

- Yield trial of different accessions conducted during 2015-2018 at five locations across India under AICRPS, coordinated varietal trial showed that maximum yield (pooled) was recorded in SG 2604 followed by Acc. 247.

- Mutants identified against *Pythium* sp. and *Ralstonia solanacearum* are being evaluated under coordinated varietal trials.

- Extracts of ginger were prepared using petroleum ether, methanol and water sequentially. Among them, petroleum ether extract showed highest antioxidant and antidiabetic activity. 6- shogaol showed higher antioxidant activity, whereas 6-gingerol exhibited higher antidiabetic activity.

- New technology for integrated management of wilt integrating physical (soil solarization), chemical (soil amelioration with calcium chloride -3%) and biological (ginger apoplastic bacterium - *Bacillus licheniformis*) methods was developed. The formulation of the bioagent was launched as 'Bacillich'.

- *In vitro* studies with solid and liquid forms of sodium and potassium silicate and sodium meta silicate on *M. phaseolina* showed that silicates restricted the mycelial growth of the fungus.

- Morphological and molecular characterization of foliar pathogens resulted in identifi cation of *Exerohilum rostratum*, *Colletotrichum gloeosporioides*, *C. capsici* and *Botryo diplodia* sp. Five strains of *Trichoderma* spp and eleven isolates of plant growth promoting bacteria were isolated and characterized based on morphology and using molecular tools.

- Among the 18 PGPR isolates tested against fungal pathogens, isolates IISR GB1, IISR GB2, IISR GB7(3) and IISR TB4 showed maximum antagonistic activity against *Pythium myriotylum*, *Phytophthora capsici*, *Exserohilum rostratum* and *Macrophomina phaseolina* under *in vitro* conditions. Under greenhouse conditions, the ginger rhizomes treated with the bacterial isolate IISR GB7 (3) (*Bacillus* spp.) and IISR TB4 (*Bacillus safensis*) did not develop any soft rot symptoms.

- Seed treatment and three rounds of foliar spray 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.

- Field studies indicated that spinosad, flubendiamide and chlorantraniliprole were effective in the management of shoot borer (*Conogethes punctiferalis*) even at the lowest dose (0.3 mL/ litre) tested. The combination of chlorantraniliprole and spinosad was also equally effective in managing the insect.

TURMERIC

- One thousand four hundred and four accessions are being maintained in the field gene bank. The germplasm conservatory was further enriched with four accessions from Nagaland.

- Morphological characterization of 165 accessions was done and a total of 12 quantitative and 10 qualitative characters were recorded for each accession.

- To identify extra-long and bold turmeric lines, 12 accessions of Salem Local (Erode and Salem districts of Tamil Nadu) and four accessions of Mydukkur (Andhra Pradesh) were characterized for morphological characters.

- First generation seedlings (204 Nos), mother genotypes (20 Nos), second generation seedlings (432 Nos), Third generation seedlings (47 Nos) first generation inbreds (839 Nos), second generation inbreds (11 Nos), third generation inbreds (402 Nos), fourth generation inbreds (367 Nos) and inter-varietal hybrids (36 Nos) are being maintained.

- 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 varieties evaluated under 100.0% organic management, significantly higher yield was recorded by IISR Pragati (22.1 t/ha) followed by Kanthi (19.2 t/ha). Higher oil content was noticed in varieties IISR Prathibha (6.0%), IISR Alleppey Supreme (5.9%) and least oil content was noticed in Suvarna.

- Minimum drying time of 10 h was recorded for drying of cured sliced turmeric by hot air oven at 100°C and maximum time of 165 h (6.88 days) was recorded for sun drying of uncured sliced turmeric.

- Nano-curcumin was prepared using sonication based protocol, to increase the bio-availability of curcumin. The nano-curcumin thus developed had 2.5 fold increased solubility in both water as well as in virgin coconut oil.

- Survey of hotspot areas indicated high population of the lesion nematode, *Pratylenchus* spp., in Thanneerpanthal region (3.2/g soil) in Coimbatore District (TN) and Gobichettipalayam (4.7/g soil) in Erode District (TN).

- *In vitro* screening of antagonistic bacteria against *Pratylenchus* spp, showed maximum mortality with *Pseudomonas putida* BP25 (92.7%) followed by *Alcaligens fecalis* IISR 859 (68.7%), *Bacillus megaterium* BP17 (58.1%) and *Bacillus licheniformis* GP107 (10%) 24 h after exposure.

- New generation insecticides such as spinosad, flubendiamide and chlorantraniliprole were effective in the management of 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.

VANILLA

- A total of 78 accessions of vanilla (65 *Vanilla planifolia,* 7 *Vanilla spp.* from Andaman, 2 *Vanilla spp.* from Wayanad and one each of *V. pilifera, V. aphylla, V. tahitensis* and *V. wightiana)* are being conserved under protected conditions.

- A modified RP-HPLC method was standardized for simultaneous detection and quantification of major flavor compounds *viz*., vanillin, p-hydroxybenzoic acid, p-hydroxybenzaldehyde and vanillic acid.

- *Chaetomium* isolates from healthy plants were characterized by sequencing the ITS region. Homology search using the BLAST showed 98 - 100% identity with *C. globosum*. Among the isolates tested against *P. meadii*, FVREP4 recorded maximum inhibition (56%) over control followed by FVLEP2 and FVLEP7 with 40% inhibition.

- Field evaluation of biocontrol agents (*Bacillus amyloliquefaciens* and *C. globosum*) indicated that soil and foliar application of *B. amyloliquefaciens* reduced disease incidence to less than 10.0%.

TREE SPICES

- *Cinnamomum gamblii*, *C. neolipsium* and *C. macrocarpum* were collected from Palakkad and Wayanad districts of Kerala. The essential oil content in the bark samples of 10 accessions varied from 1.2–3.0%.

- A comprehensive SpiceCom database was developed which provides complete overview of approximately 650 phytochemicals in spices and enables retrieving data based on botanical name, chemical constituents, International Chemical Identifier, physicochemical properties, pharmacological activity and relevant literature related to them.

- A wild relative of clove *Syzigium claviflorum,* collected from Nicobar Islands was obtained from ICAR- NBPGR, Thrissur and added to the germplasm. Essential oil content of clove samples collected from three locations varied from 10.0– 19.33%.

- *Garcinia morella* and *G. talbotii* were collected from Wayanad district, two exotic species, G*. atroviridis* and *G. macrophylla* were collected from farmer's field in Wayanad and another exotic species, *G. madruno* was collected from Bengaluru, Karnataka.

- Elite lines of *G. gummigutta* trees at Peruvannamuzhi with high yield and dry recovery were identified. The fresh fruit weight varied from 29.09 to 141.00 g, the fresh fruit to dry rind recovery varied from 5.13 to 14.5% and the dry rind yield per tree varied from 0.5 to 30 kg.

- *In situ* data of elite allspice trees recorded from farmer's field at Wayanad, Kerala revealed that the dry fruit yield per tree per year varied from 5.0 to 27.3 kg and the dry recovery ranged from 25.5 to 32.3%.

- The antioxidant and antidiabetic potential of allspice berry extracts in different solvents were determined. Hexane extract showed maximum antidiabetic potential. Total phenols were maximum in chloroform extract and flavonoids in methanol extract.

- Sex chromosome specific RAPD markers were evaluated in male, female & monoecious plants of nutmeg. The NM1 D5 primer differentiated female from male and monoecious. The female showed two different specific patterns to discriminate themselves from male and monoecious.

- Application of amendments (lime and lime + dolomite @ 1.0 kg each) along with site specific nutrients and micronutrients significantly enhanced soil fertility at all depths and yield of nutmeg. Supplemental micronutrient sprays specific to nutmeg along with the site specific soil fertility based nutrient management increased the nut and mace yield up to 25% in the treated plots as compared to farmers practice.

- Etiology of nutmeg decline disease was studied in Peruvannamuzhi, Angamali, Kakkadampoyil and Palakkad regions of Kerala. Based on morphological and

molecular studies, the fungus isolated from diseased samples was identified as *Lasiodiplodia theobromae*.

GENERAL

- The facility for DNA Fingerprinting and Barcoding was established for undertaking fingerprinting services to facilitate varietal release for various AICRPS centres. So far 25 varieties of spices have been fingerprinted including black pepper, ginger, turmeric, coriander, fenugreek, fennel, celery and the uniqueness established for the new varieties in comparison with its closely related/resembling varieties.

- The ITM-BPD unit launched a new initiative christened 'SPIISRY' in its continuing quest to supply good quality spices and allied products to the consumers. The unit also launched an array of spice based products owing to the increasing demand for sophisticated finished products from oils and oleoresins and health and wellness products.

- Two very promising Zn solubilizing bacteria have been isolated, characterized and tested for their solubilizing efficiency. The two isolates, IISR GB7 (3) (*Bacillus* sp.) and IISR TB4 (*Bacillus safensis*) possessed markedly higher Zn solubilization efficiency both in liquid and soil.

- A farming system model with a combination of spices, fodder and vegetables was established at IISR Chelavoor campus along with a dairy unit.

- Spice processing facility was established at IISR main campus and started functioning for training and production of value added products. Hands on training were provided to 15 entrepreneurs.

- Standardization of substrates for mass multiplication of arbuscular mycorrhizal fungi (AMF) was attempted. Amendment with vermiculite +10% FYM followed by vermiculite +10% vermicompost were found to be superior in enhancing the root biomass, shoot and root length of both the hosts**.** In comparison to maize, the increase in root colonization (80%) was much higher in napier grass under vermicompost amendment.

- Microrhizome of ginger varieties (IISR Mahima, IISR Varada) and turmeric varieties (Sona, IISR Prathibha, Kanti and Varna) were subcultured and 3100 plantlets of ginger and 500 turmeric raised in cultures and are being hardened in protrays and poly bags under nursery.

ECONOMICS

- The projected per capita demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148.0 g, 53.0 g, 1.22 kg and 1.63 kg respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7 –5.7 fold from the present levels.

- The global cinnamon demand has been growing at a CAGR of 4.1% since the turn of this century. The area under cinnamon has almost doubled during this period.

- The research gains from ginger, turmeric and black pepper were estimated to be 1617.1 crores, while for small cardamom and nutmeg it was 101.2 crores and 31.7 crores, respectively.

DUS TESTING FACILITY

- Preliminary observations for the on-site testing of 4 black pepper and 6 small cardamom varieties were completed. Example varieties of black pepper, small cardamom, ginger and turmeric were maintained at respective centres.

- DUS testing completed for 19 turmeric varieties which include 14 farmers' varieties and 4 varieties of common knowledge and one extant variety. DUS testing completed for 7 ginger varieties which include 4 farmers' varieties and 3 varieties of common knowledge.

BIOINFORMATICS CENTRE

- A detailed *in-silico* analysis was carried out in ginger *Ralstonia* strains, race 4/Biovar 3 to get a better insight into the pathogenicity of strains and to predict host-adapted polymorphisms.

- The whole genome data generated for two plant-associated *P. aeruginosa* strains were compared with other clinical and environmental isolates to find out the genes responsible for their virulence.

- A database on *Ralstonia solanacearum* causing bacterial wilt in several economically important crops was developed, which includes manually curated whole genome data of 11 Indian strains. The database is openly accessible at http://192.168.1.14/ralstoniadb/.

PESTICIDE RESIDUE ANALYSIS FACILITY

- A facility for pesticide residue analysis was established at ICAR-IISR headquarters. The facility sponsored by SHM (Kerala) is equipped with Liquid chromatography,

Mass Spectrometry (LCMSMS) and GC with FPS and ECD detectors to check both non- volatile and volatile pesticide residues, respectively in spice samples.

TRIBAL SUB PLAN (TSP) AND SPECIAL COMPONENT PLAN (SCP)

- Capacity building and front line intervention programmes for tribal population in spices sector development in NE states and tribal empowerment in Paderu Tribal agency Area, Vishakapatanam district, Andhra Pradesh, Attapady Tribal block. Palakkad district, Kerala, Golpara and Kamrup districts, Assam, Namsai district in Arunachal Pradesh and Koraput district in Odisha were taken up under Tribal Sub Plan (TSP) and Special Component Plan (SCP).

PROGRAMMES OF NATIONAL IMPORTANCE

- 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 2019. Various programmes including cleaning the institute premises, laboratories, collection and segregation of plastic wastes, creating awareness among the general public, farmers and students regarding the ill effects of plastics were conducted.

- Swachhta Pakhwada 2019 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 2019. Cleanliness and sanitation drive in the villages adopted under *Mera Gaon Mera Gaurav*, cleaning public premises and awareness programs on pollution due to plastic were organized for students and public.

- Vigilance Awareness Week was observed from 28 October 2019 to 02 November 2019 in all the three campuses of ICAR-IISR *viz*., IISR headquarters (Kozhikode), Regional station (Appangala) and Experimental Farm (Peruvannamuzhi), besides KVK, Peruvannamuzhi.

- Recycling of organic wastes is given top priority and ban on single use plastic in the campus was strictly enforced.

- Partial substitution of electrical energy using solar energy for routine activities is being followed.

- Soil test based fertilizer recommendation is being advocated instead of blanket recommendation and soil health cards are issued with specific nutrient recommendations to all crops.

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 2307.70 lakhs during the year. The institute earned total revenue of 45.2 lakhs through sale of planting materials, biocontrol agents, trainings, publications and consultancy services etc.

Staff

The institute has a sanctioned strength of 45 scientific, 35 technical, 24 administrative and 31 supporting staff, of which 36, 26, 12 and 9 of scientific, technical, administrative and supporting staff, respectively are in position. The KVK has a sanctioned strength of 1 scientific, 11 technical, 2 administrative, and 2 supporting staff, of which 1 scientific, 8 technical, 1 administrative and 1 supporting staff, respectively are in position.

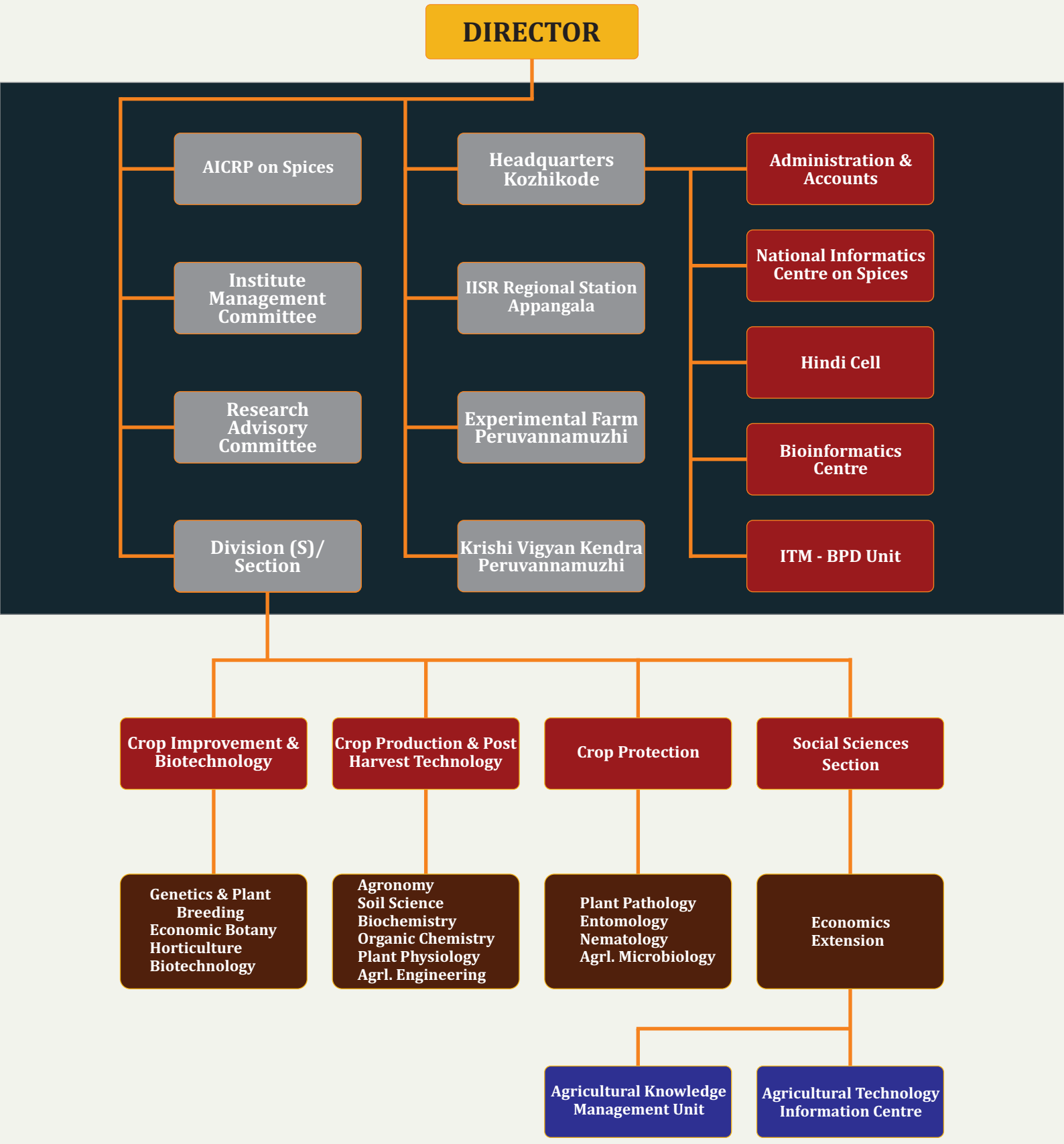
STAFF POSITION OF THE INSTITUTE

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientist	45	30	0	06	36	09
Technical	35	14	08	04	26	09
Administration	24	11	0	01	12	12
Supporting	31	02	01	06	09	22
Total	135	57	09	17	83	52

STAFF POSITION OF KVK

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientist	01	-	01	-	01	-
Technical	11	-	08	-	08	03
Administration	02	-	01	-	01	01
Supporting	02	-	01	-	01	01
Total	16	-	11	-	11	05

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 3466 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 replaced. 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.

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. The spacing, nutrient and water requirements have been standardized for different soil types of pepper growing regions. Mathematical models for optimum climatic factors for high production of black pepper have been developed. 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^{-1} enhanced yield substantially. High production technologies and mixed cropping systems were developed for increasing productivity. 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 *Phytophthora* 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.

Large scale multiplication of biocontrol agents such as *Trichoderma* for distribution to farmers for management of disease was also undertaken. These organisms were deposited in the national repository of microorganisms at IMTECH, Chandigarh for future reference. 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. Endophytic bacteria effective against *Phytophthora capsici* and *R. similis* in black pepper have been isolated. Culture filtrates of BRB 13 at 40µL mL^{-1} caused 100% mortality of *R. similis* within 24h. Basal application of *T. harzianum* and aerial spray with 1% Bordeaux mixture was found effective in controlling anthracnose disease. 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 benefical 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 EC_{50} and EC_{90} 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.

Drought effects could be mitigated by spray of antitranspirants such as lime and kaolin. 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^{-1} with the adoption of scientific packages as compared to 620 kg ha^{-1} 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. A video on Augmenting black pepper production – a success story (Malayalam, English, Hindi) was produced.

CARDAMOM

Germplasm collections (621) 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 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. 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. A novel soil pH based micronutrient mixture for enhancing growth, yield and quality of cardamom has been developed and non-exclusively licensed.

GINGER

Six hundred and sixty eight 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 *Ralstonia 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 Rs. 3.75 bed^{-1} for N, Rs. 1.30 bed^{-1} for P and Rs. 0.60 bed^{-1} 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 actinomycete 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) was effective for disease control and plant growth promotion. PGPR formulation to enhance nutrient mobilization and growth, yield and biocontrol was developed and commercialized.

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 tested against shoot borer larvae under *in vitro* conditions. One species of EPN belonged to *Oscheius gingeri* and was identified as new species on the basis of morphological and molecular characterization. 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 Prathiba, IISR Alleppey Supreme and IISR Kedaram were released for commercial cultivation.

Molecular genetic fingerprints of 16 *Curcuma* species using RAPD and ISSR markers revealed high degree of polymorphism. A total of 140 microsatellites containing genomic DNA fragments were isolated adopting the selective hybridization method with di and trinucleotide biotinylated probes. Two synonymous *Curcuma* species *viz*., *C. 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 Rs. 0.65 bed^{-1} for N, Rs. 0.40 bed^{-1} for P and Rs. 0.85 bed^{-1} of $3m^2$ for K. Increase in curcumin content was recorded when sprayed with micro nutrients like zinc and boron. The optimum spacing, nutrient and water requirement were standardized for different soils and organic farming system was developed for turmeric. 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 (*Conogethes punctiferalis*) and its natural enemies and crop loss due to shoot borer was generated. Lamdacyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer. The improved varieties and technologies were disseminated to farmers and other agencies through publications and demonstrations. The adoption of released varieties like IISR Prathibha in Andhra Pradesh, Karnataka and Tamil Nadu were studied. A novel soil pH based micronutrient mixtures for enhancing growth, yield and quality of turmeric, ginger, black pepper and cardamom were developed. Video film on success story of a 'IISR Prathibha' grower was produced.

TREE SPICES

The germplasm of important tree spices like nutmeg, clove, cinnamon including cassia, garcinia and allspice are being conserved. IC Numbers for cinnamon, clove, nutmeg and allspice accessions were obtained from NBPGR, New Delhi. Cassia C1 (IC 370415) has been registered as INGR 05029 with NBPGR, New Delhi for its high oleoresin content (10.5%) besides a dwarf clove accession. The cassia elite line A1 (IC 370400) has been registered with NBPGR for high cinnamaldehyde content in bark oil (81.5%) and leaf oil (80.5%). Two high quality cinnamon varieties, IISR Navashree and IISR Nithyashree and a nutmeg variety, IISR Viswashree were released. Nutmeg accession, A11/25 was found to be promising for high yield. Nutmeg accession A9-71(IC-537220), as a source of high sabinene (45.0% sabinene in nutmeg oil and 41.9% sabinene in mace oil) was registered with NBPGR. Tissue culture protocols have been developed for nutmeg. Protocols for DNA isolation from nutmeg have been standardized. Performance of nutmeg on *M. malabarica* continued to be better than other rootstocks for productivity. Green chip budding with orthotropic buds was standardized in nutmeg on *Myristica fragrans* rootstock with 90-100% success.

GC-MS study revealed the presence of two chemotypes in *Cinnamomum verum*. 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 *Cinnamomum 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 the other (PT-17).

Protocols for micro propagation through direct shoot multiplication as well as callus regeneration were standardized. Root rot and wilting were found to be the major problems 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 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.

RESEARCH ACHIEVEMENTS 2019

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BLACK PEPPER

Genetic resources

A total of 3466 accessions are being maintained in the Experimental farm, Peruvannamuzhi. A new field gene bank with 300 accessions and a model black pepper plot on non-living standards with nine released varieties, 19 promising lines and farmers varieties was established at Experimental farm, Peruvannamuzhi (Fig.1). An unique black pepper accession with extra long spike (34.5 cm) was collected from Tata Coffee, Madikeri, Karnataka (Fig.2)

Fig.1 Newly established black pepper plot on non-living standards

Fig.2 Unique black pepper accession with extra long spike collected from Madikeri, Karnataka

Characterization of black pepper germplasm

Based on IPGRI descriptors, 82 germplasm accessions were characterized for 17 quantitative and 12 qualitative traits. Dry berry weight showed positive correlation with fresh berry weight, fresh rachis weight and number of spikes/ vine. Number of matured berries and number of immature berries/ spike showed positive correlation with setting percentage. However, number of immature berries/ spike and berry size showed negative association with setting percentage. Wide range and high coefficient of variation (CV) were recorded for berry weight, and number of spikes /vine whereas, lower CV was observed for berry size (Table 1). Germplasm accessions found promising for specific traits *viz.,* bold berries, fruit setting, dry recovery, spike length and yield were shortlisted (Table 2).

Table 1 Quantitative traits of black pepper germplasm accessions

Trait	Mean	SD	CV	Range	
				Min	Max
Plant height (cm)	521.10	79.49	15.25	290.00	690.00
Lateral branch length (cm)	50.77	8.71	17.16	29.33	71.67
Nodes/LB	21.07	7.35	34.91	11.00	42.33
Leaf petiole length (cm)	1.83	0.38	21.01	0.44	2.86
Leaf length (cm)	14.08	1.99	14.10	8.98	20.80
Leaf width (cm)	8.00	1.26	15.75	5.46	11.42
Peduncle length (cm)	1.24	0.32	25.90	0.44	2.04
Spike length (cm)	9.04	1.62	17.96	4.72	13.32
Immature berries/spike	23.26	8.43	36.24	7.33	46.00
Matured berries/spike	49.07	15.97	32.54	20.00	98.40
Fruiting %	67.37	11.44	16.98	30.30	89.09
Berry size (cm)	0.56	0.05	8.62	0.45	0.67
No. of spikes/vine	364.26	188.58	51.77	56.00	821.00
Rachis weight (g)	119.39	68.96	57.76	12.00	290.00
Fresh berry weight (g)	1021.22	542.05	53.08	172.00	2851.00
Dry berry weight (g)	326.07	180.03	55.21	48.00	925.00
Dry recovery (%)	31.91	4.39	13.74	24.23	41.27

SD: Standard Deviation; CV: Coefficient of Variation

Table 2 Germplasm identified for specific traits

Trait	Accession No.	Remarks
Bold berries	6649, 5777, 6628, 5795, 6676	>6.5mm
Fruit setting (%)	6628, 5757, 5766, 6689, 6691	89.1-83.4%
Dry recovery	6709, 6611, 6718, 6728, 6668	41.56- 40.03%
Spike length	6690, 6660, 6676, 5787, 6689	16.8 – 11.7cm
Yield	5795, 6707, 5789, 6693, 6759	3.25- 2.05kg

Yield evaluation and variability studies

Genetic variability and correlations for yield and yield attributes were estimated in nine genotypes comprising of five hybrids, two open pollinated progenies and two IISR varieties (control). Highest Phenotypic Coefficient of Variation (PCV) was recorded for rachis weight/ vine (56.86) followed by dry berry yield/ vine (48.36) and fresh berry yield/ vine (48.05). Rachis weight/ vine (75.60 and 88.84) followed by fresh berry yield/ vine (81.11 and 80.28) and dry berry yield/ vine (79.52 and 79.21) recorded high heritability. Dry berry yield/ vine was positively correlated with rachis weight/ vine, fresh berry yield/ vine, spike length and lateral branch length both at genotypic and phenotypic level. Genotypes HP 2173 (HP1117 × Thommannkodi), OPKM, HP 780, HP 1411 and HP 820 were found promising for economically important characters (Table 3).

Table 3 Comparison of black pepper genotypes for economically important characters

Genotype	Dry berry yield (g)	Dry recovery (%)	Fresh berry yield (g)	Test weight (g)
HP 2173	1269.3^{a}	32.82^{b}	3856.5^{a}	15.27^{bc}
HP 1411	554^{cd}	33.64^{ab}	1645.85^{cde}	11.75^{e}
IISR-Thevam	809.3^{b}	29.06^{cd}	2774.66^{b}	16.28^{b}
HP 780	437.33^{cd}	36.11^{a}	1209^{de}	17.61^{a}
HP 820	652.20^{bc}	31.72^{bc}	2059.16^{c}	11.91^{de}
Sreekara	613.22^{bcd}	32.64^{b}	1872.91^{cd}	12.96^{d}
OPKM	454.47^{cd}	27.71^{d}	1633.16^{cde}	14.517^{c}
HP 728	397.71^{d}	29.06^{cd}	1380^{cde}	14.32^{c}
$P_{24}O_4$	398.53^{d}	35.98^{a}	1098^{e}	10.83^{e}

Variability for pericarp traits in black pepper genotypes

Eighteen genotypes were characterized based on berry components. Traits *viz*., spike length, number of mature berries/spike, dry seed weight, fresh seed weight and berry weight showed high positive correlation (>0.8) with spike weight. Path analysis confirmed that berry weight and seed size contribute directly to spike weight. Grouping of genotypes based on Scott-Knott test revealed Panniyur-1 and Nedumchola as contrasting genotypes for maximum number of traits. Based on Principal Component Analysis (PCA), the first PC accounted for 42.4 % of variation with fresh berry weight, dry seed weight and fresh pericarp weight being the major contributors. Contrasting genotypes for some of the traits studied are presented in Table 4.

Table 4 Contrasting genotypes for seed and pericarp traits in black pepper genotypes

Trait	Contrasting genotype	
	High	Low
Berry size	Chumala, Panniyur-1, Agali and IISR Malabar excel	Thekkan, Sreekara, Jeerakamundi and Karuvilanchi
Seed size	Agali, IISR Girimunda, Panniyur-1 and Naraykodi	Thekkan, Karuvilanchi, Sreekara and Jeerakamundi
Pericarp thickness	IISR Malabar Excel, Chumala, Arakulamunda and IISR Thevam	Nadumchola, Agali, IISR Girimunda and Thekkan
Pericarp to seed size ratio	IISR Malabar Excel (47.93 %), Arakulamunda (44.31 %), Chumala (39.80%) and Thekkan (34.81%)	Agali (23.77 %), IISR Girimunda (24.64 %), Nadumchola (27.74%) and IISR Shakthi (28.22 %)
Dry/fresh pericarp weight ratio	Nadumchola (43.24 %), Thekkan (43.07 %), PLD-2 (41.51 %) and Subhakara (36.94 %)	IISR Malabar Excel (26.30%), Panniyur-1 (26.49%), Arakulamunda (27.64%) and Karuvilanchi (29.13 %)
Dry/fresh seed weight ratio	Jeerakamundi (71.92%), Agali (71.84%), IISR Malabar Excel (70.85%) and Mundi (69.86 %)	IISR Thevam (49.18), Chumala (49.87%), IISR Girimunda (54.97%) and Arakulamunda (54.99 %)

R genes in tagging *Phytophthora* resistance

The R gene involved in recognition of host immune response identified from the proteomics of IISR-Shakthi- *Phytophthora* interaction was analysed for its association with *Phytophthora* resistance. The PCR amplification of this gene (Fig.3), using the gene specific primer showed amplification in all the tested genotypes with various levels of resistance except $P_{24}O_4$ (Open pollinated progeny of IISR-Shakthi).

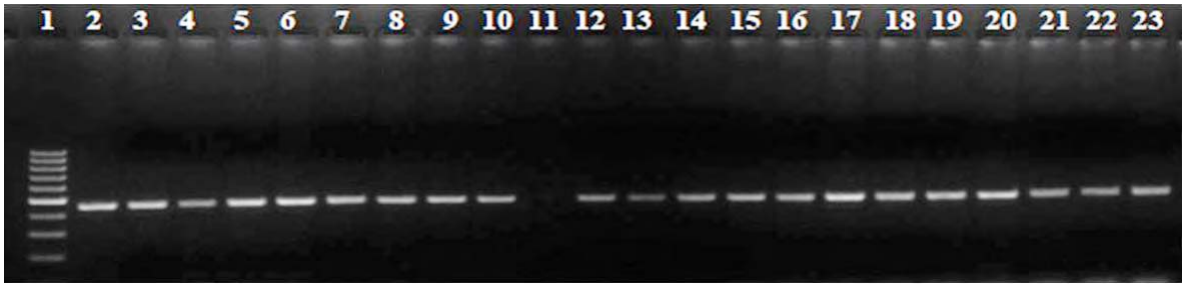


Fig. 3 Lane 1-Ladder (100bp), 2-IISR Shakthi, 3-IISR Thevam, 4-Subhakara, 5-Sreekara, 6- IISR Girimunda, 7-Panchami, 8-Pournami, 9-Panniyur-1, 10-PLD-2, 11-P24O4, 12-Kalluvally, 13-Karimunda, 14- IISR Malabar Excel, 15-Narayakodi, 16-Vadakkan, 17-Chumala, 18-Agali, 19-ACC-114, 20-Cultivar-1324, 21-New HP, 22-HP-780, 23-1108-Perambramundi

R gene related to disease resistance based primers when tested in different varieties and cultivars showed single band for the genotypes Vadakkan, Agali and ACC-114 and a specific banding pattern for Narayakodi and Chumala (Fig.4).

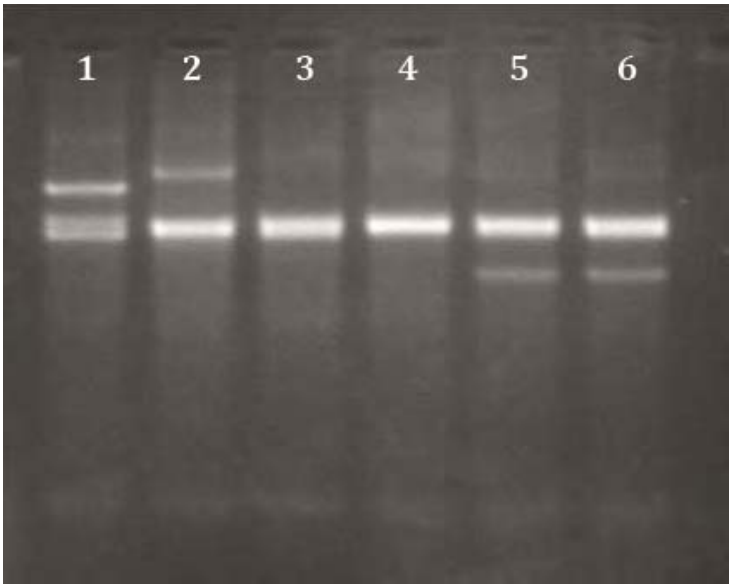


Fig. 4 Lane 1-Narayakodi; 2- Chumala; 3-Vadakkan; 4-Agali; 5- Cultivar 1324; 6- New HP

DNA Fingerprinting and Barcoding

DNA fingerprinting of 20 important varieties and cultivars was initiated at the DNA Fingerprinting and Barcoding Facility. Seven polymorphic ISSR primers were identified for distinguishing 9 candidates and a representative gel showing a distinguishing marker in Panniyur 5 is shown in Fig.5.

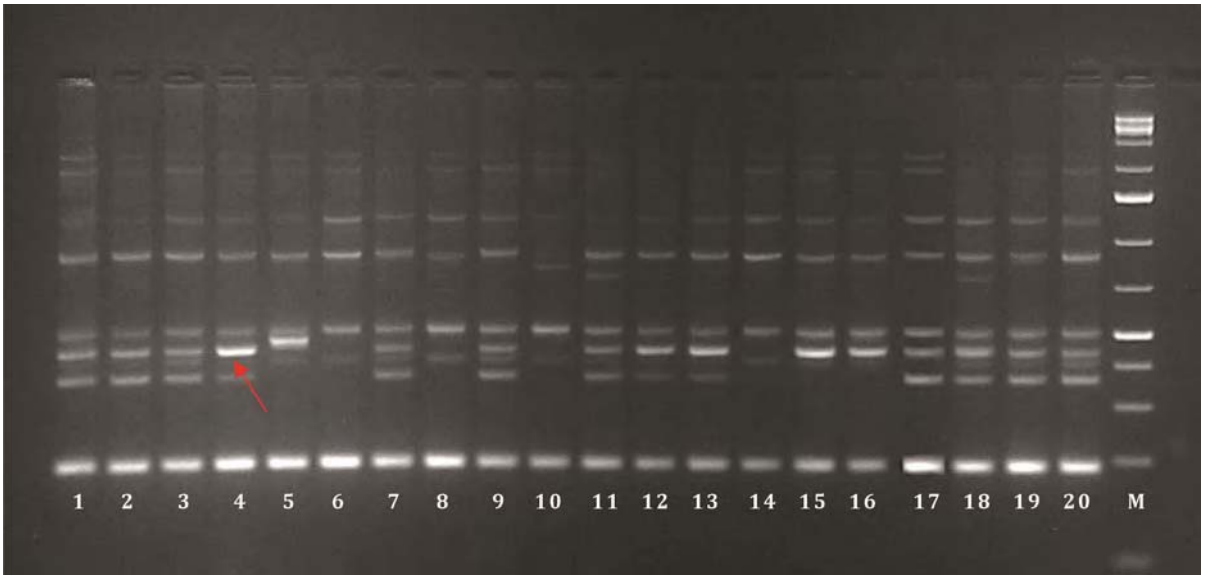


Fig.5 Lanes: 1-Panniyur 1, 2-Panniyur 2, 3-Panniyur 3, 4-Panniyur 4, 5-Panniyur 5,6-Panniyur 6, 7-Panniyur 7, 8-Panniyur 8, 9-Panniyur 9, 10-IISR Girimunda, 11-IISR Malabar Excel, 12-Panchami, 13- PLD 2, 14-Pournami, 15-IISR Shakthi, 16-Shubhakara, 17-Sreekara, 18-IISR Thevam, 19-Arka Coorg Excel, 20- Vijay, L-1kb plus ladder. Red arrow indicates unique distinguishing marker in variety Panniyur 5.

Genes encoding novel compounds

Major genes encoding novel compounds were identified from hybrid transcriptomes of *P. nigrum* and *P. longum*. The alkaloid tropine synthesizing gene tropine reductase was identified and sequenced from *P. nigrum.* Lysine 6 dehydrogenase gene synthesizing the alkaloid 'Pipecolate', which induces systemic resistance in plants, was identified from *P. longum*. Ten rare flavonoid and four lignin derivatives coding genes and the chromosomal location of all these genes were also identified.

Antimicrobial peptides

A total of 111 and 127 transcripts with AMP signature in *P. nigrum* and P. *colubrinum* transcriptome, respectively were identified. Annotation with PhytAMP and CAMP R3 showed 48 & 37 potential AMPs in *Piper nigrum* and *P. colubrinum* respectively with nine novel AMPs.

Development of fertigation schedule

Drip fertigation schedules for varieties IISR Thevam, IISR Girimunda and IISR Shakthi were standardized. 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 (15.30 kg dry) followed by IISR Thevam (12.03 kg dry).

Drought management

Antitranspirants *viz*., Kaolin 2%, Kaolin 2% + 0.5 % MOP, lime 1.5%, lime 1.5% + 0.5% MOP and Miracle 3mL/litre were sprayed and physiological parameters like photosynthetic gas exchange parameters, canopy temperature, chlorophyll fluorescence and yield characters was recorded. Sparying lime 1.5% showed higher photosynthetic rate with lower leaf temperature.

Spiking intensity and fruit setting

Spiking intensity and berry setting were recorded from 50 plantations (Madikeri, Virajpet, Somvarpet, Sakleshpur, Mudigere, Chickmanglore, Puttur and Sirsi). Spike intensity ranged between 12.2 to 25.4 per 0.5 m^2 canopy area with mean of 20.2 and berry set percentage ranged from 59.24 to 76.07 with a mean of 69.32.

Influence of altitude and management practices

Black pepper vines grown at 1040 MSL (3412 ft) flowered in July- August but the vines showed severe spike drop due to anthracnose and lack of bisexual flowers resulting in low yield. To initiate early flowering in May, shade regulation was done in February and sprinkler and hose irrigation was given from March 10 onwards at 10-15 days interval. Flowering and fruit setting was recorded in May-June. Prophylactic sprays of carbendazim (2g/litre) in April and Bordeaux mixture (1.0%) in May, reduced spike shedding signifcantly.

Spiking intensity was recorded between 891 MSL (2923 ft) to 1168 MSL (3832 ft). No of spices per m^2 ranged from 30.75 (1087 MSL) and 59 (891MSL) with a mean of 40.73. Spike length (cm) ranged from 10.64 (926 MSL) to 17.4 (1018 MSL) with a mean of 13.36. No of berries/ spike ranged from 51.8 (926 MSL) to 84.7 (1078 MSL) with a mean of 71.4. The data clearly indicated pepper that can be grown at the higher altitude (1078 MSL; 3536 feet) by adopting early shade regulation and irrigation.

Chemo-diversity

Quality analysis of berries from 25 genotypes was completed for essential oil, oleoresin, piperine and total alkaloid content (Table 5). Total alkaloid content ranged from 16.7 - 35.7 mg/g with highest alkaloid content in Subhakara (35.7 mg/g) and lowest in Panniyur 4 (16.7 mg/g). Oleoresin was negatively correlated with bulk density (r=-0.49), while it was positively correlated with essential oil content (r=0.44) and piperine content (r= 0.71) whereas, piperine showed moderate negative correlation with bulk density (r= -0.58). The concentration of piperine at different maturity stages was evaluated. The varieties IISR Thevam and Panchami recorded highest piperine content at 3.5 – 4 months maturity, whereas in Sreekara, piperine content was the highest at 3.0-3.5 months maturity (Fig.6).

Table 5 Biochemical qualities of black pepper genotypes

Name of cultivar	Bulk Density (g/L)	Oleoresin (%)	Essential oil (%)	Piperine a (%)	Piperine b (%)	Total alkaloid content (mg/g)
Kaniakadan	565	9.6±0.07	3.4±0.28	5.1±0.09	2.9±0.22	20.1±0.47
IISR-shakthi	514	11.6±0.11	5.4±0.28	5.2±0.06	3.1±0.19	24.1±0.48
Neelamundi	435	9.9±0.27	2.6±0.28	4.4±0.29	2.3±0.07	27.9±0.41
Chumula	594	6.7±0.06	3.8±0.28	2.9±0.02	1.7±0.08	NA
Panalkodi	471	8.4±0.01	3.5±0.14	4.2±0.02	2.5±0.51	27.5±0.46
Agali	532	7.0±0.01	2.9±0.14	3.9±0.09	2.1±0.24	34.3±0.75
IISR Malabar Excel	486	8.2±0.60	3.7±0.14	4.3±0.03	1.9±0.06	27.0±0.36
Kalluvally	339	12.7±0.55	5.3±0.14	5.9±0.19	3.1±0.16	34.8±1.22
Jeerakamunda	506	10.7±0.10	2.6±0.28	5.7±0.21	3.7±0.27	NA
Narayakodi	567	9.05±0.07	3.4±0.28	2.5±0.01	1.0±0.08	31.0±0.38
IISR Girimunda	581	6.6±0.08	3.2±0.0	4.1±0.56	2.2±0.01	23.2±0.61
Sreekara	556	10.7±0.29	4.7±0.14	5.7±0.07	3.6±0.04	25.5±0.32
Kathirinmelkathir	551	10.2±1.48	4.2±0.29	5.1±0.01	3.3±0.04	23.1±0.35
Perumkodi	430	9.8±0.10	3.5±0.14	5.6±0.36	3.1±0.13	27.9±0.36
Balancotta	377	8.9±0.09	3.3±0.14	5.1±0.07	3.4±0.09	23.6±0.33
Kanjirakadan	517	9.3±0.02	4.5±0.14	5.6±0.00	3.4±0.01	33.9±0.21
Subhakara	520	10.4±0.06	4.7±0.14	6.1±0.02	4.0±0.08	35.7±0.32
Panchami	373	11.3±0.01	3.1±0.14	6.0±0.01	3.8±0.04	30.2±0.42
Arakulamunda	539	9.2±0.07	3.8±0.29	4.8±0.01	2.4±0.04	19.7±0.26
Panniyur 1	489	8.9±0.02	3.3±0.14	5.1±0.01	2.8±0.04	19.3±0.03
Karimunda	523	10.1±0.05	3.3±0.42	4.3±0.01	2.9±0.01	26.0±0.20
IISR Thevam	574	7.5±0.05	3.3±0.14	3.5±0.01	1.8±0.01	34.2±0.14
ACC-7220	617	9.9±0.14	3.5±0.14	3.2±0.08	1.6±0.01	27.6±0.21
Panniyur 4	417	10.5±0.08	3.1±0.14	5.6±0.05	3.9±0.04	16.7±0.31
ACC-1071	541	6.0±0.01	3.3±0.14	3.1±0.02	1.5±0.03	22.2±0.30

a- Estimated using spectrophotometer, b- Estimated using HPLC

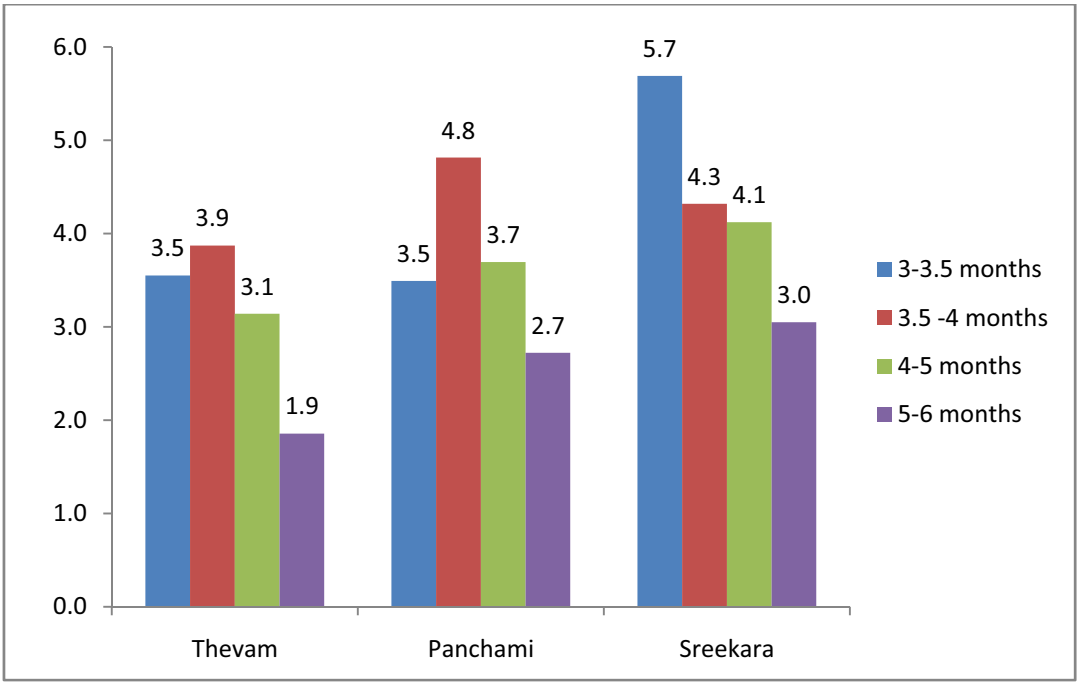


Fig.6 Piperine concentration in black pepper varieties at different maturity stages

Biochemical and anatomical studies of abscission zone

The abscission process was studied using physical, biochemical and histological analysis of the abscission zone in leaf and spike. As the ripening progressed the detachment force (DF) reduced significantly and varied among different cultivars. The reduction in DF was more in case of spike than berry. Protein content increased gradually as the ripening of leaf, spike and berry progressed. Correlation between the protein content of spike abscission zone (AZ) and berry AZ was observed indicating the effect of protein translocation to berry during maturity. Reducing sugar content increased gradually during maturation process in spike, leaf and berry and sugar translocation to berry during maturity was observed by increased sugar content. The involvement of Reactive oxygen species (ROS) was more in case of leaf than in case of spike.

Phloroglucinol staining revealed clear lignification of the AZ in berry and spike as the maturity of the berry increased, while in case of leaf AZ, significant difference in lignification was not visible. Ruthenium red staining of AZ showed no significant variation for mucilage substances in case of berry and spike, while leaf showed an accumulating pattern for mucilage substances in AZ during maturity which disappeared upon ripening. Ruthenium red- Toluidine blue staining gave a clear AZ demarcation of leaf AZ due to pectin degradation.

Detachment force during aging

Detachment force (DF), the force with which the spike gets detached from the stem was measured to know the effect of aging on DF in two different cultivars *viz*., Agali and Kumbakal. As the ripening progressed, the DF reduced significantly and reduction was

more in case of spike than in berry (Fig.7). The reduction in DF was found to vary among cultivars and the reduction (88.0% and 40.0%) was enhanced due to ripening of spikes. However, 43.0% and 55.0%, reduction in DF was observed due to ripening of berries in Agali and Chumala, respectively (Table 6).

Table 6. Detachment force (Newton) measurement in two different cultivars

Sample	Agali	Chumala
Ripe Spike	0.53±0.33	2.32±1.27
Mature Spike	4.35±2.02	3.90±1.37
Ripe Berry	2.20±0.92	1.63± 0.93
Mature Berry	3.90±1.30	3.67± 1.52

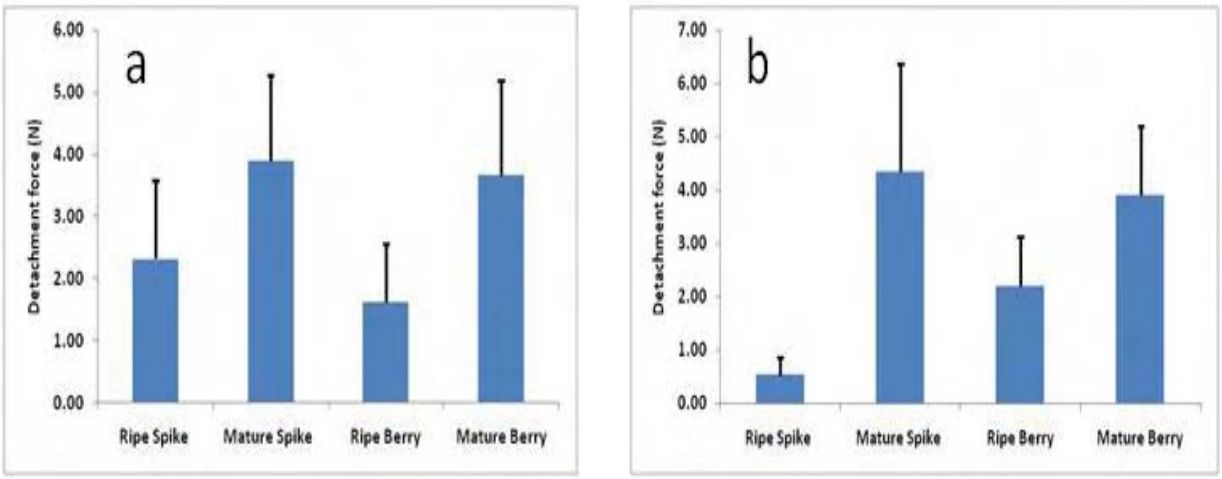
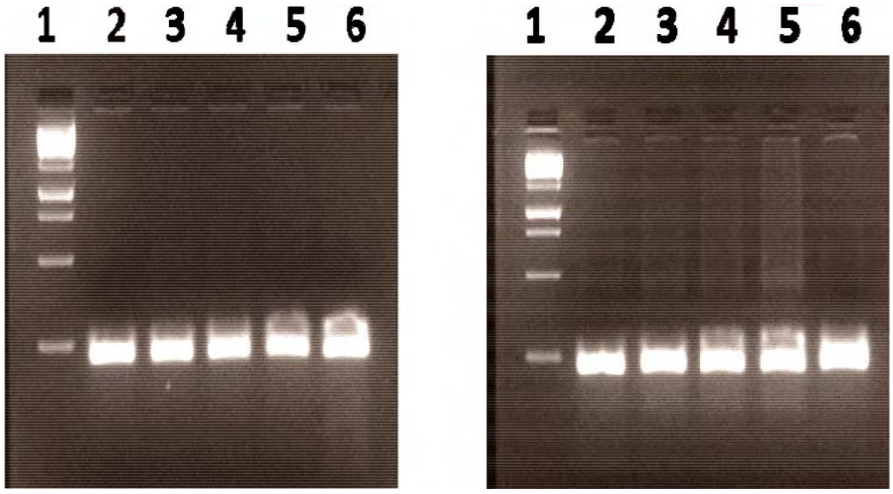


Fig.7 DF measurement in berry and spike of (a) Chumala (b) Agali

Ypt1 gene based recombinase polymerase amplification assay for detection of *Phytophthora* spp.

A novel molecular assay based on recombinase polymerase amplification (RPA) was developed for the detection of *Phytophthora* spp (Fig.8). A primer set based on *Ypt1* gene successfully amplified a 230/231bp product, when the assay was performed at 37°C with 14 mM magnesium acetate and 1.0M betaine for 40 minutes. The optimized RPA assay could detect *Phytophthora* from infected leaf, stem and root using both purified DNA and crude extracts. The assay was 10 times more sensitive than PCR, robust and highly specific in differentiating *P. capsici* and *P. tropicalis*.



(1) **(2)**

Fig.8 Recombinase polymerase amplification detection of (1) *P. capsici* and (2) *P. tropicalis.* Lane 1. 1 Kb DNA Ladder, Lane 2-6. RPA products amplified from *P. capsici* / *P. tropicalis*

Phylogenetic analysis of *Phytophthora* isolates using Cox I gene

Phytophthora isolates *viz*., group I (05-06, 01-03, 06-09, 99-162) , group II (98-93, 97-55, 11-27, 11-29, 98-02) isolates and ATCC cultures of *P. capsici* (ATCC4034) and *P. tropicalis* (ATCC76651) were amplified using primers FM 84 (5'-TTTAATTTTTAGTGCTTTTGC-3') and FM 83 (5'-CTCCAATAAAAAATAACCAAAAATG-3'). The Cox I sequences of *P. capsici, P. tropicalis* and other *Phytophthora* species *P. meadii, P. colocasiae, P. citricola, P. oleae, P. palmivora, P. ramorum, P. nicotianae* and *P. infestans* retrieved from NCBI were used for the phylogenetic analysis. In the phylogenetic analysis, the group I isolates were found to cluster with *P. capsici* isolates from *Cucumis melo* (AB688168), cucumber (AB688171), tomato (AB688176) and *Capsicum annuum* (AY129166) from NCBI with a bootstrap value of 89% (Fig.9). Group II isolates were found in a separate cluster with *P. tropicalis* isolates from NCBI (HQ261467, HQ708417 and GU945500). Based on Cox I gene analysis, groupI isolates belonged to *P. capsici* and group II isolates belonged to *P. tropicalis*.

Screening of germplasm accessions for *Phytophthora* resistance

Forty-five germplasm accessions were screened using two isolates of *Phytophthora viz*. *P. capsici* (05-06) and *P. tropicalis* (98-93) by aerial inoculation to study the symptom development on stem, leaf and also root. The defense response *viz*., conductivity, production of total phenols, polyphenols and ortho dihydroxy phenols were also recorded in screened accessions. Among the 45 accessions screened, six resistant accessions (Acc. 5764, 6787, 7243, 7319, 7218 and 7344) showed stem lesion in the range of 0-5 mm size with total phenols of <5 mg/100 mg, polyphenols of <10 mg and conductivity <300 µS.

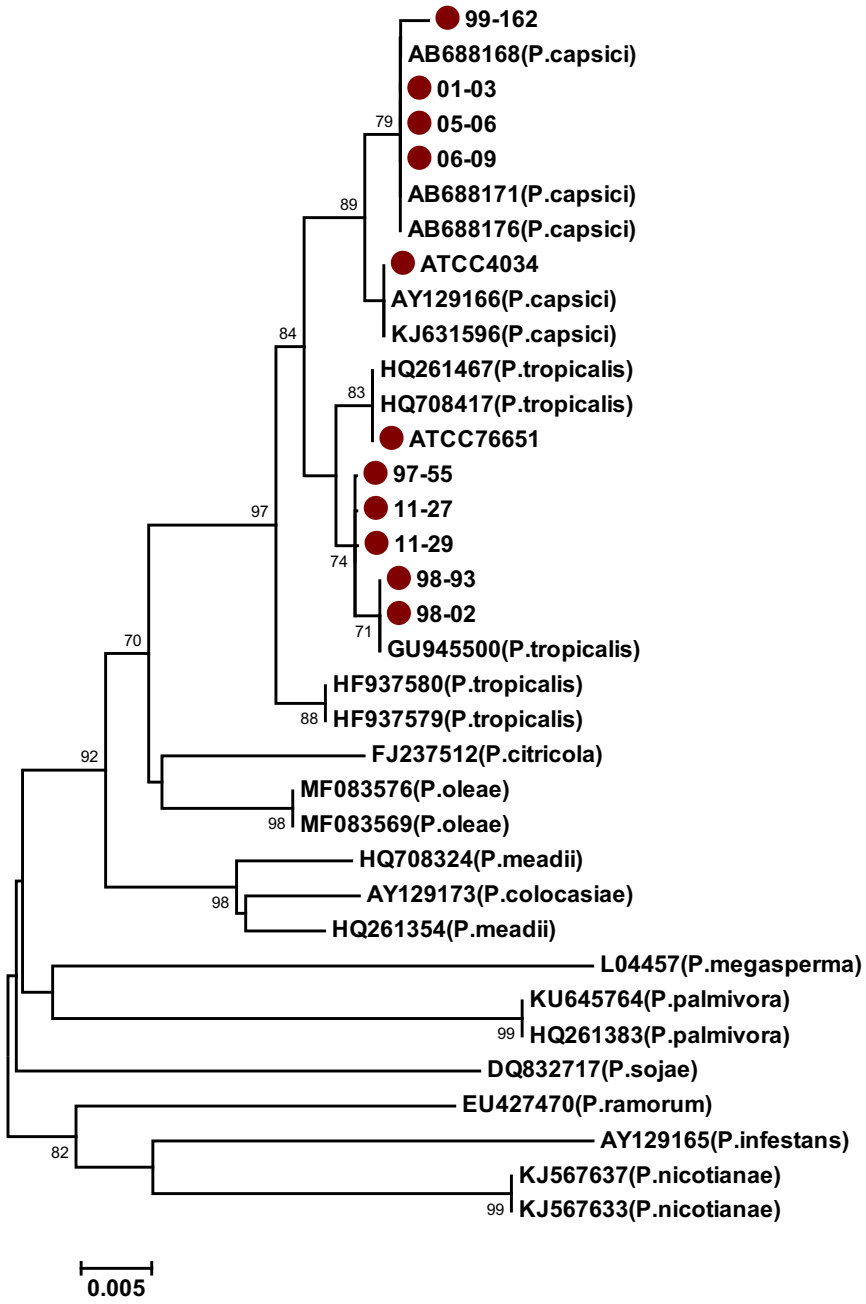


Fig.9 Phylogenetic analysis of *Cox* subunit I sequences of *Phytophthora* species using neighbor joining algorithm.

Evaluation of *Lecanicillium psalliotae*

Studies on the antagonistic activity of *Lecanicillium psalliotae* against *P. capsici* indicated that plants challenged with *P. capsici* recovered after the application of *L. psalliotae* under greenhouse conditions. Root regeneration and shoot growth were observed in *L. psalliotae* treated plants (Fig.10a & 10b). Under field conditions, there was 50% reduction in yellowing symptoms in four-year-old vines treated with *L. psalliotae* indicating rejuvenation of the root system.

Fig.10a Root damage caused by *Phytophthora*

Fig. 10b Root regeneration in *L. psalliotae* treated plants

Biological management of *Pythium deliense*

Streptomyces albulus and *Trichoderma harzianum* showed 100% inhibition of *Pythium deliense* under *in vitro* conditions. Under hydroponic system, black pepper plants treated with *T. harzianum* and *S. albulus,* when challenge inoculated with the pathogen showed no root infection but significant root regeneration was observed. *In planta* evaluation showed reduction in the intensity of yellowing in *T. harzianum* and *S. albulus* treated vines to an extent of 75.2% and 74.4%, respectively.

RPA assay for detection of piper yellow mottle virus

Recombinase polymerase amplification (RPA) and reverse transcription (RT) RPA assays were optimized for the detection of piper yellow mottle virus (PYMoV). Out of the eight primer pairs targeted to amplify open reading frames (ORFs) 2 and 3 of the virus, the primer pair targeted to amplify ORF2 gave specific amplification only with DNA isolated from infected plant but not with healthy plant confirming specificity of the primer in the detection of PYMoV through RPA. Optimization of RPA assay, using the identified primer pair showed that 18 mM magnesium acetate, 40 min incubation time and a temperature range from 39 °C to 42 °C as optimum for the successful detection of PYMoV using diluted crude DNA extract as template. An expected product of size 191 bp was obtained for positive control, while negative control and water control did not yield any product. The identity of the RPA product was established by directly sequencing the product. RPA assay was ten times more sensitive compared to PCR for the detection of PYMoV using CTAB isolated total DNA than crude DNA extract. PYMoV was also detected successfully by RT-RPA using 1.0 µL of cDNA as template. RPA and RT-RPA assays can be adopted as a substitute to PCR for the detection of PYMoV.

Amplification and sequencing of target genes in *Radopholus similis*

Out of the 20 target genes short-listed through transcriptome mining, nine genes - abhydrolase domain-containing protein (Rs-AB), immune-dominant hypodermal antigen Ac16 (Rs-Ac16), astacin-like metalloendopeptidase (Rs-AsLM), carbonate dehydratase, eukaryotic-type (Rs-CDh), EGF-like domain protein (Rs-ElDP), vacuolar protein sorting-associated protein 45 (Rs-VpSA), glycoside hydrolase, superfamily domain-containing protein (Rs-GH), pectatelyase (Rs-PL) and reticulocalbin-2 (Rs-ReCa2) were amplified, cloned and sequenced from *R. similis*. The sequences obtained were further processed, analyzed using BLAST tool and submitted to NCBI database (Table 7). These sequences were translated into putative protein sequences and subjected to *in silico* analysis for studying their physical and chemical properties and for identifying the domains and motifs present in these proteins. Phylogenetic analysis was carried out for each protein to understand their evolutionary significance.

Table 7 Target genes sequenced from *R. similis*

Gene Id	Accession No.	Length	Description
Rs-AB	MN184224	1104	abhydrolase domain-containing protein
Rs-Ac16	MN184227	249	immunodominant hypodermal antigen Ac16
Rs-AsLM	MN184226	996	Astacin-like metalloendopeptidase
Rs-CDh	MN184225	354	carbonate dehydratase, eukaryotic-type
Rs-ElDP	MN184223	468	EGF-like domain protein
Rs-VpSA	MN184222	936	Vacuolar protein sorting-associated protein 45
Rs-GH	MN184221	774	Glycoside hydrolase, superfamily domain-containing protein
Rs-PL	MN184220	690	pectatelyase
Rs-ReCa2	MN184219	836	Reticulocalbin-2

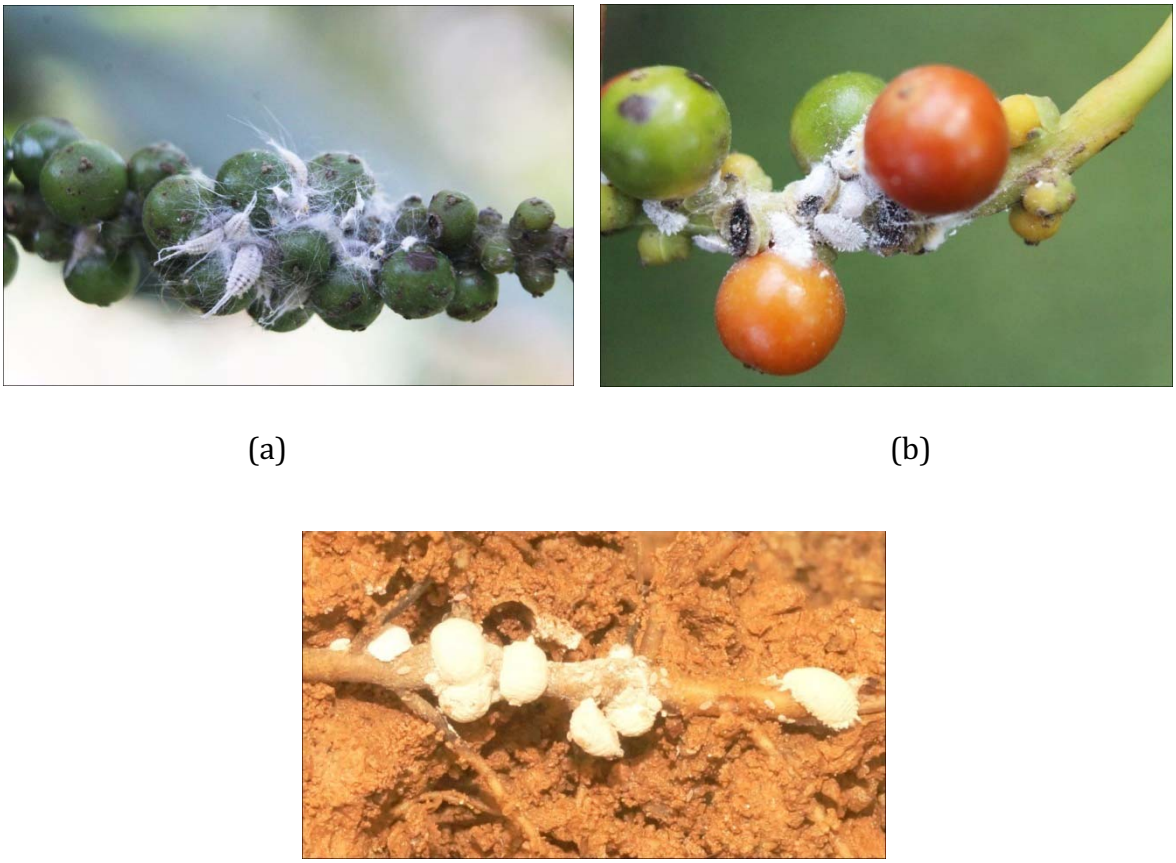
Plant growth promoting properties of *Pochonia chlamydosporia*

In vitro and *in vivo* studies conducted have showed that *Pochonia chlamydosporia*, the nematophagous fungus, possess several growth promoting traits *viz*., phosphorous and zinc solubilization, production of ammonia, siderophores and cell-wall degrading enzymes like α-amylase, cellulose and pectinase. A pot culture trial of black pepper plants (var. Sreekara) with different potting media (sterilized soil, unsterilized soil & vermiculite + farmyard manure) was conducted to study the growth promoting ability of *P. chamydosporia*. Different quantities (1.0 g – 5.0 g) of *P. chlamydosporia* multiplied on rice substrate were used as the inoculum and the growth of the plants were compared with control (uninoculated) plants after six months. Studies indicated that fungus applied at higher dose (5.0 g) significantly increased shoot and root growth

parameters of black pepper compared to untreated plants. The contents of major, secondary and micronutrients in both soil and plant were also markedly enhanced.

Survey for mealy bugs

Surveys for incidence of mealy bugs infesting black pepper was carried out in twenty locations in Kerala and Karnataka. Mealy bugs feeding on different plant parts such as leaves, berries, cling roots, collar region, main roots and feeder roots were collected, coded and wet preserved in the insect repository at ICAR-IISR, Kozhikode. A spatial distribution pattern of different genera was observed on black pepper. Mealy bug species belonging to *Ferrisia* and *Icerya* genus were mainly found on young shoots and berries, whereas *Planococcus* spp. was found to be associated with berries, collar region and root system (Fig.11a, b & c). Preliminary surveys indicate that *Ferrisia, Planococcus* and *Icerya* were observed in low altitude area like Calicut and Peruvannamuzhi and the genus *Planococcus* was observed in Wayanad district and Kodagu. The mealy bugs are being cultured using potato sprouts and squash under laboratory conditions for further morphological and molecular studies.



(a) (b)

(c)

Fig.11 Mealy bugs infesting different parts of black pepper (a) *Ferrisia* sp (b) and (c) *Planococcus* sp.

CARDAMOM

Genetic resources

A total of 622 germplasm accessions are being maintained at National Active Germplasm Site (NAGS) which consists of 423 accessions from Appangala; 102 accessions from Pampadumpara; 41 accessions from Mudigere and 56 from Sakleshpur. Out of 168 germplasm lines screened under field conditions, three lines *viz*., IC349358, IC349333 and IC349334 showed dual resistance to rhizome rot and leaf blight.

Breeding

In PET III, 23 inter-varietal hybrids were evaluated and superior hybrids were shortlisted. Hybrid progenies *viz.,* IISR Vijetha × GG (progeny no. 1), Mudigere 1 × IISR Vijetha (progeny no. 2), ICRI 4 × IISR Vijetha (progeny no. 14), PV 2 × Appangala 1 (progeny no. 7), IISR Vijetha × GG (progeny no. 3), PV 2 × IISR Vijetha (progeny no. 1), ICRI 4 × IISR Avinash (progeny no. 2), Mudigere 1 × IISR Vijetha (progeny no. 3) and Mudigere 3 × IISR Vijetha (progeny no. 5) were planted for further evaluation.

The open pollinated progenies of pre potent clones *viz.,* IC 584058, IC 349627, IC 349422, *Njallani* green gold and IC 349537 were evaluated for yield and moisture stress tolerance. A trial under AICRP for Spices with nine farmer's varieties of small cardamom *viz*., Arjun, Wonder cardamom, Panikulangara, Thiruthali, Elarajan, Patchakai, Njallani, PNS Gopinath supplied by National Innovation Foundation (NIF) and a check variety Appangala-1 were planted during June 2017. Morphological observations *viz.,* plant height, number of tillers, number of bearing tillers, number of panicles and panicle length (cm) were recorded. First harvest yield data is given in Table 8.

Table 8 Observations on morphological and yield contributing traits for the year 2019

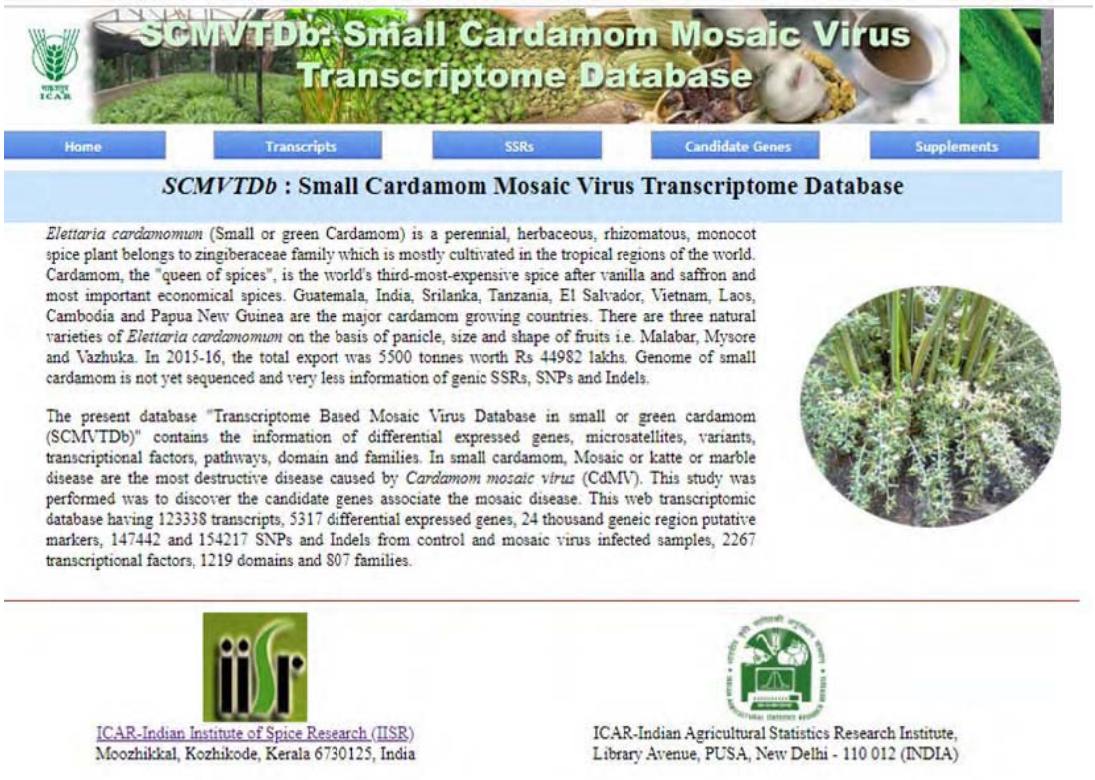
Variety	Plant height(cm)	Number of tillers	No. of bearing tillers	No. of panicles	Panicle length(cm)
Thiruthali	208.74^{a}	24.26^{a}	11.39^{a}	18.53^{a}	49.15^{a}
Wonder cardamom	151.70^{bc}	13.90^{bc}	4.63^{b}	6.13^{bc}	34.00^{b}
Green Gold	160.84^{bc}	15.27^{bc}	4.94^{b}	6.75^{bc}	30.01^{b}
Panikulangara	149.08^{bc}	19.91^{ab}	5.40^{b}	6.81^{bc}	29.63^{b}
Appangala-1	131.26^{c}	15.14^{bc}	4.02^{b}	5.16^{bc}	27.60^{b}
Elarajan	166.86^{abc}	15.63^{bc}	6.13^{b}	9.82^{b}	34.11^{b}
Pappaulu	191.33^{ab}	16.61^{abc}	4.85^{b}	6.55^{bc}	36.21^{ab}
Arjun	152.85^{bc}	14.14^{bc}	3.79^{b}	5.07^{bc}	27.70^{b}
Patchakai	123.91^{c}	9.75^{c}	3.29^{b}	4.36^{bc}	25.79^{b}
PNS Gopinath	136.28^{c}	9.17^{c}	3.06^{b}	3.33^{c}	23.72^{b}
CD @ 5%	*	*	**	**	*

CVT on hybrids

The CVT trial consisting of nine hybrids *viz.,* Bold × IC 547219, (GG × Bold) ×Appangala 1 and (GG × NKE 19) × Bold from IISR RS, Appangala; MHC-1 & MHC-2 from ICRI, Myladumpara; SHC-1 & SHC-2 from ICRI RS, Sakaleshapura and PH-13 & PH-14 from Pampadumpara was laid out with national check variety *Njallani* green gold.

Database

A Small Cardamom - Mosaic Virus Interactive Transcriptome Database (SCMVTDb) was developed by ICAR -IISR in collaboration with ICAR-IASRI.



Organic farming

Higher availability of major, secondary and micronutrients were recorded in soil, when FYM, VC (vermicompost) and NC (neem cake) were applied in combination compared to single application. Also, the availability OC, N, P, Ca, Mg, Fe and Zn were high in organic and integrated management system. Among the organic nutrient sources, NC+VC application recorded 1.3 kg dry cardamom capsules/ plot (of 12 plants) followed by FYM + NC (0.85 kg/plot) and VC (0.81 kg/plot). Integrated management yielded significantly higher fresh capsule yield (1.48 kg/ plot) followed by chemical management (1.3 kg/ plot). Highest oil content (5.7%) was observed in organic management (Fig.12).

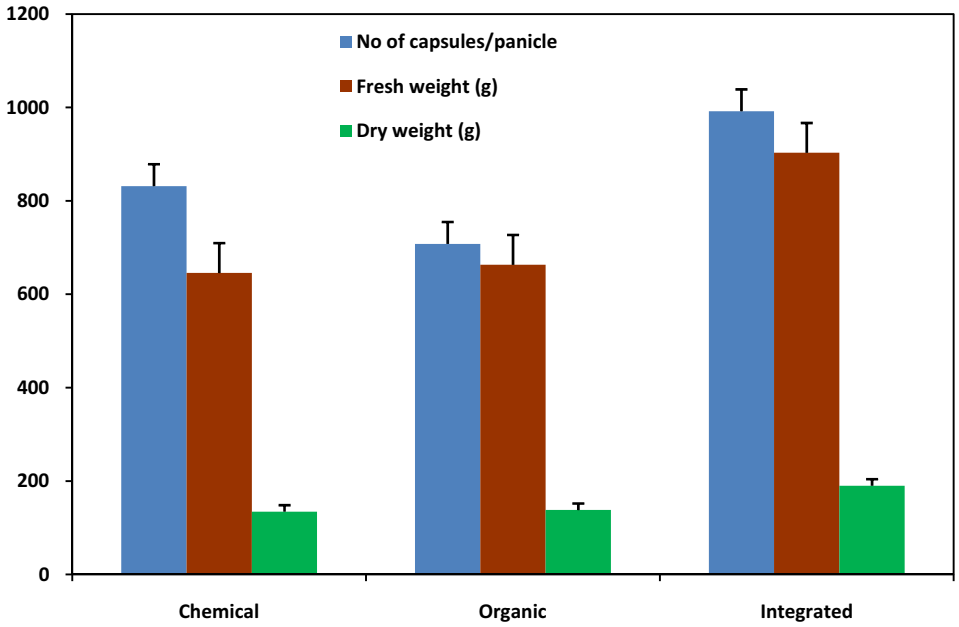


Fig.12 Yield attributes of cardamom under different management systems

Yield and quality of elite lines under moisture stress

Six genotypes of cardamom (IC 349537, IC 584058, GG×NKE-12, IC 584078, CL 668, HS 1, IC 584090) with one check (Appangala 1) were evaluated for drought tolerance under AICRPS. Mositure stress was imposed in summer from February to April by with holding irrigation whereas in control, plants were irrigated by sprinkler (25mm) once in 12-15 days. Plant height, number of tillers, panicle length and yield were reduced under moisture stress. Accession IC 584058 recorded a yield of 400.34 kg/ha in control and 278.78 kg/ha under stress, followed by Accession IC 584090 (307.32 kg/ha) in control and 166.33 kg/ha under stress. Essential oil content ranged from 6.81 to 8.18% and oleoresin content ranged from 3.61 to 5.55%.

Effect of light intensity on growth, yield and quality

Effect of light intensity, full sunlight and two shade conditions (75 % and 50 % shade) was studied on growth, physiological characteristics, yield and chemical quality in variety Appangala-1. Plants grown under 50 % shade produced physiologically more active tillers and higher capsule setting as well as yield/ plant. The highest photosynthetic rate, stomatal conductance, transpiration rate, chlorophyll fluorescence and lowest canopy temperature were observed on plants exposed to 75% shade. Oleoresin content was higher in capsules of plants under full sunlight, however no significant difference was observed in essential oil content. The concentration of α-terpinyl acetate and 1, 8- cineole were highest under full sunlight and 75.0 % shade level, respectively.

Identification and characterization of cardamom vein clearing virus CdVCV

The contigs obtained from small RNA (sRNA) and RNA-sequencing (RNA-seq) of virus infected plants when subjected to BLAST search using NCBI plant virus database indicated the occurrence of a nucleorhabdovirus. Contigs showed maximum identity with black currant associated nucleorhabdovirus (BCaRV) (GenBank accession MF543022), datura yellow vein virus (DYVV) (KM823531), sonchus yellow net virus (SYNV) (L32603), apple root stock virus A (ARV-A) (MF 778545) and alfalfa-associated nucleorhabdovirus (AaNV) (MG848563).Total RNA was extracted from symptomatic and healthy leaves of cardamom and was subjected to RT-PCR using specific primers designed based on NGS contig sequence. Cloning and sequencing of RT-PCR products by the Sanger method produced a sequence of 13,392 nucleotides from the infected cardamom plant. The BLAST N and BLAST X search of the sequence showed identities with nucleorhabdoviruses. The sequenced region contained six open reading frames (ORFs) and partial 3' leader (185 nt) and 5' trailer (177 nt) sequences, which resembles that of other nucleorhabdoviruses. Comparison of the complete genome sequences between known species of nucleorhabdoviruses showed a maximum identity of 52% while maximum identity in different ORFs was 56% and 68% at the nt and aa levels, respectively. This was also evident in phylogenetic analysis. Hence, CdVCV should be considered a member of a new virus species in the genus, *Nucleorhabdovirus*.

Plant morphological traits associated with field resistance to thrips

Screening of 180 accessions was carried out for three years at Appangala, Karnataka, which resulted in identification of eight accessions resistant to thrips. The average capsule damage by thrips in these accessions ranged from 13.7% to 16.7%. Based on the threshold values for different categories, 16, 80, 50 and 26 accessions were rated as moderately resistant, moderately susceptible, susceptible and highly susceptible respectively, to the pest. Further studies were carried out to study the role of plant morphological traits such as panicle type, persistence of flower bract and nature of adherence of leaf sheath in imparting resistance against thrips. Plants with prostrate panicles, non-persistent bracts and loose leaf sheath had significantly less thrips damage, compared to plants with erect/ semi-erect panicle, persistent bracts and with either intermediate or tight leaf sheath (Fig.13).

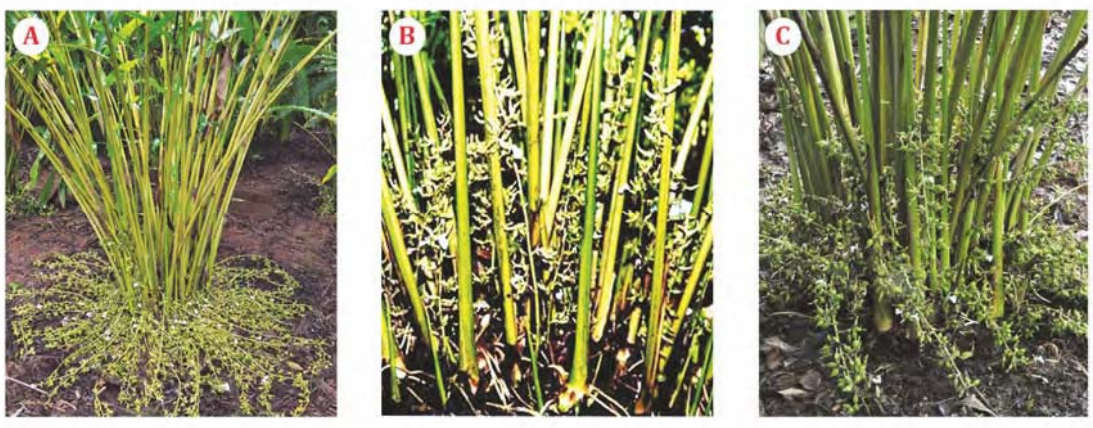


Fig.13 Cardamom accessions with different panicle (**a** prostrate panicle, **b** erect panicle and **c** semi-erect panicle) and flower bracts types (**d** non-persistent bract and **e** persistent bract) (arrow indicates presence or absence of flower bract).

GINGER

Genetic resources

Six hundred and sixty eight accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with 12 accessions which included five red ginger accessions from Nagaland.

Characterization

One hundred and five accessions were characterized for major quality parameters. Maximum essential oil was recorded in Acc. 282 and Acc. 396. The crude fibre content ranged from 3.2 to 8.6% (Table 9).

Table 9 Variability in quality characters among ginger accessions

Parameter	Range	Promising accessions
Essential oil (%)	1.0-3.0	High essential oil: 3.0 % Acc. 282, Acc. 396
Oleoresin (%)	3.3-10.3	High oleoresin: 8.1 % Acc. 282, Acc. 222
Crude fibre (%)	3.2-8.6	High fibre: 8.1% Acc. 848 Low fibre: 3.2 % Acc. 512 (3.19%), Acc. 410 (4.03%), Acc. 553 (4.04%), Acc. 243 (4.4%)

Four ginger genotypes from North eastern region (NER) of India along with Rio de Janeiro were characterized for different quality characters. The essential oil was maximum (4.3%) in Nagaland Pink ginger, which also recorded maximum oleoresin and fibre contents (Table 10).

Table 10 Quality attributes of NER ginger genotypes

Genotype	Essential oil (%)	Oleoresin (%)	Fibre (%)	6-[G] (%)	8-[G] (%)	6-[S] (%)	Total
Nagaland Pink	4.3	9.09	10.19	1.92	0.22	0.55	2.70
Nagaland Local	1.0	2.60	4.61	0.36	0.09	0.15	0.60
Nadia	1.3	5.63	7.06	0.74	0.10	0.14	0.98
Rio-de Janeiro	1.0	4.85	4.93	0.64	0.11	0.13	0.89
Thekkadi Local	1.5	5.46	3.82	0.89	0.13	0.12	1.13
Bhaise	1.3	6.66	8.55	0.62	0.11	0.21	0.94

Molecular characterization

A total of 40 accessions collected from different locations of North East India were genotyped using selected SSR markers. 50 new primers were designed from ginger transcriptome using Batch primer online tool, out of which, 34 produced amplicons. All 40 genotypes were screened using 34 SSR primers and 10 of them showed unique polymorphic bands (ZO SSR2, ZO SSR7, ZO SSR8, ZO SSR15, ZO SSR 16, ZO SSR25, ZO SSR28, ZO SSR35, ZO SSR36 and ZO SSR38) within the genotypes.

Yield evaluation

Yield trial of different accessions was conducted during 2015-2018 at five locations across India under AICRPS, Coordinated Varietal trial. Among the ginger accessions, maximum yield (pooled) was recorded in SG 2604 followed by Acc. 247.

Mutation breeding

Ten M1V6 and 102 M1V12 mutants are being maintained in the Institute. Two potential mutants identified against *Pythium* sp. (V 0.5/2 and R 1.25/4) and three potential mutants against *Ralstonia solanacearum* (HP 0.5/2, HP 0.5/15 and G1.00/4) have been included in the new CVT trial 2019 of ginger disease tolerance.

Micronutrient spray optimisation

A field study was conducted to optimise the spray schedules of ginger micronutrient formulation with two varieties (IISR Varada & IISR Rejatha). The treatments involved single spray at 60 days after planting (DAP); two sprays at 90 & 120 DAP and application of encapsulated Zn solubilizing bacteria *B. megaterium* applied twice (60^{th} and 90^{th} day). The variety IISR Varada recorded the highest rhizome yield with two sprays of micronutrient mixture, which was on par with the treatment involving ZnSB2 treatment (Fig.14)

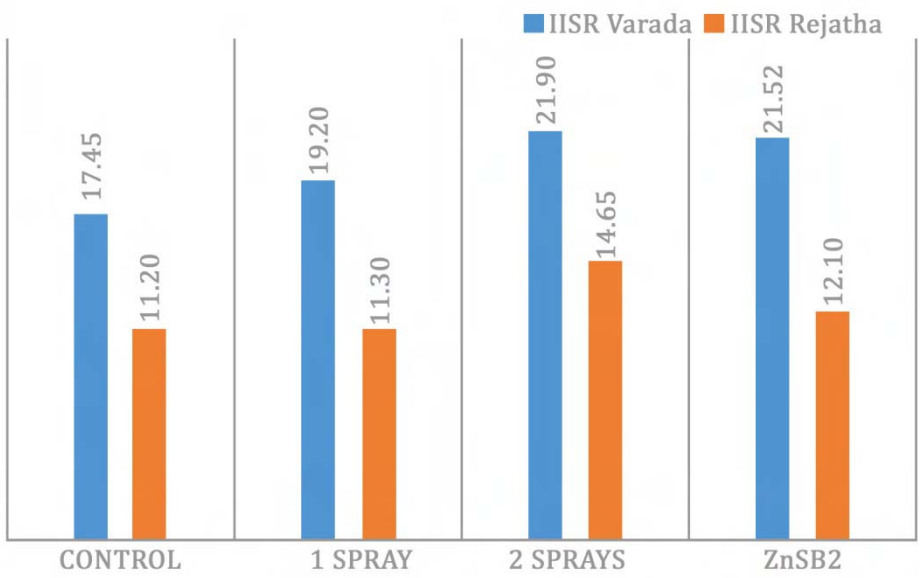


Fig.14 Fresh yield (t/ ha) of ginger as influenced by micronutrient sprays and Zn solubliser (ZnSB2) [CD: T-1.99; T x V: NS]

High value compounds

Extracts of ginger were prepared by extraction with petroleum ether, methanol and water sequentially. Each extract was separately concentrated to dryness in rotary evaporator and antioxidant and antidiabetic potential of the extracts, 6-gingerol and 6-shogaol were determined by DPPH free radical scavenging assay and α- glucosidase inhibitory assay respectively. Among the extracts, petroleum ether extract of ginger showed highest antioxidant and antidiabetic activity. 6- Shogaol showed higher antioxidant activity where as 6- gingerol exhibited higher antidiabetic activity.

Bacterial wilt management

A new technology for integrated management of wilt integrating physical (soil solarization), chemical (soil amelioration with calcium chloride) and biological (ginger apoplastic bacterium - *Bacillus licheniformis*) methods was developed and multi-location evaluation trials were conducted at nine locations including North- East. The talc formulation of *B. licheniformis* was launched as '*Bacillich'* and was also encapsulated for field delivery.

Effect of silicates on *Macrophomina phaseolina* causing dry rot

In vitro studies with solid and liquid forms of sodium, potassium silicate and sodium meta silicate on dry rot causing fungi (*M. phaseolina*) showed that silicates restricted the mycelial growth. The biochemical analysis of mycelia exposed to different silicates showed increase in glycerol and EPS content leading to alterations in cell wall structure. The lipid peroxidation and the cell permeability were also high in silicate treated

mycelium. Silicon treatment enhanced the activities of peroxidase (POD), polyphenol oxidase (PPO) and phenylalanine ammonia-lyase (PAL) in rhizomes inoculated with *M. phaseolina*.

Morphological and molecular characterization of foliar pathogens and antagonists

Morphological and molecular characterization of four foliar pathogens of ginger and turmeric (*Exerohilum rostratum* (Syn: *Bipolaris rostrata*), *Colletotrichum gloeosporioides*, *C. capsici*, *Botryodiplodia* sp,), five strains of *Trichoderma* and eighteen isolates of PGPR were completed. *Trichoderma* strains identified are *T. lixii* (IISR KA 15), *T. asperellum* (IISR TN 3), *T. harzianum* (IISR KL 3), *T. erinaceum* (IISR APT1) and *T. atroviridae* (IISR APT2). A total of 100 bacterial isolates were obtained from random soil samples collected from ginger and turmeric growing areas of Kerala, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana states and screened for their antagonistic activity against major pathogens of spice crops. About 18 shortlisted bacterial isolates were further characterized based on phenotypic and molecular characters. Among the 18 isolates tested against fungal pathogens of spices, isolates IISR GB1, IISR GB2, IISR GB7(3) and IISR TB4 showed maximum antagonistic activity against *Pythium myriotylum*, *P. capsici*, *E. rostratum* and *M. phaseolina* under *in vitro* conditions. Green house trials using the bacterial isolates, IISR GB7 (3) (*Bacillus* spp.) and IISR TB4 (*Bacillus safensis*) against the ginger soft rot pathogen, *P. myriotylum,* indicated that the challenge inoculated plants did not develop any soft rot symptoms.

Physiological and biochemical changes during ginger- *Exerohilum rostratum* interaction

Physiological and biochemical changes occurring during ginger- *E. rostratum* (Syn: *B. rostrata*) interaction were studied under greenhouse conditions. The activity of the enzymes, peroxidase and PAL increased 2HAI (hours after inoculation) in artificially inoculated plants compared to control and after 72 HAI the activity started decreasing. On the other hand, the defence enzymes glutathione reductase, polyphenol oxidase and catalase showed only slight variations during initial hours of inoculation but by 24 HAI a sudden increase in the activity was observed followed by decrease in enzyme activity.

Field evaluation of fungicides and biocontrol agents

Fungicides (tebuconazole 0.1% and combination product of carbendazim + mancozeb 0.2%) and biocontrol agents (*T. harzianum* and *Bacillus amyloliquefaciens*), short-listed in preliminary trials were tested against ginger foliar diseases under field conditions. 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 (Table 11). Alternately, first spray with tebuconazole (0.1%) followed by carbendazim +mancozeb (0.2%) at 15 days' interval was found to be equally effective.

Table 11 Field evaluation of fungicides and biocontrol agents against foliar pathogens

Treatment name	Treatment description	Mean disease severity (%)
T1	Seed treatment and spraying tebuconazole (0.1%)	16.34^{e}
T2	Seed treatment and spraying carbendazim – mancozeb (0.2%)	23.78^{d}
T3	Seed treatment and spraying mancozeb (0.2%)	45.46^{c}
T4	Seed treatment and drenching *Trichoderma* talc formulation	57.08^{c}
T5	Seed treatment and drenching *Trichoderma* spore suspension	72.03^{a}
T6	Seed treatment and drenching *Bacillus amyloliquefaciens* (GRB 35)	56.34^{bc}
T7	Seed treatment and spraying azoxystrobin (0.01%)	31.22^{d}
T8	Seed treatment and drenching metalaxyl –mancozeb (Treated control)	65.08^{ab}
T9	Absolute control	69.86^{a}

Characterization of the viruses associated with chlorotic fleck disease

The two viruses associated with chlorotic fleck disease of ginger were tentatively identified as ginger chlorotic fleck associated tombusviridae virus (GCFaTV) and ginger chlorotic fleck associated ampelovirus (GCFaAV). Complete genomes of GCFaTV and partial genome of GCFaAV were cloned, sequenced and analysed. The complete nucleotide sequence of GCFaTV genomic RNA consists of 4143 nt and contains six open reading frames (ORFs). Pairwise comparison of the complete nt sequence of GCFaTV showed identities ranging from 34 to 47% with different genera of Tombusviridae. Phylogenetic analysis of this virus with other viruses under the family Tombusviridae revealed uniqueness of GCFaTV and hence need tobe considered as a new genus under this family. The partial genome of GCFaAV contained 5514 bases of the virus and showed similarity with different ampeloviruses. The maximum identity of GCFaAV with different species of ampeloviruses was only 65%, which is well within cut off percent used to differentiate species within the genus, *Ampleovirus*. Therefore, the present virus isolate, GCFaAV infecting ginger should be considered as a member of a new virus species in the genus *Ampelovirus*.

Dose optimization of new generation insecticides against shoot borer (*Conogethes punctiferalis*)

New generation insecticides such as spinosad, flubendiamide, chlorantraniliprole and a combination of spraying chlorantraniliprole and spinosad alternatively at fortnightly intervals were tested under field conditions for two consecutive years for optimizing the effective dose against shoot borer infesting ginger. Pooled analysis of the data indicated that all the insecticides were effective in the management of the pest even at the lowest dose (0.3 mL/ litre) tested. The combination treatment of spraying of

chlorantraniliprole and spinosad alternatively, was also equally effective in managing the insect.

MANGO GINGER

Two shortlisted mango ginger (*Curcuma amada*) accessions have been included in the new CVT trial 2019. The seed rhizomes of two genotypes (Acc. 265 and Acc. 347) were multiplied and supplied to seven AICRPS centres for multiplication and planting under CVT.

TURMERIC

Genetic resources

One thousand four hundred and four accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with four accessions from Nagaland.

Characterization

Characterization of 165 accessions was carried out based on different morphological traits. A total of 12 quantitative and 10 qualitative characters were recorded for each accession.

Evolving extra-long and bold turmeric lines

Twelve accessions of Salem Local (Erode and Salem district of Tamil Nadu) and four accessions of Mydukkur (Andhra Pradesh) were characterized for morphological characters. Also, open pollinated seeds of 17 turmeric accessions from germplasm were collected and 420 seedling progenies were raised.

Maintenance of seedling progenies, hybrids and inbreds

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

Self-pollination studies in inbreds, OP seedlings and cultivars

Self-pollination has been performed in 17 fourth generation inbreds of 138/11/1, four OP seedlings and ten cultivars. Fruit set was observed in one fourth generation inbred (138/11/1/I_1-12-I_2-2-I_3-64-I_4-1) and one second generation OP seedling (SLP 359/4/8) only.

Pollen fertility analysis in inbreds

Pollen fertility based on stainability was tested in 10 third generation inbreds of 138/11/1. Five inbreds showed pollen fertility above 90 % (Table 12).

Table 12 Pollen based on staining in inbreds

Sl. No.	Identity of Inbred	Pollen fertility by stainability (%)
1	138/11/1/I_1-12-I_2-2-I_3-26	93.96
2	138/11/1/I_1-12-I_2-2-I_3-30	91.37
3	138/11/1/I_1-12-I_2-2-I_3-64	90.01
4	138/11/1/I_1-12-I_2-2-I_3-83	90.95
5	138/11/1/I_1-12-I_2-2-I_3-118	85.57
6	138/11/1/I_1-12-I_2-2-I_3-142	86.87
7	138/11/1/I_1-12-I_2-2-I_3-153	75.87
8	138/11/1/I_1-12-I_2-2-I_3-160	94.83
9	138/11/1/I_1-12-I_2-2-I_3-359	85.68
10	138/11/1/I_1-12-I_2-1-I_3-1	96.83
11	138/11/1/I_1-12-I_2-3-I_3-6	10.03
12	138/11/1/I_1-12-I_2-4	53.43

Shoot and flower colour variation in OP seedlings of SLP 359/4

Observations on colour of emerging shoots in 24 second generation OP progenies of SLP 359/4 revealed that three of them had light red colour (359/4-OP4, 359/4-OP7, 359/4-OP11) one had red colour (359/4-OP 22) and all others had green colour for emerging shoots similar to mother parent (Table 13). The shoot colour appeared as a result of recombination and the possibility of recessive genes with additive effect controlling this character. Two OP seedlings of SLP 359/4 *viz*., SLP 359/4-OP8 and SLP 359/4-OP13 showed pink colour on the dorsal petal unlike the normal flowers in the other OP seedlings and other cultivars which made these seedlings distinctly different at the stage of flower bud emergence.

Table 13 Shoot color variation among the OP seedlings of SLP 359/4

SL No.	Identity of seedling	Colour of emerging shoot
1	SLP 359/4 (Mother)	Green
2	SLP 359/4-OP1	Green
3	SLP 359/4-OP2	Green
4	SLP 359/4-OP3	Green
5	SLP 359/4-OP4	Light red
6	SLP 359/4-OP5	Green
7	SLP 359/4-OP6	Green

8	SLP 359/4-OP7	Light red
9	SLP 359/4-OP8	Green
10	SLP 359/4-OP9	Green
11	SLP 359/4-OP10	Green
12	SLP 359/4-OP11	Light Red
13	SLP 359/4-OP12	Green
14	SLP 359/4-OP13	Green
15	SLP 359/4-OP14	Green
16	SLP 359/4-OP15	Green
17	SLP 359/4-OP16	Green
18	SLP 359/4-OP17	Green
19	SLP 359/4-OP18	Green
20	SLP 359/4-OP19	Green
21	SLP 359/4-OP20	Green
22	SLP 359/4-OP21	Green
23	SLP 359/4-OP22	Red
24	SLP 359/4-OP23	Green
25	SLP 359/4-OP24	Green

Evaluation of different management systems

Among the management systems, organic system (75%) recorded maximum yield (13.9 t/ha) which was on par (13.8 t/ha) with integrated system (75%+25%). Maximum oil content (5.3%) and curcumin were recorded in 100% and 75% organic management system, whereas higher oleoresin content (13.6%) was recorded in 75% organic system (Fig.15). The B/C ratio was found to be higher in integrated (50:50) system (2.22) followed by inorganic system (2.13).

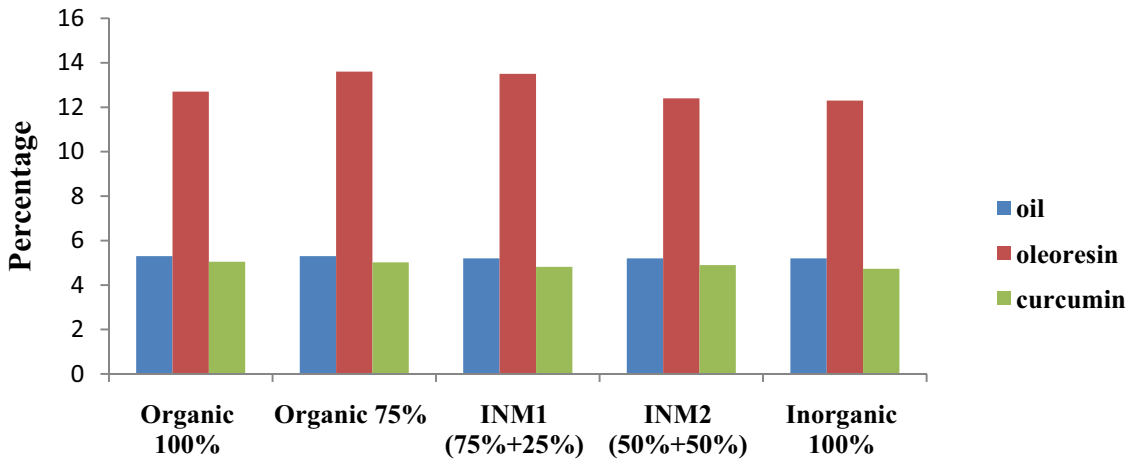


Fig. 15 Effect of different management systems on quality of turmeric

Response of different turmeric varieties to organic farming

Among the 12 turmeric varieties evaluated under 100% organic management, significantly higher yield was recorded by IISR Pragati (22.1 t/ha) followed by Kanthi (19.2 t/ha). Higher oil content was observed in varieties IISR Prathibha (6.0%), IISR Alleppey Supreme (5.9%) and least oil content was noticed in Suvarna. Among the varieties, IISR Prabha (15.2%), IISR Pragati (15.0%) and IISR Kedaram (14.6) were superior in oleoresin content and least was recorded in Sona (10.4%). The variety IISR Pragati (6.3 %) and IISR Kedaram (6.27%) recorded maximum curcumin followed by IISR Prabha (6.14%) and Suguna (6.14%).

Micronutrient spray optimization

A field study was conducted to optimise the spray schedules of turmeric micronutrient formulation with three varieties (IISR Prathibha; IISR Alleppey Supreme; IISR Pragati). The treatments involved single spray at 60 days after planting (DAP); two sprays at 90 & 120 DAP and application of encapsulated Zn solubilizing bacteria (*B. megaterium*) applied twice (60th and 90th day). Irrespective of the treatments, IISR Pragati yielded significantly higher rhizome yield, though maximum yield was recorded in the treatment involving ZnSB2 applied twice on 60th and 90th day (Fig.16). This was however, on par with the treatment involving single and two sprays of turmeric micronutrients.

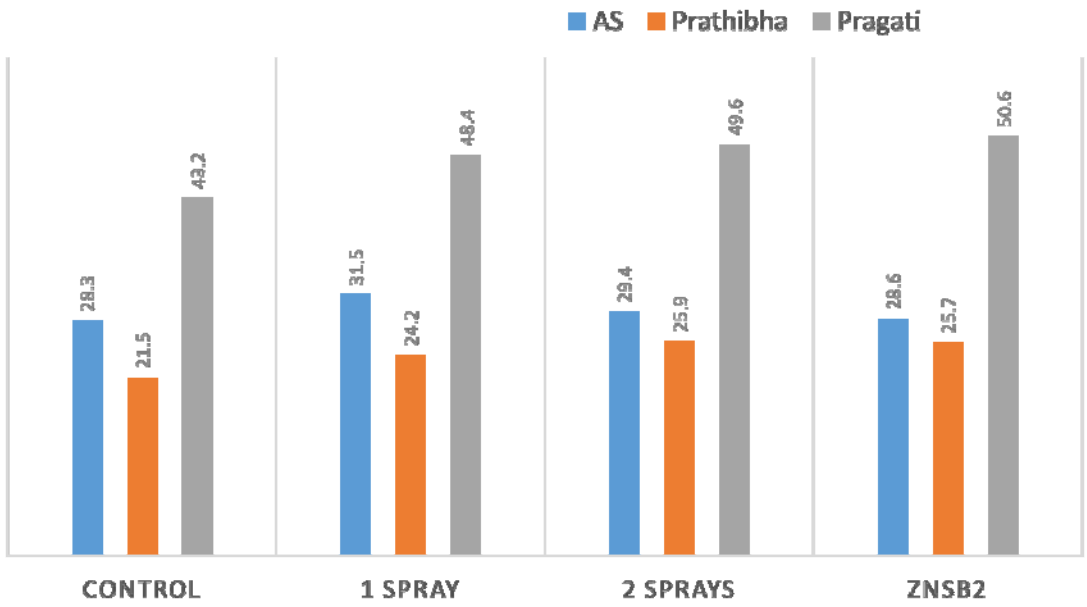


Fig.16 Fresh yield (t/ ha) of turmeric as influenced by micronutrient sprays and Zn solubliser (ZnSB2)[CD- T- 2.1; T x V- NS]

Effect of curing and slicing on quality

Turmeric (IISR-Alleppey Supreme) was cured by traditional water boiling method for 45 min, sliced in a mechanical slicer (5-7 mm thick) and dried in hot air oven drier by

spreading (bed thickness of 5 cm) on the trays (size 44.8 × 38 cm) at different temperatures (50, 60, 70, 80, 90 and 100°C). Sun drying (30- 36°C) and solar tunnel drying (36-55°C) served as control. Similar experiments without curing was done with slicing and mechanical drying of fresh rhizomes in hot air oven at different temperatures with sun drying and solar tunnel drying as control. The results indicated that minimum drying time of 10 h was recorded for drying of cured sliced turmeric by hot air oven at 100°C and maximum time of 165 h (6.88 days) was recorded for sun drying of uncured sliced turmeric. Studies on quality evaluation indicated that maximum value of essential oil (5.53%), oleoresin (13.07%) and curcumin content (5.01%) were recorded for uncured sliced turmeric compared to cured sliced turmeric.

Developing nano-curcumin for increased bio availability

Nano-curcumin was prepared using sonication based protocol, to increase the bio-availability of curcumin. The nano-curcumin thus developed had 2.5 fold increased solubility in both water as well as in virgin coconut oil and can be used as potential bio-available formulation of curcumin (Fig.17).

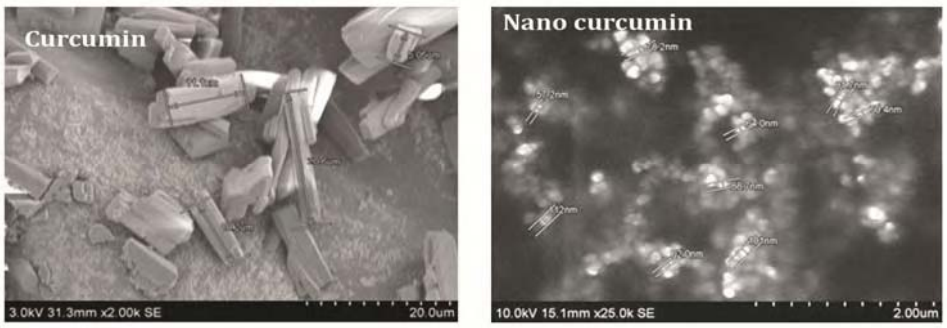


Fig.17 Curcumin crystals under scanning electron microscopy

Dose optimization of new generation insecticides

New generation insecticides such as spinosad, flubendiamide, chlorantraniliprole and a combination of spraying chlorantraniliprole and spinosad alternatively, at fortnightly intervals were tested under field conditions at Peruvannamuzhi for two consecutive years for optimizing the effective dose against shoot borer infesting turmeric. Pooled analysis of the data indicated that all the insecticides were effective in the management of the pest even at the lowest dose (0.3 mL/ litre of water) tested. The combination treatment of spraying of chlorantraniliprole and spinosad alternatively, was also equally effective in managing the shoot borer.

Distribution of lesion nematodes

Analysis of survey samples collected from Tamil Nadu indicated that high population of lesion nematode, *Pratylenchus* spp., was recorded in Thanneerpanthal region (3.2/g soil) in Coimbatore District and Gobichettipalayam (4.7/g soil) in Erode district. *Pythium* spp. was found to be associated with rhizomes infected with nematodes. The symptoms of nematode attack are marginal drying of leaves with yellowing, stunting of

plants and dried rhizomes with light to dark brown shrunken spots in advanced stage of nematode infection (Fig.18).

(a) **(b)**

Fig.18 a) Symptoms of lesion nematode infection in turmeric b) infected rhizomes

Screening of biocontrol agents

In vitro screening of antagonistic bacteria against *Pratylenchus* spp, showed maximum mortality with *Pseudomonas putida* BP25 (92.7%) followed by *Alcaligens fecalis* IISR 859 (68.7%), *Bacillus megaterium* BP17 (58.1%) and *Bacillus licheniformis* GP107 (10%) 24 h after exposure. Screening of potential actinomycetes against lesion nematodes showed highest mortality with *Kitasatospora setae* KM 6054 (76.7%) followed by *Streptomyces tauricus* MRRL B-12497.

VANILLA

Conservation

A total of 78 accessions of vanilla (65 *Vanilla planifolia,* 7 *Vanilla spp.* from Andaman, 2 *Vanilla spp.* from Wayanad and one each of *V. pilifera, V. aphylla, V. tahitensis* and *V. wightiana)* are being conserved under protected conditions.

Quality profiling

A modified RP-HPLC method was standardized for simultaneous detection and quantification of major flavor compounds of vanilla *viz*., vanillin, p-hydroxybenzoic acid, p-hydroxybenzaldehyde and vanillic acid. The compounds were separated in a C18 column with acetonitrile, methanol and water as mobile phase solvent and gradient elution method was used. The present method could separate these four compounds within 15 minutes of run time.

Molecular characterization of *Chaetomium globosum*

Chaetomium isolates from healthy vanilla plants were characterized by sequencing the ITS region. Homology search using the BLAST showed 98 - 100% identity with *C. globosum*. The sequences obtained were deposited in the NCBI Genbank with accession numbers MN075322, MN075323 and MN075324 (Fig.19).

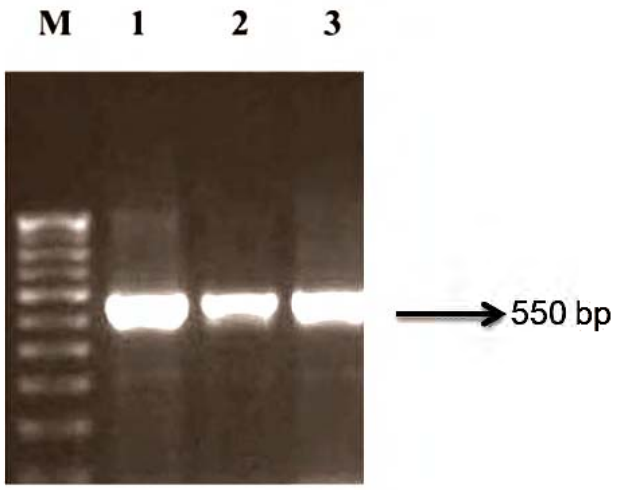


Fig.19 ITS amplification of *Chaetomium globosum* isolates from vanilla (Lane 1 – Marker, Lane 2 – FVREP4, Lane 3 – FVLEP2 and Lane 4 – FVLEP7).

Antagonism of *Chaetomium* isolates to other pathogens

Under *in vitro* conditions, *Chaetomium* isolates were tested for their antagonism to pathogens *viz*., *Phytophthora meadii*, *Colletotrichum gloeosporioides* and *Sclerotium rolfsii*. Among the isolates tested against *P. meadii*, FVREP4 recorded maximum inhibition (56%) over control followed by FVLEP2 and FVLEP7 with 40% inhibition. Against *C. gloeosporioides,* the maximum inhibition (82%) was observed with FVLEP4 followed by FVSEN4 and FVAREN1.

Plant growth promotion *by Chaetomium* spp.

The *Chaetomium* isolates when screened for plant growth promoting traits showed that all isolates produced enzymes like laccase and siderophores, however cellulase production was observed only in FVREP4, FVSEN4 and FVLEP7. IAA was produced by FVREP4 isolate alone and zinc solubilization was recorded by all isolates with FVSEN4 and FVLEP7 showing the highest efficiency.

Field evaluation of biocontrol agents

Under field conditions, soil and foliar application of *Bacillus amyloliquefaciens*, showed reduced wilt incidence (<10%) which was found to be on par with chemical control.

TREE SPICES

CINNAMON

Genetic resources

Cinnamomum macrocarpum (Fig.20), *C. gamblii* (Fig.21) and *C. neolipsium* were collected from Palakkad and Wayanad districts of Kerala. The essential oil content in the bark samples of 10 cinnamon accessions was analyzed and the oil content varied from 1.2–3.0%.

Fig. 20 *Cinnamomum macrocarpum* collected from Wayanad

Fig. 21 *Cinnamomum gamblii* collected from Nelliyampathy

High value compounds

A comprehensive SpiceCom database was developed which provides complete overview of approximately 650 phytochemicals in spices and enables retrieving data based on botanical name, chemical constituents, International Chemical Identifier, physicochemical properties, pharmacological activity and relevant literature related to them. By molecular docking approach using Schrodinger suite 2019-2, the binding interactions of phytoconstituents of cinnamon with different protein targets implicated in diabetic signaling pathway were determined. By *in silico* studies, the promising lead compounds were identified as procyanidin B5 and epicatechinas.

CLOVE

A wild relative of clove, *Syzigium claviflorum,* collected from Nicobar Islands was obtained from ICAR- NBPGR, Thrissur and added to the germplasm. Essential oil content of clove samples collected from three locations varied from 10 to 19.33%.

GARCINIA

Garcinia morella and *G. talbotii* and two exotic species, G*. atroviridis* and *G. macrophylla* were collected from Wayanad district. *G. madruno* an exotic species was collected from Bengaluru, Karnataka. Yield data of *G. gummigutta* trees at Peruvannamuzhi were recorded and elite trees in terms of high yield and dry recovery (Fig.22) were identified. The fresh fruit weight varied from 29.09 to 141.0 g, the fresh fruit to dry rind recovery varied from 5.13 to 14.5% and the dry rind yield per tree varied from 0.5 to 30 kg.

Fig. 22 Promising *Garcinia gummigutta* accession with high yield and high dry recovery

ALLSPICE

In situ data of elite trees were recorded from farmer's field at Wayanad (Fig.23) and all the accessions were added to the germplasm. The dry fruit yield per tree per year varied from 5 to 27.3 kg and the dry recovery ranged from 25.5 to 32.3%. The oil and oleoresin content ranged from 1.1 to 1.7 and 10.1 to 12.8%, respectively.

Fig. 23 Promising accession of all spice identified at farmers field

High value compounds

Antioxidant and antidiabetic potential of allspice was determined with hexane, chloroform and methanol extracts of allspice berries. Hexane extract showed maximum antidiabetic potential. Total phenols were maximum in chloroform extract and flavonoids in methanol extract. Chloroform extract was chromatographed and fractionated into 384 fractions by elution with hexane- chloroform mixtures.

NUTMEG

The morphological and yield parameters of nutmeg germplasm were recorded and 11 accessions were shortlisted as high yielding. The oil, oleoresin and butter content and the chemical composition of oil of both nut and mace of the shortlisted accessions were studied.

Sex chromosome based markers

Sex chromosome specific RAPD markers were evaluated in male, female & monoecious plants of nutmeg. The NM1 D5 primer (Fig.24) differentiated female from male and monoecious. The female showed two different specific patterns to discriminate themselves from male and monoecious. Sequencing of the female specific band is made towards development of female specific marker.

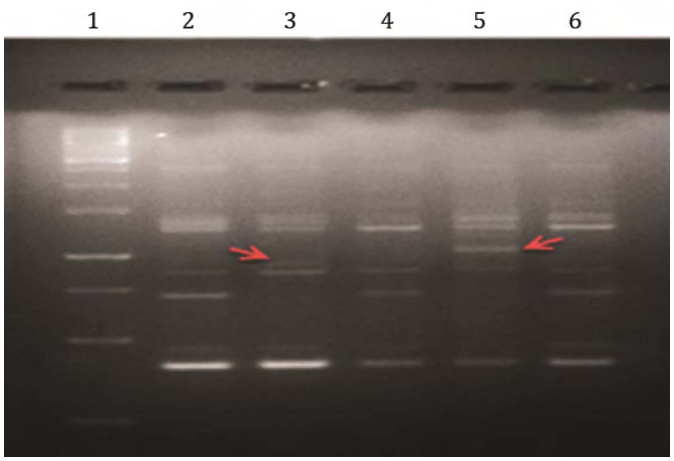


Fig. 24 Lane 1-Ladder(1 kb), Lane 2-Male,Lane 3-Female, Lane 4-Monoecious, Lane 5-Female, Lane 6-Male

The NM2 P8 primer (Fig.25) differentiated monoecious (absence of the band) from male & female. The sequencing of the amplification product identified the gene as C-terminal S-isoprenylcysteine carboxyl O-methyl transferase belonging to PEMT superfamily having 62.0% similarity to the protein of *Cinnamomum micranthum* f. *kanehirae.*

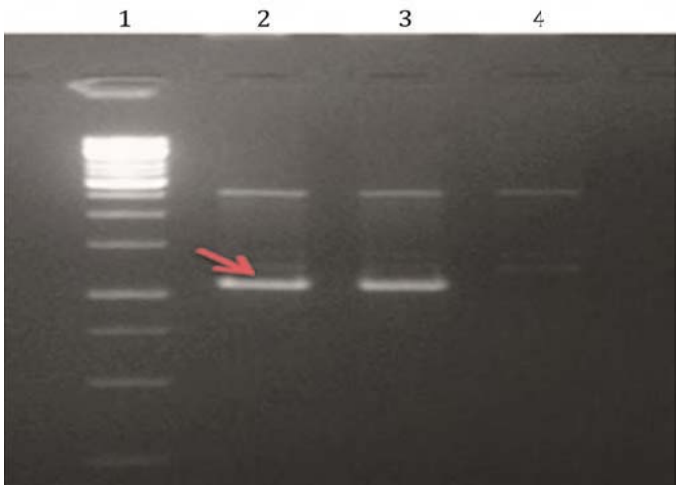


Fig. 25 Lane 1-Ladder (1 kb), Lane 2-Male, Lane 3-Female, Lane 4-Monoecious

Site specific nutrient management

Application of amendments (lime and lime + dolomite @ 1 kg each) along with site specific nutrients and micronutrients significantly enhanced soil fertility at all depths and yield of nutmeg (Fig.26 & Fig.27) Supplemental micronutrient sprays specific to nutmeg along with the site specific soil fertility based nutrient management increased the nut and mace yield up to 25% in the treated plots as compared to farmers practice, thereby increasing the income of farmers.

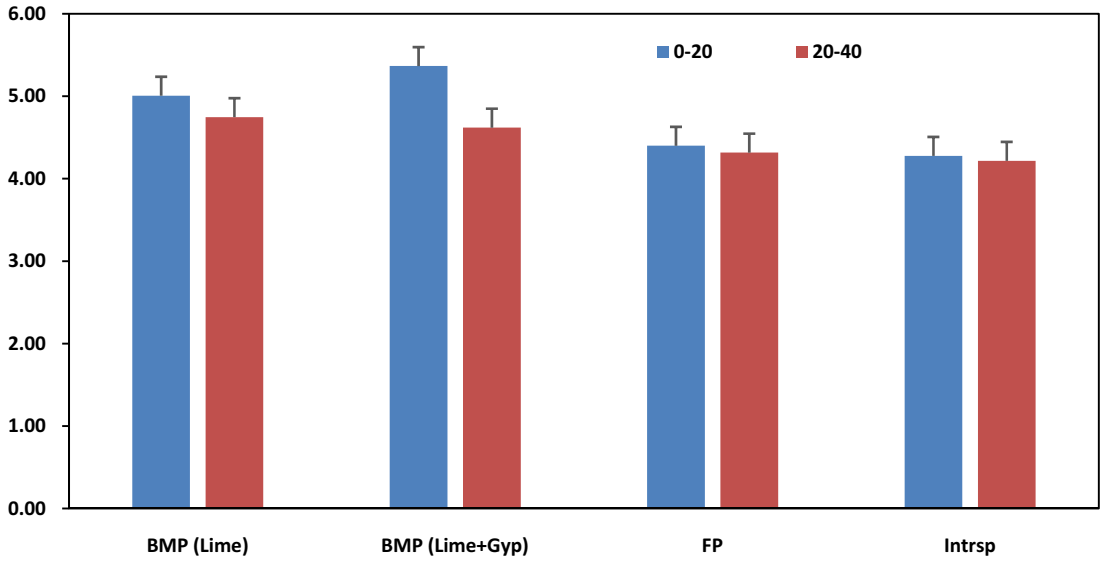


Fig. 26 Effect of best management practice (BMP) as compared to farmers practice on soil pH in nutmeg

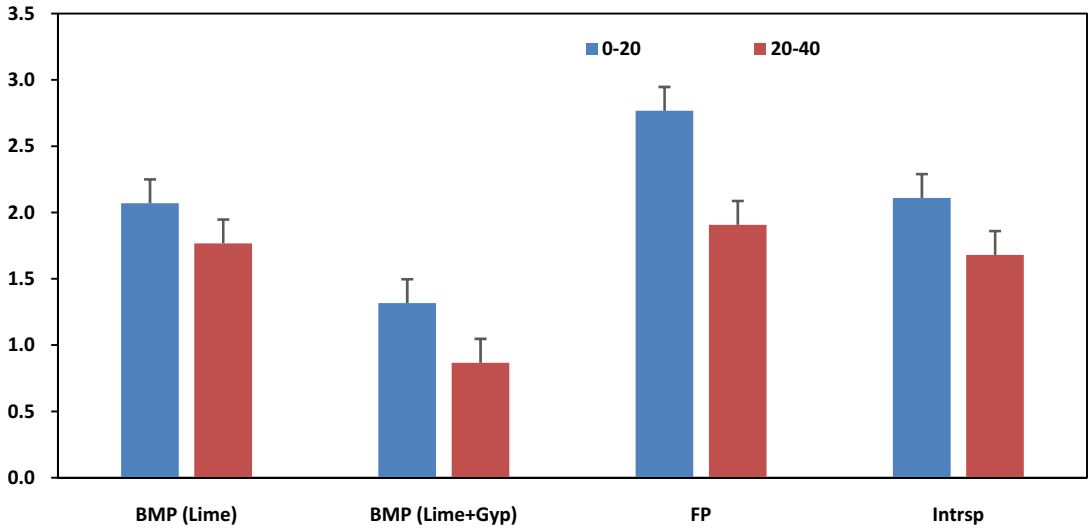


Fig. 27 Best management practice (BMP) as compared to farmers practice on soil Al concentration (mg/kg) in nutmeg

Etiology of decline disease

Nutmeg trees exhibiting declining symptoms were observed in Peruvannamuzhi, Angamali, Kakkadampoyil and Palakkad regions of Kerala. The external symptoms of the disease include general decline of the tree, water soaked lesions on branches and tree trunk with necrotic lesions beneath the bark, necrosis of vascular tissues and die back of branches (Fig.28).

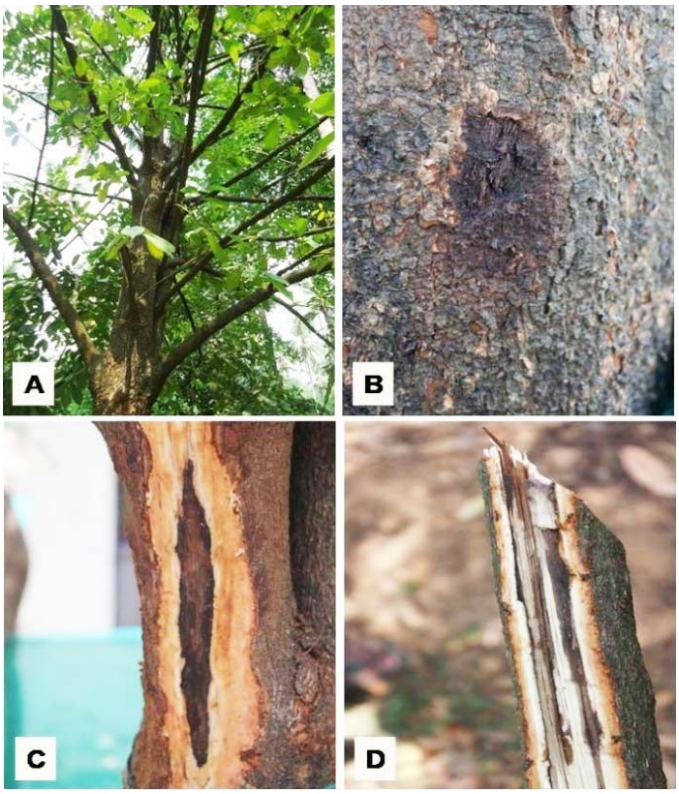


Fig.28 Manifestation of symptoms (A) Decline of tree (B) Water soaked lesion (C) Necrotic lesions on bark (D) Necrosis of vascular tissues

Based on the colour, growth pattern of the colony, conidia, hyphal architecture and molecular characterization with ITS and beta tubulin gene regions, isolates were identified as *Lasiodiplodia theobromae*. On nutmeg saplings, the symptoms developed under *in vitro* conditions were similar to that observed under field conditions. Necrotic lesions were formed 20-22 days after inoculation and the lesions were found extending beyond the point of inoculation beneath the bark. Among the fungicides evaluated under *in vitro* conditions, Bordeaux mixture (1.0%), mancozeb (0.2%) and carbendazim-mancozeb (0.1%) completely inhibited mycelial growth of the pathogen.

GENERAL

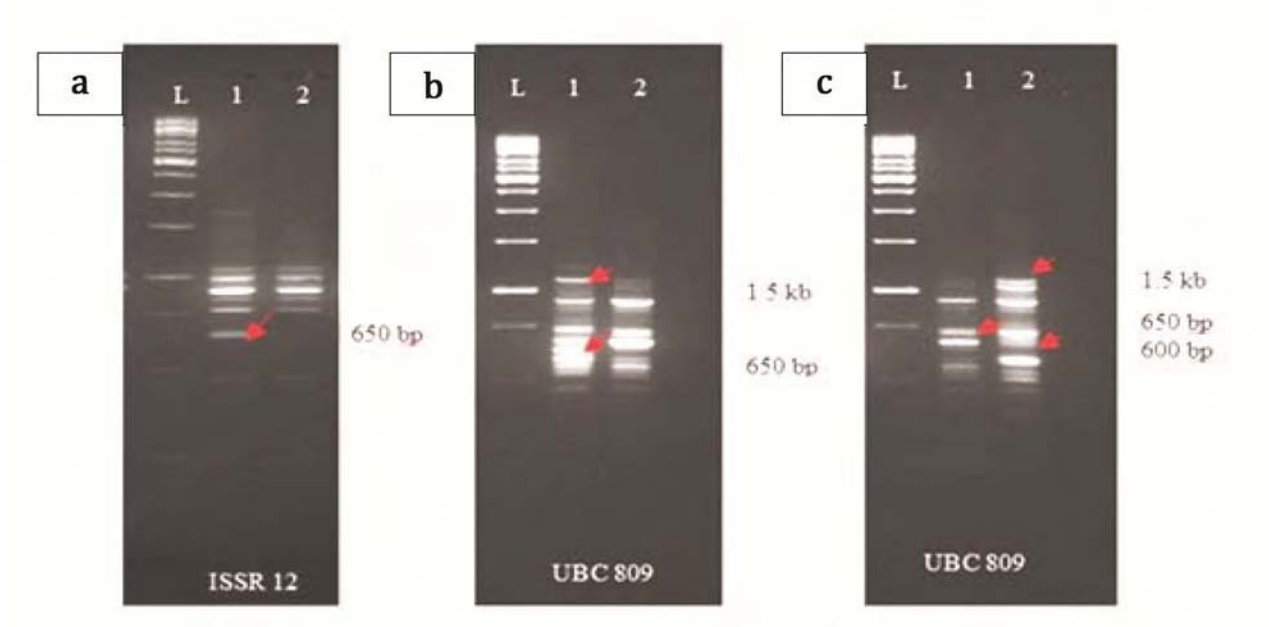
DNA Fingerprinting and Barcoding

The facility for DNA Fingerprinting and Barcoding was established for undertaking fingerprinting services to facilitate varietal release for various AICRPS centres (Table 14). 25 varieties of spices have been fingerprinted including black pepper, ginger, turmeric, coriander, fenugreek, fennel, celery and the uniqueness was established for the new varieties in comparison with its closely related/resembling varieties. A representative fingerprint developed at the DNA Fingerprinting Facility at IISR is provided in Fig.29.

Table 14 Details of varieties fingerprinted, source and status of registration

SL. No	Crop	Candidate Variety	Status of registration under CVRC	Name of the firm/ institute/ person submitting the sample
1	Coriander	ACr-3	Gazette notification No. 3-72/2019-SD.IV Dated 10.10.2019	ICAR-NRCSS, Ajmer
2		ACr-2	Under process	
3		WFPS 48-1	Under process	AICRPS, Kota
4		WFGS 48-2	Under process	
5		RD-416	Under process	NRCSS, Dholi
6		RD-417	Under process	
7		JD(S1)-1	Under process	Dept. of Horticulture, JNKVV, Jabalpur
8		ICS-4	Under process	AICRPS, Raigarh.
9		Suguna	Gazette notification No. 575 (E)/ S.O. 692 (E).Dt. 5th February, 2019	HRS, Guntur
10		Susthira	Gazette notification No. 3-72/2019-SD.IV Dated 10.10.2019	
11		Suruchi	Gazette notification No. 2017 vide G.O.MS. No.98, Dt. 27.12.2017, Govt. of Andhra Pradesh	
12	Fennel	AF-3	Gazette notification No. 3-72/2019-SD.IV Dated 10.10.2019	
13	Celery	Ajmer Celery-2	Under process	
14	Fenugreek	AM-1	Under process	AICRPS, Kota
15		LFC-103	Gazette notification No. 3-72/2019-SD.IV Dated 10.10.2019	
16		AFg-5	Under process	ICAR NRCSS, Ajmer
17	Turmeric	Roma	Gazette notification No. S.O. 692(E) Dated 05.02.2019	AICRPS, Pottangi
18		Suranch	Under process	
19		Rasmi	Gazette notification No. S.O. 692(E) Dated 05.02.2019	

20		Surama	Gazette notification No. S.O. 692(E) Dated 05.02.2019	
21		TCP-129	Under process	Uttar Banga Krishi Viswa Vid yalaya, Pundibari
22		TCP-64	Under process	
23	Ginger	Suprabha	Gazette notification No. S.O. 692(E) Dated 05.02.2019	AICRPS, Pottangi
24		Suravi	Gazette notification No. S.O. 692(E) Dated 05.02.2019	
25		Suruchi	Gazette notification No. S.O. 692(E) Dated 05.02.2019	
26	Black pepper	PRS 161	Under process	Pepper Research Station, Panniyur



**Unique bands indicated in red*

Fig.29 a,b,c DNA fingerprints generated for turmeric varieties using ISSR primers (IISR12, UBC 809). a: L- 1kb ladder; 1- Suranch, 2- Roma, b: L—1 kb ladder; 1-Lakadong; 2-Rasmi c: L-1 kb ladder; 1- Suroma; 2- IISR Prathibha

Micronutrient-microbial interaction in soils under spices

Out of the 100 PGPR strains, six isolates showed Zn solubilisation under i*n vitro* conditions. Out of this 6, two isolates, IISR GB7 (3) (*Bacillus* sp.) and IISR TB4 (*Bacillus safensis*) possessed markedly higher Zn solubilisation efficiency. These two bacterial isolates were further tested for their ability to release Zn at different time intervals in liquid medium augmented with 500 ppm Zn as ZnO and $Zn_3(PO_4)_2$

Zn solubilisation rate was significantly higher at all days of sampling in treatments with Zn solubilising bacteria [IISR GB7 (*Bacillus* sp.) and IISR TB4 (*B. safensis*)]. Maximum Zn release was recorded at 6 days after incubation (DAI) in the treatment with ZnO added with IISR GB7, which decreased abruptly at 12 DAI. In all treatments with and without Zn solubilising bacteria and irrespective of Zn sources, Zn release was almost identical at 12 DAI. The kinetics of Zn release was also determined in soils *per se* augmented with 50 ppm Zn as ZnO. The treatment with IISR TB4 (*B. safensis*) registered markedly higher Zn solubilisation at 4, 6 and 8 DAI followed by a steep decrease at 12 DAI (Fig.30).

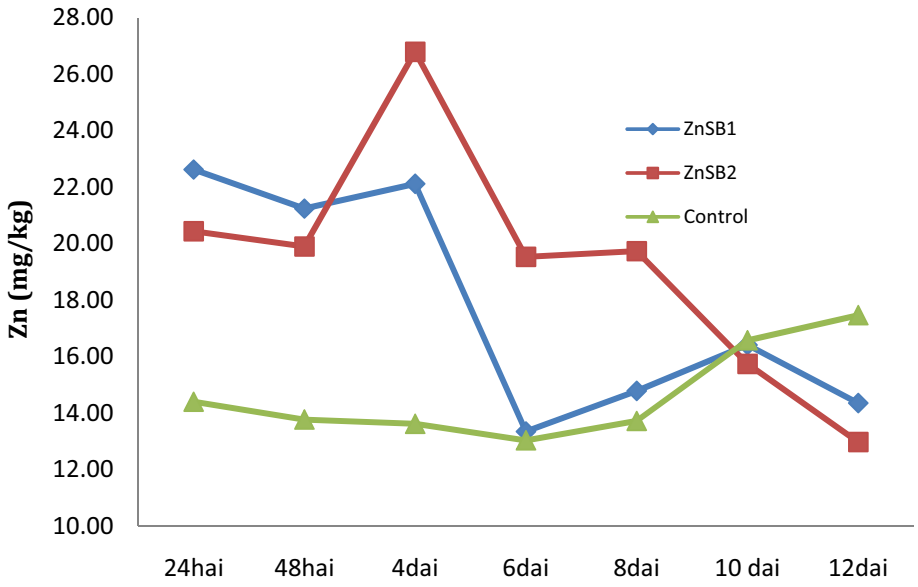


Fig.30 Zn solubilisation rates in soil augmented with Zn solubilising bacteria and insoluble Zn source [ZnO] at different days of incubation (DAI)

Establishment of farming system model

A farming system model plot 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 was established at IISR Chelavoor campus along with a dairy unit of three cows and their calves. Turmeric (480 kg), banana (100 kg), tapioca (75 kg), yams (20 kg each), pineapple (10 kg), arrow root (17 kg), maize (19 kg), vegetable cowpea (10 kg) and coconut (2200 nos) were harvested from the model plot. Employment generated from this plot was 415 man days/year with a profit of Rs 1.23 lakhs from one acre.

Value chain incubation facility for processing of spices

Spice processing facility was established at IISR main campus and started functioning for training and production of value added products. Hands on training were provided to 15 entrepreneurs on production of value added products from nutmeg rind like squash, jam, candy, syrup and preserve and products with ginger *viz*., ginger lime squash, ginger candy and ginger garlic paste were also prepared. Two of the trained entrepreneurs have ventured into commercial production of nutmeg based products.

Surveillance and documentation of pests and diseases of spices

Four cardamom and black pepper plantations in Sakleshpur and Shanivarasanthe (Karnataka), four nutmeg plots (Angamali, Kakkadamapoyil, Palakkad and Peruvannamuzhi in Kerala) and three black pepper plantations (Yercaud, Tamil Nadu) were surveyed for the incidence of pests/diseases. The major diseases observed in cardamom were leaf blight, rhizome rot, capsule rot, katte and kokke kandu, foot rot, slow decline and anthracnose in black pepper and general decline in nutmeg.

Production of nucleus planting materials of improved varieties

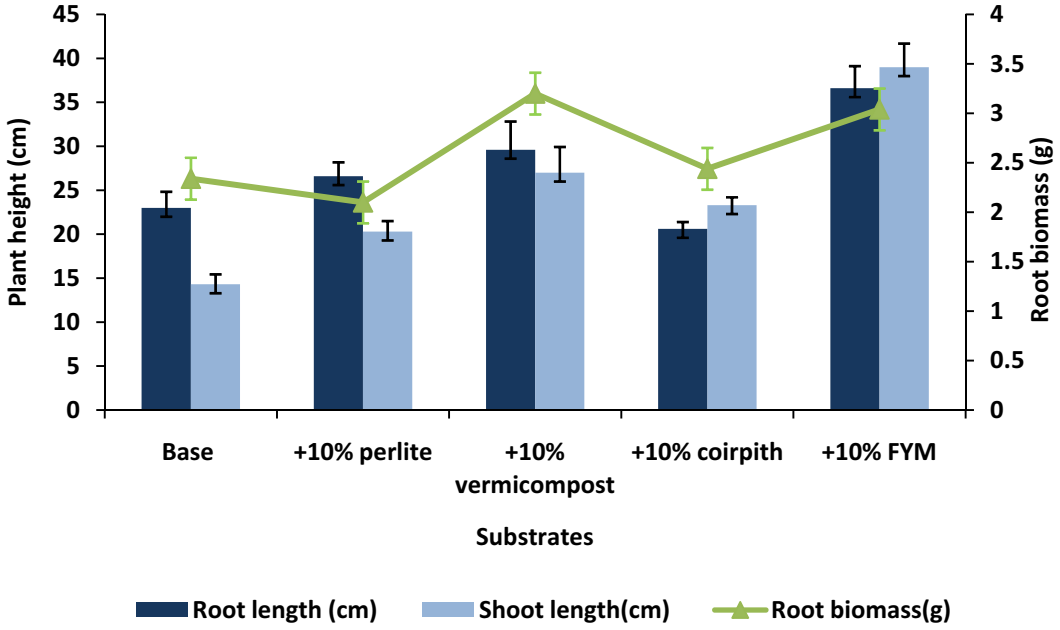
About 70000 rooted cuttings of improved varieties of black pepper were multiplied from Main Campus, Kozhikode and Regional Station (RS), Appangala and distributed to farmers. Improved varieties of ginger (200 beds) and turmeric varieties (550 beds) are planted and maintained for seed production at Experimental Farm, Peruvannamuzhi. The cardamom suckers (2000 Nos) were multiplied and distributed from Regional station, Appangala. Three thousand seedlings of cinnamon varieties were produced and distributed to farmers for planting. Microrhizome of ginger varieties (IISR Mahima & IISR Varada) and turmeric varieties (IISR Sona, IISR Prathibha, Kanti and Varna) were subcultured, plantlets of ginger (3100 Nos) and turmeric (500 Nos) were raised in cultures and being hardened in portrays and poly bags under nursery. IDM for bacterial wilt was demonstrated in nine agro climatic zones of the country at AICRPS centres and farmers field in Kozhikode and Madikeri districts. Twenty released varieties and cultivars of black pepper were tested with polymorphic primers to identify and develop the varietal specific markers.

Standardization of mass multiplication of arbuscular mycorrhizal fungi

A pot culture experiment was carried out under polyhouse conditions to study the effect of different substrates (Base (B) -vermiculite alone, B+10% perlite, B+10% vermi-compost, B+10% coirpith compost, B+10% FYM) on colonization and spore production of arbuscular mycorrhizal fungi (AMF) using maize and napier grass. Organic amendments and different substrates significantly influenced AMF spore formation and a higher spore load of 135 spores/ 50 g substrate was recorded in the treatment containing B+10% vermicompost with napier grass as a host when compared to the other substrates**.** AMF structures such as arbuscules, vesicles and hyphae were

observed in all the substrates inoculated**.** In comparison to maize, the increase in root colonization (80%) was much higher in napier grass under vermicompost amendment. Among the treatments, amendment with B+10% FYM followed by B+10% vermicompost were found superior in enhancing the root biomass, shoot and root length of both the hosts (Fig. 32a & b).

a)



b)

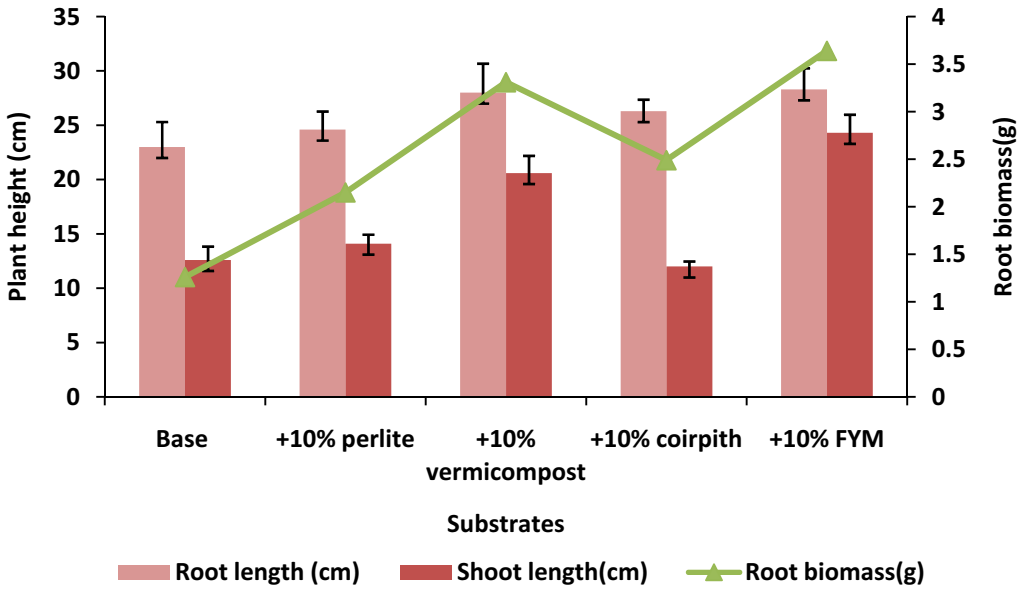


Fig.32 Root length, shoot length and root biomass of maize (a) and Napier grass (b) as influenced by different AM inoculated substrates.

Economics

Demand projections and crop scenarios for futuristic crop planning

The forecasted population increase is up to 1619 millions in 2050 with increased GDP and per capita food spending. As spices are of high value with nutraceuticals compounds, its per capita demand may increase many fold by 2050 (Table15). The projected per capita demand for major spices like black pepper, cardamom, ginger and turmeric is estimated to be about 148 g, 53 g, 1.22 kg and 1.63 kg respectively. With this increase, production levels to meet the local and global demand are estimated to be increased by 2.7 - 5.7 folds from the present levels.

Table15 Demand projection of major spices for 2030 and 2050

Crop	2030		2050	
	Consumption demand	Productivity requirement *	Consumption demand	Productivity requirement *
Black pepper	181.43	1335	239.25	1760
Ginger	1528.8	9504	2152.5	13381
Turmeric	1522.9	6791	2882.2	12809
Cardamom	38.8	404.2	79.1	823.9

** Assuming area under cultivation remains constant at 2017-18 level*

The research gains from ginger, turmeric and black pepper were estimated to be 1617.1 crores, while for small cardamom and nutmeg it was 101.2 crores and 31.7 crores, respectively. The use of micronutrient technology resulted in an incremental production of 17541 tonnes of spices major spices valued at 308.8 crores. The contribution of the institute in additional value created through processing of spices in the domestic market is estimated to be 942.4 crores.

Analysis of cinnamon economy

The domestic production of cinnamon is highly inadequate to meet the consumption demand of cinnamon. The sharp mismatch between domestic production and requirement is being met through import of cinnamon and related species like *C. aromaticum*/*C. cassia*, *C. burmannii* and *C. laoureiri*. The global cinnamon demand has being growing at a CAGR of 4.1% since the turn of this century. The area under cinnamon has almost doubled during the same period. Currently, cinnamon is grown in 0.28 million hectares with a global production of 225 thousand tonnes. Nearly 75.0% of the global cinnamon production comes from Indonesia and China. In quantity terms, cassia imports grew a CAGR of nearly 11.0% during the last decade. Cassia cinnamon accounts for more than 90 percent of the total cinnamon imports into the country. The value of cinnamon imports (more than 3000 million INR) is a significant component of the spice imports. Enhancing domestic availability of cinnamon is an urgent priority in these circumstances. The strategy for enhancing domestic availability of cinnamon need

to be inclusive with both true cinnamon and cassia cinnamon as significant components of focus. Import substitution of cinnamon can be achieved through popularization of cinnamon cultivation, promotion of low coumarin cassia genotypes and establishment of effective mechanisms for aggregation and marketing of cinnamon produced within the country.

DUS testing facility

ICAR-IISR is the nodal DUS testing centre for major spices including black pepper, small cardamom, ginger, turmeric and nutmeg. The co-nodal centres are ICAR Research Complex for NEH Region, Umiam, Meghalaya for ginger and turmeric and Indian Cardamom Research Institute (Spices Board), Myladumpara, Kerala for small cardamom. Preliminary observations for the on-site testing of 4 black pepper and 6 small cardamom varieties were completed. Example varieties of black pepper, small cardamom, ginger and turmeric were maintained at respective centres. DUS testing completed for 19 turmeric varieties which include 14 farmers' varieties and 4 varieties of common knowledge and one extant variety. DUS testing completed for 7 ginger varieties which include 4 farmers' varieties and 3 varieties of common knowledge. Presently the authority issued certificate for 6 black pepper varieties and 9 small cardamom varieties.

Bioinformatics centre

In silico studies

A detailed *in silico* analysis was carried out in ginger *Ralstonia* strains, Race 4/Biovar 3 to get a better insight into the pathogenicity of strains and to predict host-adapted polymorphisms. The whole genome data generated for two plant-associated *P. aeruginosa* strains were compared with other clinical and environmental isolates to find out the genes responsible for their virulence.

Development of tools and databases

A database on *Ralstonia solanacearum* causing bacterial wilt in several economically important crops was developed, which includes manually curated whole genome data of 11Indian strains. Data-driven studies based on this database will pave way for an improved understanding of host pathogen interaction. The database is openly accessible at http://192.168.1.14/ralstoniadb/.

Pesticide residue analysis facility

A facility for pesticide residue analysis was established at ICAR-IISR headquarters The facility sponsored by SHM (Kerala) is equipped with Liquid chromatography Mass Spectrometry (LCMSMS) and GC with FPS and ECD detectors to check both non- volatile and volatile pesticide residues, respectively in spice samples.

Tribal sub plan (TSP) and special component plan (SCP)

Under the programme, capacity building and front line intervention programmes for spices sector development in NE states and tribal empowerment, support in selected tribal locations for capacity building and asset creation was provided. The locations were Paderu Tribal agency Area, Visakhapatnam district, Andhra Pradesh, Attapady Tribal block. Palakkad district, Kerala, Golpara and Kamrup districts, Assam, Namsai district in Arunachal Pradesh and Koraput district in Odisha.This was carried out through participatory field visits, surveys to identify technology and yield gaps and multi stake holder need assessment meetings. Prospective need based intervention plans including capacity building and demonstration programmes were prepared.

- Capacity building of six turmeric FPOs in Visakhapatnam Tribal Agency Area, Andhra Pradesh: Post harvest handling and value addition benefiting 800 tribal farmers including FPO leaders. Four processing units with turmeric polisher and improved boiler (TNAU Model) were commissioned benefitting 4000 tribal farmers and the FPO's have launched organic turmeric products with a brand.
- Establishment of IISR Pragati seed garden in Attapady Cooperative Farming Society: Supplied 2 t of turmeric (IISR Pragati) to Attapady Cooperative Farming Society for further distribution to Tribal farmers.
- Project support through capacity building for area expansion in black pepper in Assam:Two training programmes and field visits were conducted for 300 farmers.
- Project support through capacity building and supply of planting material for introduction of improved verities of ginger in turmeric in Namsai district, Arunachal Pradesh: One workshop on organic cultivation of ginger and turmeric was conducted and it was proposed to establish 10 ha ginger and 10 ha turmeric demonstration plots.
- Introduction and popularization of tree spices in Koraput district, Odisha and Visakhapatnam district Andhra Pradesh: Mother plot with 2000 allspice seedlings at HARS, Pottangi and HRS, Chintappalli was established.

ATIC AND EXTENSION SERVICES

- ATIC provided advisory and scientific services including sale of technology products of the institute to various stakeholders including a large number of school and university students' during their visit to the institute from time to time. A total of 2467 farmers from across the country visited ATIC for advisory services.

- Eighteen farmer groups from different states visited as a part of exposure visit programs under ATMA.

- Two editions of Certified Farm Advisor program (CFA) sponsored by National Institute of Agricultural Extension Management (MANAGE) Hyderabad were organized during 21 January - 04 February 2019 and 11 November – 25 November 2019 in which 35 officers representing the department of horticulture/agriculture from various states attended.

- Training program on recent research advances and technologies in spices research under corporate social responsibility mode to Staff of Kancor ingredients, Kochi (12 participants) and Fair trade network for Asia pacific (14 participants) during 6-10 May 2019 and during 24-26 June 2019 were organized.

- Ten on demand training programs for the State departments on production and processing technologies were organized.

- ATIC participated in the Business Product Expo organized by CIBA, Chennai in January 2019, National Horticulture Fair, Bengaluru in January 2019, and Exhibition in connection with Agriculture Science Congress, New Delhi in February 2019. In addition, ATIC participated in six state/district level exhibitions.

- The revenue generation through the sale of planting material and other products from ATIC was 45.24 lakhs during 2019 (Table16).

Table16 Revenue generation from ATIC in 2019

SL. NO.	ITEMS	AMOUNT(Rs)
1	Planting material (MIDH)	759025.00
2	Planting material (General farm)	292254.00
3	Farm Produce	362307.50
4	Diagnostic Services	57150.00
5	*Trichoderma* formulation	141500.00
6	*Pochonia* formulation	27450.00
7	Bacillich	378150.00
8	Micronutrients	1068000.00
9	Biocapsules	831100.00
10	Publications	196095.00
11	GST	6978.00
12	KVK	24480.00
13	Milk	328878.00
14	Others	50530.00
	Total	**4523897.00**

ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

The XXX Workshop of All India Coordinated Research Project on Spices was held at Tamil Nadu Agricultural University, Coimbatore during 16-18 November 2019. The workshop was inaugurated by Dr T. Janakiram, ADG (Hort. Sci.) ICAR, New Delhi. During the inaugural session the "Best AICRPS Centre Award 2018-19" was presented to High Altitude Research station, OUA & T, Odisha and Narendra Dev University of Agriculture & Technology, Kumarganj, Uttar Pradesh.

Eight booklets/pamphlets on spices production technologies from different AICRPS centres were released during the workshop. Three varieties one each in fennel, ajwain and nigella suitable for different growing regions were recommended for release during the workshop (Table 17). Five different technologies covering ginger, coriander and cumin were also recommended during the workshop.

Table 17 Varieties of seed spices recommended for release during the XXX AICRPS Workshop

Crop	Name of the variety	Developer	Area of adaptation /recommended for	Salient features
Fennel	RF-290	SKNAU, Jobner	Rajasthan, Gujarat, Bihar, Haryana and Uttar Pradesh	Erect and tall plants with more number of umbels, medium maturity type and high yielding with average yield- 2065 kg/ha
Ajwain	Ajmer Ajwain-73	NRCSS, Ajmer	Rajasthan, Gujarat, Chhattisgarh, Haryana, Andhra Pradesh and Uttar Pradesh	High yielding with total oil - 9.15% and essential oil- 6.38%. Average yield -1066 kg/ha. Highly tolerant to root rot and *Sclerotium* rot.
Nigella	Ajmer Nigella-1	NRCSS, Ajmer	Rajasthan, Chhattisgarh, Haryana, West Bengal, Uttarakhand and Uttar Pradesh	High yield with an average yield - 909.7 kg/ha and total oil -19.7%

The following technologies were recommended for adoption:

- Technology for the management of bacterial wilt in ginger caused by *Ralstonia pseudosolanacearum* (ICAR-IISR, Kozhikode)
- Micro irrigation and fertigation management in cumin (Jobner and Ajmer)
- Management of coriander powdery mildew using new generation fungicides (Jobner)
- Use of organic nutrients for disease management in cumin (Jobner)

KRISHI VIGYAN KENDRA

Krishi Vigyan Kendra, Peruvannamuzhi, imparted regular training programmes in agriculture and allied fields for the farmers, farm women, rural youth and extension functionaries. The kendra conducted eighty training programmes in various disciplines, benefitting 3105 people, including 446 participants from the weaker sections of the society.

Three sponsored trainings were organized by KVK on beekeeping (sponsor- HORTICORP), planting material production and nursery management (sponsor- District Kudumbasree Mission), skill development trainings on "Quality seed production " and "Friends of Coconut" (sponsor- ASCI, New Delhi). Training program sponsored by Coconut Development Board was conducted and the participants were given free coconut climbing machine and one year life insurance through CDB.

Three paid training programmes were organized on breeding and culture of ornamental fishes, goat rearing and plant propagation techniques to develop the skill of trainees to initiate business ventures. A vocational training programme was conducted on "Breeding and culture of ornamental fishes" for rural youth including students and an on job training on "Good Agricultural practices' was organized for students with main focus on plant propagation, identification of pests and diseases of crops, preparation and use of botanicals and bio control agents, use and maintenance of plant protection equipment and processing and value addition of fruits and vegetables.

Technology week named 'Thaarum Thalirum' was conducted at KVK during March 2019 (Fig.33). Seminars were organized on topics like vegetable cultivation, cultivation of pulse crops, coconut cultivation and trainings on ornamentals fish culture, poultry rearing, value added product development of spices & fruits were also held. National Agriculture Education Day was observed at Krishi Vigyan Kendra, Peruvannamuzhi, 447 students and 53 teachers from eleven schools from Nochat, Perambra, Koorachandu, Chembanoda, Peruvannamuzhi, Kothode, Koothali, Naduvannur, Meppayur visited various demo units and interacted with scientists on new agricultural technologies.

Krishi Vigyan Kendra observed world soil day by distributing soil health cards and black pepper micro nutrient mixture to farmers (Fig.34). Total six soil health campaigns were conducted in Aroor, Chaniyamkadavu, Vattoli, Cherukkad, Naduvannur, Nadapuram areas of the district in which 286 farmers participated. Farmers were briefed on importance of soil health management, soil testing and demonstrated the procedure for soil sample collection for nutrient analysis. Awareness seminar on "Protection of plant varieties and Farmer Rights Act" was organized and the programme was attended by farmers from Kozhikode, Baluserry, Thamaraserry, Naduvannur, Maruthonkara, Perambra, Meppayur, Chembanoda, Kuttiyadi, and Nadapuram.

Video conferencing of progressive farmers with Hon'ble Prime Minister

Krishi Vigyan Kendra organized video conferencing of six progressive farmers from Kozhikode district during the Prime Minister's web interaction programme with farmers all over India. The programme was held at National Information Centre, Civil Station, Kozhikode as part of PM's review of agriculture related schemes *viz*., Soil Health Card Scheme, Prime Minister Fasal Bima Yojana, Pradhan Mantra Krishi Sinchayee Yojana, Prime Minister Kaushal Vikas Yojana, e- NAM, etc The live interaction program was also viewed by about 100 persons including farmers and staff of KVK, IISR.

Fig.33 Inaguration of technology week

Fig.34 Distribution of soil health card

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

- ITM-BPD UNIT of ICAR-IISR launched a new initiative christened "SPIISRY" to supply good quality spices and allied products to the consumers. SPIISRY was inaugurated by Dr. T Janakiram, Assistant Director General, (HS II) ICAR, New Delhi on 12 July 2019 (Fig.35). The value added products of spices are being displayed and sold through the counter.

- The institute entered into an MOA (Memorandum of Association) with Kerala Start-up Mission (KSUM) for nurturing start-ups and innovation. Dr. Saji Gopinath, CEO, KSUM and the officials from Calicut Management Association (CMA) visited the institute and executed the MOA on 04 April 2019 (Fig.36).

- ITM-BPD Unit participated in 8th edition of Malabar Round table on 25 April 2019 organized by Calicut Management Association (CMA) in association with KSUM.

- The unit organized an exhibition cum sales of the institute technologies, products and incubatee products at ICAR-IISR on 01 July 2019, which marked the 24th Foundation Day of ICAR-IISR.

- The unit won accolades for promoting ICAR-IISR technology on Biocapsules during the ICAR foundation day held on 16 July 2019. M/s Codagu Agritech, a licensee of this technology, was a special invitee for this year's celebrations and presented the technology before the Hon'ble Prime Minister.

- The Krishidhan Nursery of ITM-BPD Unit continues to provide marketing support through the sale of planting materials produced by registered farmers/licensees of spices.

- A product development lab facility has been set up for developing spice based innovative food and naturopathy products with the objective of better income through value addition (Fig.37). Equipment's such as dehydrator, blender, visi cooler, electric cooking heater, batch coder, laboratory oven, hot air oven, cake and chocolate making tools etc. were purchased through NAIF.

- The unit ventured into spice based product development owing to the increasing demand for sophisticated finished products from oils and oleoresins and health and wellness products. An array of spice based products *viz*., cinnamon spice candle, cardamom soap, vanilla soap, exfoliating coffee scrub, spice rub for cold & flu, ginger & clove warming rub for sore muscles, relaxing spice pillow spray, skin protection lotion, turmeric night serum and insect repellent spray were launched.

- The major spice based food products developed by the ITM BPD unit are dry ginger coffee, ginger sorbet, turmeric infused honey, health mix, masala tea, spice based cakes and spice based chocolates. Other exciting products being developed are ginger vanilla body butter, pain balm, vanilla cinnamon brown sugar scrub, vanilla homemade body wash, foot scrub, cough drops, turmeric tonic, hair detangler, homemade lotion etc.

- During the year, one license on nutmug variety IISR Viswashree (Table 18) and 3 patents on micro nutrient formulations were obtained (Table 19).

Table 18 Licenses issued by ITM-BPD unit

Name of Technology/ Know-How	IP Protection (Yes/ No)	Name of Contracting Party	Mode of Partnership	Date of Licensing	Revenue Earned (Rs.)
Nutmeg variety -IISR Viswashree	Yes (PPV&FRA Registration No-)	Mrs.Vijitha Polson, Nirappel Nursery, Pattikad PO, Thrissur, Kerala	Licensing	03-08-19	25,000

Table 19 Management of IP portfolio by ITM-BPD unit

IPRs	Application/ Registration No.	Name of Innovation/ Technology/ Product/ Plant Variety	Date of application Filed/ submitted	Date of Application Granted / Registered
Patent	4708/CHE/2013	A micronutrient composition for ginger and a process for its preparation (For soils with pH above 7)	18/10/2013	Patent granted (Patent no : 314133)
Patent	3794/CHE/2013	A micronutrient composition for ginger and a process for its preparation (For soils with pH below 7)	27/08/2013	Patent granted (Patent no : 318672)
Patent	4754/CHE/2013	A micronutrient composition for turmeric and a process for its preparation	22/10/2013	Patent granted (Patent no : 320502)

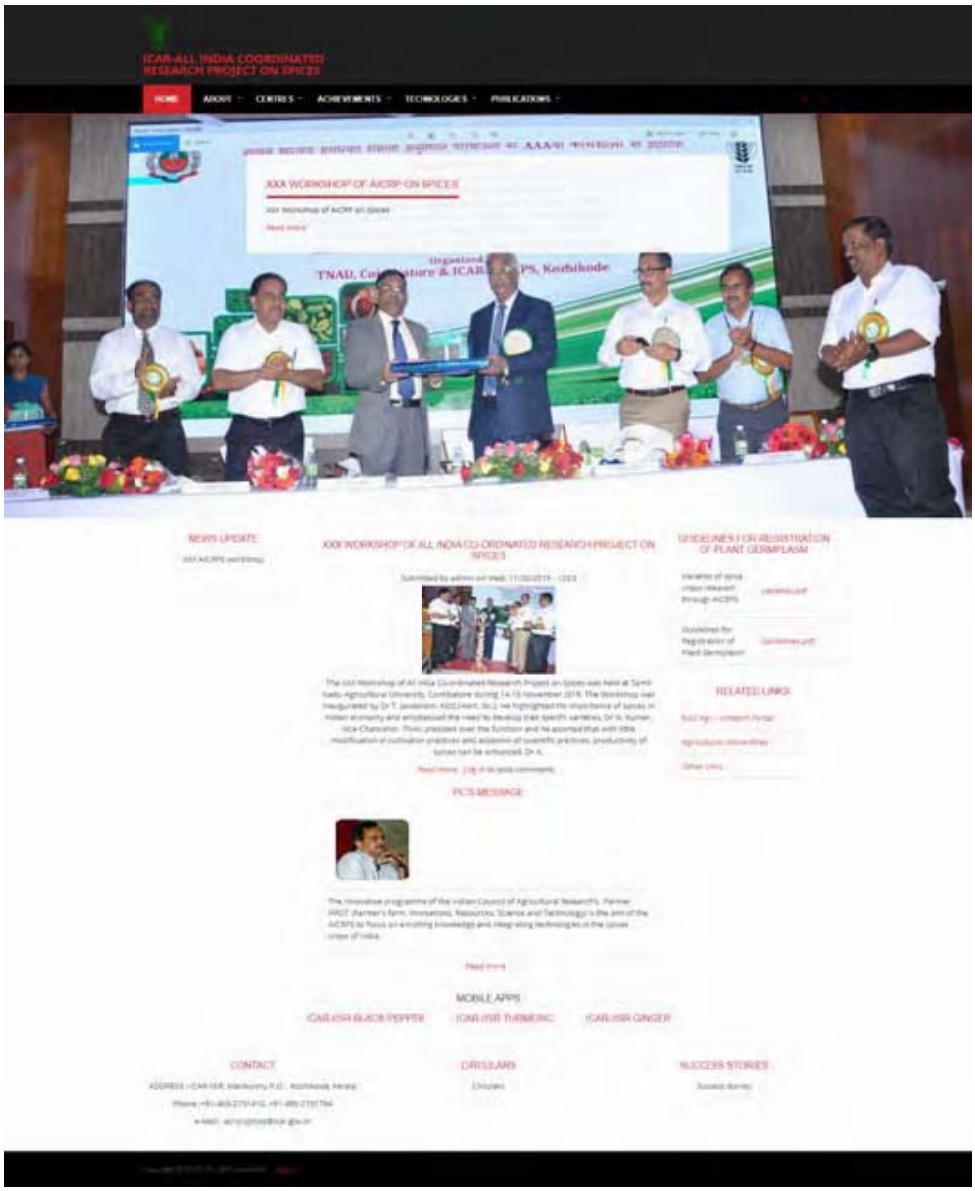
Fig.35 SPIISRY inauguration by Dr. T Janakiram, Assistant Director General, (HS II) ICAR, New Delhi on 12 July 2019

Fig.36 Signing of MOA between Kerala Start up Mission and ICAR-IISR for promoting Agritech Start-ups on 04 April 2019

Fig.37 Product Lab and Incubation Centre of BPD-ITMU

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 updation 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 email, webserver etc., are also carried out. The Personnel Management Information System Network of ICAR (PERMISnet II) and Project Information & Management System of ICAR (PIMS-ICAR) were updated by AKMU. The repair and maintenance of computers and its accessories, audio visual support to various activities were also facilitated through AKMU. Apart from this, AKMU assists in analyzing and interpreting geographical data using ArcGIS & DIVA GIS and statistical analysis of scientific data using SAS and other statistical software and for developing mobile based applications.



हिन्दी अनुभाग

राजभाषा कार्यान्वयन समिति की बैठक

संस्थान की राजभाषा कार्यान्वयन समिति की बैठक प्रत्येक तिमाही में आयोजित की हैं। पहली बैठक 22 जून 2019, दूसरी 19 सितंबर 2019, तथा तीसरी बैठक 19 दिसंबर 2019 को डा. के. निर्मल बाबू, निदेशक एवं अध्यक्ष, राजभाषा कार्यानव्यन समिति की अध्यक्षता में संपन्न हुई। तथा बैठक में निदेशक महोदय ने संस्थान की राजभाषा कार्यान्वयन की समीक्षा भी की।

आईसीएआर-आईआईएसआर इलायची अनुसंधान केन्द्र अप्पंगला में दिनांक 14 मई 2019 को राजभाषा कार्यान्वयन समिति की बैठक आयोजित की। प्रस्तुत बैठक में सुश्री. एन. प्रसन्नकुमारी वरिष्ठ तकनीकी अधिकारी ने राजभाषा कार्यान्वयन के प्रमुख बिन्दुओं का विवरण दिया।

हिन्दी कार्यशाला

राजभाषा को लोकप्रिय बनाने के लिए आई आईएसआर, कोषिक्कोड में हिन्दी कार्यशालाएं आयोजित की गयी।

श्रीमती प्रवीणा, हिन्दी प्राध्यापक, हिन्दी शिक्षण योजना, कोषिक्कोड ने दिनांक 12 जून 2019 को संस्थान में आयोजित हिन्दी कार्यशाला में टिप्पणि एवं मसौदा लेखन पर व्याख्यान दिया।

श्रीमती प्रवीणा, हिन्दी प्राध्यापक, हिन्दी शिक्षण योजना, कोषिक्कोड ने दिनांक 25 सितंबर 2019 को संस्थान में आयोजित हिन्दी कार्यशाला में टिप्पणि एवं मसौदा लेखन पर व्याख्यान दिया।

संयुक्त हिन्दी कार्यशाला (अक्तूबर-दिसंबर 2019) की रिपोर्ट

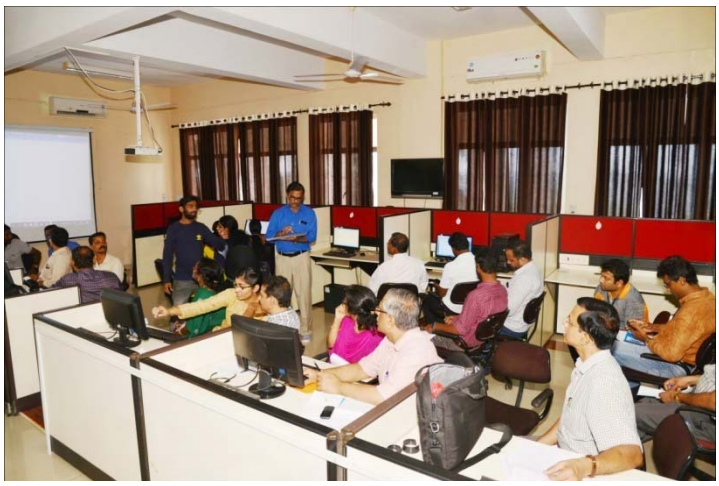
भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में अक्तूबर दिसंबर 2019 की तिमाही में एक पूर्ण कार्यदिवसीय हिन्दी कार्यशाला आयोजित की। यह कार्यशाला भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान एवं सुपारी और मसाला विकास निदेशालय ने मिलकर संयुक्त रूप से आयोजित की।

दिनांक 11 दिसंबर 2019 को सुबह 10 बजे आईसीएआर गीत के साथ कार्यशाला शुरू हुई। डा. लिजो तोमस, वरिष्ठ वैज्ञानिक एवं हिन्दी अधिकारी ने उद्घाटन समारोह में सम्मिलित मान्यवरों, कार्यशाला

के प्रतिभागियों एवं संस्थान के अधिकारियों /कर्मचारियों का स्वागत किया। तत्पश्चात् डा. के. निर्मल बाबू, निदेशक, भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान ने अध्यक्षीय भाषण प्रस्तुत किया। तदुपरान्त श्री. बाबुलाल मीणा, उपनिदेशक, सुपारी और मसाला विकास निदेशालय ने कार्यशाला का उद्घाटन करते हुए भाषण दिया। उन्होंने अपने भाषण में हिन्दी भाषा के महत्व एवं हिन्दी में कार्य करने के लिए अनुकूल वातावरण पैदा कराने के संबन्ध में विस्तृत रूप से व्याख्यान दिया। इसके बाद कार्यशाला के पहले सत्र में कक्षा चलाने के लिए सन्निहित श्री. के. के. रामचन्द्रन, उपनिदेशक, आयकर विभाग, कोच्चि ने हिन्दी कार्यशाला के महत्व पर प्रकाश डाला। फिर डा. पी. एन. ज्योति, हिन्दी अनुवादक, सुपारी और मसाला विकास निदेशालय के धन्यवाद ज्ञापन के साथ उत्घाटन सत्र खतम हुआ।

कार्यशाला के पहले सत्र में श्री. के. के. रामचन्द्रन, उपनिदेशक, आयकर विभाग, कोच्चि ने हिन्दी के शुद्ध प्रयोग के बारे में विस्तृत रूप से व्याख्यान दिया। उन्होंने स्लाइड प्रदर्शन के द्वारा हिन्दी व्याकरण एवं हिन्दी टिप्पणी लेखन के शुद्ध रूप को परिचित कराया। टिप्पणी लिखते समय अधिकारियों/कर्मचारियों को साधारण रूप से सामना करने वाली त्रुटियों को सुधार किया। अपराह्न 1.15 बजे श्रीमती एन. प्रसन्नकुमारी के धन्यवाद ज्ञापन के साथ पहला सत्र समाप्त हुआ।

कार्यशाला का दूसरा सत्र अपराह्न 2 बजे शुरू हुआ। प्रस्तुत सत्र में श्री. एम. अरविन्दाक्षन, वरिष्ठ हिन्दी अनुवादक, कर्मचारी भविष्य निधि संगठन ने कम्प्यूटर में हिन्दी का टंकण कैसे करें इसके बारे में स्लाइड प्रदर्शन करके विस्तृत व्याख्या की। उसके बाद प्रतिभागियों को हिन्दी टंकण का अभ्यास भी कराया। शाम को 4.30 बजे कार्यशाला का सत्र समाप्त हुआ। समापन सत्र में डा. लिजो तोमस, वरिष्ठ वैज्ञानिक ने सभी प्रतिभागियों को प्रमाण पत्र वितरण किया।



हिन्दी सप्ताह 2019

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड में दिनांक 23 सितंबर 2019 को डा. सन्तोष जे. ईपन, प्रभारी निदेशक की अध्यक्षता में हिन्दी सप्ताह का शुभारंभ हुआ। डा. लिजो तोमस वैज्ञानिक एवं अध्यक्ष, हिन्दी सप्ताह समारोह समिति ने उद्घाटन समारोह में सभी सदस्यों का स्वागत किया। स्वागत भाषण में सभी सदस्यों का स्वागत करके हिन्दी सप्ताह के अवसर पर ओयोजित किये जाने वाले विभिन्न कार्यक्रमों की रूपरेखा प्रस्तुत की। साथ ही डा. त्रिलोचन महापात्र, महानिदेशक, भारतीय कृषि अनुसंधान परिषद से प्राप्त अपील एवं केन्द्र कृषि एवं किसान कल्याण मंत्रि श्री नरेन्द्र सिंह तोमर के सन्देश के मुख्य मदों के बारे में सभी सदस्यों को अवगत कराया। उद्घाटन समारोह में संस्थान के प्रभारी निदेशक डा. सन्तोष जे. ईपन के नेतृत्व में सभी सदस्यों द्वारा हिन्दी में अधिकाधिक काम करने का शपथ लिया गया।

उद्घाटन समारोह में दो हिन्दी प्रतियोगिताएं आयोजित कीं। एक वीडियो क्लिप पर हिन्दी में कमेंन्ट्री थी इसमें कुल 7 सदस्यों ने भाग लिया। दूसरी प्रतियोगिता हिन्दी गीत थी। इसमें 5 सदस्यों ने भाग लिया। इसी अवसर पर तीन अलग अलग चित्र प्रदर्शित करके उनके लिए अनुशीर्षक लेखन प्रतियोगिता आयोजित की। तीनों अनुशीर्षक लेखन प्रतियोगिता ओं में पन्द्रह से अधिक स्टाफ सदस्यों ने भाग लिया। इन प्रतियोगिता के विजेताओं को पहला, दूसरा, तीसरा और दो समाश्वास पुरस्कार दिये गए।

हिन्दी सप्ताह के अवसर पर दिनांक 24 सितंबर 2019 को हिन्दी सुलेख एवं स्मरण परीक्षण ओयोजित किया। इन दोनों प्रतियोगिताओं में 21 स्टाफ सदस्यों ने भाग लिया।

दिनांक 25 सितंबर 2019 को एक हिन्दी कार्यशाला आयोजित की। इसमें श्रीमती प्रवीणा, हिन्दी प्राध्यापक ने हिन्दी के शुद्ध भाषा एवं हिन्दी टिप्पणी एवं मसौदा लेखन पर व्याख्यान दिया। इस कार्यशाला में 21 स्टाफ सदस्यों ने भाग लिया। कार्याशाला के बाद हिन्दी टिप्पणी एवं मसौदा लेखन प्रतियोगिता आयोजित की। इसमें 5 स्टाफ सदस्यों ने भाग लिया।

दिनांक 28 सितंबर 2019 को हिन्दी सप्ताह के समापन समारोह के पहले हिन्दी शब्द सामर्थ्य प्रतियोगित आयोजित की। इसमें पांच टीम थे। इस अवसर पर पिछले वर्ष हिन्दी में सर्वाधिक काम किये गये स्टाफ सदस्यों के लिए प्रोत्साहन योजना आयोजित की थी। इसमें दो सदस्यों को प्रोत्साहित किया गया।

दिनांक 28 सितंबर 2019 को हिन्दी सप्ताह का समापन समारोह आयोजित किया। डा. वी. के. सुब्रमण्यन, विभागाध्यक्ष, हिन्दी विभाग, कालिकट विश्वविद्यालय ने मुख्य अतिथि के रूप उपस्थित होकर समारोह की शोभा बढ़ा दी। मुख्य अतिथि द्वारा पुरस्कार विजेताओं को पुरस्कार वितरण किया गया। समापन समारोह में सुश्री विजिषा ने एक हिन्दी गीत प्रस्तुत की। सुश्री एन. प्रसन्नकुमारी के धन्यवाद ज्ञापन के साथ समारोह का समापन हुआ।

इलायची अनुसंधान केन्द्र अप्पंगला

भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान का क्षेत्रीय स्टेशन इलायची अनुसंधान केन्द्र, अप्पंगला, करनाटक में डॉ. एस. जे. अंकेगौड़ा, कार्यालयाध्यक्ष ने दिनांक 23.09.2019 को हिंदी सप्ताह समारोह का उद्घाटन किया। उद्घाटन भाषण में जिन्होंने रजभाषा के रूप में हिंदी के महत्व एवं दैनिक सरकारी कामकाज में टिप्पणी एवं मसौदा में हिन्दी का प्रयोग करने पर भी ध्यान दिया। इसके बाद 24.10.2019 को अनुशीर्षक लेखन प्रतियोगिता भी आयोजित की गई और सर्वश्रेष्ठ तीन अनुशीर्षक के लिए पुरस्कार वितरित किए गए। दिनांक 25.09.2019 को, किसानों के लिए हिंदी गीत प्रतियोगिता आयोजित की गई। डॉ. होन्नाप्पा असंगी ने कविता पाठ प्रस्तुत किया। कर्मचारियों को हिंदी सीखने और बोलने में रुचि पैदा करने के लिए दिनांक 6.09.2019 को एक फिल्म उरी प्रदर्शित की गयी जिस को देखने के बाद सदस्यों में हिंदी का मनोबल बढ गया। दिनांक 27.09.2019 को स्टाफ सदस्यों के लाभ के लिए स्मरण परीक्षण की प्रतियोगिता आयोजित की। दिनांक 28.09.2019 को हिंदी सप्ताह के समापन समारोह में हिन्दी पठन प्रतियोगिता भी आयोजित की गयी।

नराकास गतिविधियां

डा. के. निर्मल बाबू, निदेशक एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति, डा. लिजो तोमस, वैज्ञानिक एवं हिन्दी अधिकारी तथा सुश्री एन. प्रसन्नकुमारी, वरिष्ठ तकनीकी अधिकारी ने दिनांक 25 अप्रैल

2019 को होटल मरीना रसिडेंसी, कोषिक्कोड में आयोजित नगर राजभाषा कार्यान्वयन समिति की 63वीं बैठक में भाग ली। के.

डा. के. निर्मल बाबू, निदेशक एवं अध्यक्ष, राजभाषा कार्यान्वयन समिति, डा. लिजो तोमस, वैज्ञानिक एवं हिन्दी अधिकारी तथा सुश्री एन. प्रसन्नकुमारी, वरिष्ठ तकनीकी अधिकारी ने दिनांक 26 सितंबर 2019 को होटल मरीना रसिडेंसी, कोषिक्कोड में आयोजित नगर राजभाषा कार्यान्वयन समिति की 64 वीं बैठक में भाग ली।

संस्थान के आठ अधिकारियों /कर्मचारियों ने नगर राजभाषा कार्यान्वयन समिति द्वारा संयुक्त हिन्दी पखवाडा 2019 के संदर्भ में आयोजित हिन्दी की विभिन्न प्रतियोगिताओँ में भाग लीं।

प्रकाशन

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

- आईसीएआर-आईआईएसआर वार्षिक प्रतिवेदन 2017-18
- आईसीएआर-आईआईएसआर वार्षिक प्रतिवेदन 2018-19 का कार्यकारी सारांश हिन्दी में तैयार करके वार्षिक प्रतिवेदन में शामिल किया।
- अनुसंधान के मुख्य अंश 2018-19
- मसाला समाचार (जनवरी-मार्च 2018, अप्रैल-जून 2018)
- मसालों की महक 2019 (राजभाषा पत्रिका)
- झाडी काली मिर्च
- अखिल भारतीय समन्वित मसाला अनुसंधान परियोजना के वार्षिक प्रतिवेदन का कार्यकारी सारांश हिन्दी में तैयार करके वार्षिक प्रतिवेदन में शामिल किया।

राजभाषा रिपोर्ट

संस्थान की 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 समितियों एवं सदस्यों की सूची हिन्दी में तैयार करके वेवसाइट में अपलोड किया गया। संस्थान के रिसप्शन काउन्टर की रॉटी वी में किसान चैनल प्रदर्शित किया जाता है।

संस्थान में अधिकारियों/कर्मचारियों में हिन्दी के प्रति रुचि पैदा कराने के लिए एक हिन्दी फिल्म उरी का प्रदर्शन किया गया।

संस्थान से संबन्धित विवरणों का स्लाइड (34) हिन्दी में भी तैयार करके रिसप्शन की टी वी में प्रदर्शित किया जाता है।

प्रशिक्षण

संस्थान के छः अधिकारियों ने केन्दीय हिन्दी प्रशिक्षण संस्थान द्वारा आयोजित पत्राचार पाठ्यक्रम का हिन्दी प्रबोध पाठ्यक्रम में भाग लिया। डा. शारदाम्बाल ने पत्राचार पाठ्यक्रम द्वारा आयोजित प्रबोध परीक्षा जीत ली।

संस्थान के चार अधिकारियों/कर्मचारियों ने हिन्दी प्रशिक्षण संस्थान द्वारा आयोजित पारंगत परीक्षा जीत ली।

पुरस्कार

सुश्री एन. प्रसन्नकुमारी, वरिष्ठ तकनीकी अधिकारी को केरल हिन्दी प्रचार सभा द्वारा आयोजित राजभाषा सेवी सम्मान का प्रोत्साहन पुरस्कार प्राप्त हुआ।

LIBRARY

Library subscribed twenty four Indian and eight foreign journals during the year in addition to journals accessible under Consortium of Electronic Resources in Agriculture (CeRA). Library added two hundred and fifty six publications to stock. As part of exchange programme, library continued to exchange publications with various organizations. As part of e-journal consortium, seventeen document delivery requests from other partners were caterell institute pd. Aublications for the last year period were uploaded to Krishi portal. Added two hundred full text publications to 'DSpice' institutional repository. All newly added publications were brought in to the 'KOHA' database and the Cataloguing Classification data was updated. Monthly issues of the 'Agrititbits' were brought out during all months. User awareness was done for the benefit of new patrons of library.

HUMAN RESOURCE DEVELOPMENT

A. Trainings and workshops organized by HRD cell

- Two days training programme on Information Security Awareness was organized at ICAR-IISR from 15-16 March 2019 for all the staff members.
- One-day training programme on Government e-Marketplace (GeM) was organized at ICAR-IISR on 7 May 2019. Mr. Manesh Mohan, business facilitator for GeM was the core faculty of the training programme. Twenty-three participants comprising of scientists, technical and administrative staff participated in the workshop.
- A one-month summer internship programme on "Advanced Techniques in Microbiology, Biochemistry, Biotechnology and Bioinformatics" was organized at ICAR-IISR from 01 to 31 May 2019 for post-graduate students.
- A four-day programme on "Quality Management System and Internal Audit as per ISO/IEC 17025:2017" was organized at ICAR-IISR from 04-07 September, 2019 as a prelude to NABL accreditation. Dr. Ramesh Basappa, Ex-Director, BIS and Mr. R.C. Mathew, Ex-BIS were the faculty members nominated to conduct various sessions.
- A one-day workshop on ICAR- ERP MIS-FMS was organized at ICAR-IISR on 13 December 2019. Twenty-three participants from IISR and selected administrative staffs from CPCRI and CMFRI participated in the workshop.

B. Training and capacity building for ICAR-IISR employees

Table 20 Participation of ICAR IISR staff members in training programmes

Sl. No.	Name	Training particulars	Duration	Institute
		SCIENTIFIC STAFF		
1	Dr. C. K. Thankamani	Management Development programme on Leadership Development	11-22 June 2019	NAARM, Hyderabad
2	Dr. S. J. Ankegowda	Managing Technology Value Chains for Directors and Division Heads	14 – 18 Oct 2019	ASCI, Hyderabad
3	Dr. Lijo Thomas	Intellectual Property Valuation and Technology Management	14-18 Oct 2019	ICAR – NAARM, Hyderabad
4	Ms. R. Sivaranjani	Advanced Analytical Techniques for Spices	24-25 June 2019	Agilent Technologies, Kochi
5	Dr. K. Anees	Advanced Analytical Techniques for Spices	19 Sep 2019	Agilent Technologies, Kochi

6	Dr. N. K. Leela Dr. K. S. Krishnamurthy Ms. R. Sivaranjani Dr. P. Umadevi Dr. S. Aarthi Dr. A. Ishwara Bhat Dr. R. Praveena Dr. V. Srinivasan Dr. K. Anees Dr. T. E. Sheeja Mr. V. A. Muhammed Nissar Dr. M. S. Shivakumar Dr. C. M. Senthil Kumar Dr. C. Sarathambal	Laboratory Quality Management System and Internal Audit (As per ISO 17025:2017)"	19 Sep 2019	ICAR – IISR, Kozhikode
7	Dr. A. Ishwara Bhat	Workshop for vigilance officers of ICAR institutes	31 Oct 2019	ICAR-NAARM, Hyderabad
8	Dr. K. Anees	National Conference on Integrative Plant Biology and Biotechnology.	08-09 Nov 2019	ICAR-IIRR, Hyderabad
9	Dr. M. S. Shivakumar	National Level Training on Genome-Wide QTL detection and prediction of breeding values for Precision crop breeding.	27 Nov 2019 06 Dec 2019	GKVK, Bengaluru
10	Mr. V. A. Muhammed Nissar	Hands on training/workshop on Ecological Niche Modelling	22-24 Nov 2019	Malabar Botanical Garden and Institute for Plant Sciences, Kozhikode
ADMINISTRATIVE STAFF				
1	Mr. V. V. Sayed Mohammed Mr. V. C. Sunil Kumar	Administrative and Finance Management for SO/AAO/ AFAOs/Assistants	13-17 June 2019	ICAR-CIFT, Kochi
2	Mr. P. Sundaran Mr. P. T. Jayaprakash	Hindi Workshop on Official Language	10 Oct 2019	Kerala Hindi Prachar Sabha, Thiruvananthapuram
3	Mr. V. C. Sunil	Improving Skills of Administrative Staff of ICAR dealing with Court Cases	25-27 Nov 2019	ICAR-CAZRI, Jodhpur
4	Mr. R. N. Subramanian Mr. P. Sundaran Mr. V. C. Sunil Mr. P. Rajeev Ms. N. Rebeena Mr. P. K. Rahul Ms. M. Seema Mr. P. T. Jayaprakash Ms. C. K. Beena	One day work shop on ICAR – ERP – MIS - FMS	13 Dec 2019	ICAR-IISR, Kozhikode
TECHNICAL STAFF				
1	Mr. E. S. Sujeesh	Farm Management	25 Aug 2019	ICAR-IIFSR, Modipuram
2	Mr. H. C. Rathish	Automobile Maintenance, Road Safety and Behavioural Skill	24-30 Sep 2019	ICAR-CIAE, Bhopal,

3	Ms. N. Karthika Ms. O. Shajina Ms. P. K. Chandravally Mr. B. Vishnu Mr. I. P. Vijesh kumar Ms. K. S. Hridya	Laboratory quality management system and Internal Audit (As per ISO 17025:2017)	04-07 Sep 2019	ICAR – IISR, Kozhikode
4	Mr. B. Vishnu Ms. K. S. Hridya Ms. O. Shajina Dr. E. Radha	One day workshop on ICAR – ERP – MIS - FMS	13 Dec 2019	ICAR – IISR, Kozhikode

C. Seminar/ Symposium/ conferences attended by employees

Table 21 Participation of ICAR IISR staff members in seminar / conferences

Sl. No.	Name	Seminar/Symposium/ conference/ Workshop	Duration	Institute
1	Dr. A. Ishwara Bhat Dr. R. Praveena Dr. C. Sarathambal Dr. P. Umadevi	International Conference on Plant Protection in Horticulture: Advances and Challenges (ICPPH 2019)	24-27 July 2019	ICAR-IIHR , Bengaluru
2	Ms. R. Sivaranjani	Technical symposium on QTOF LC-MS and GC-MS	15-19 Oct 2019	IIT, Chennai
3	Dr. Santhosh J. Eapen Dr. A. Jeevalatha	International Plant Protection Congress (IPPC 2019)	10-14 Nov 2019	ICRISAT, Hyderabad
4	Dr. T. E. Sheeja Dr. P. Umadevi	Workshop on Gene Editing for Enhancing Plant Productivity and Stress Tolerance	10-12 Nov 2019	ICAR-IIRR , Hyderabad
5	Dr. K. Anees	National Conference on Integrative Plant Biology and Biotechnology	8-9 Nov 2019	ICAR-IIRR, Hyderabad
6	Dr. E. Jayashree Dr. Lijo Thomas Dr. B. Pradeep	International conference on Aquatic resources and blue economy	28-30 Nov 2019	KUFOS, Kochi

D. Foreign Deputation

Table 22 Foreign deputation of ICAR IISR staff members

Sl. No.	Name	Purpose	Duration	Country
1	Dr. K. Nirmal Babu	Inaugural Ceremony of IPC & Launching of Farmers App	01-06 April 2019	Pleiku, Vietnam
2	Dr. Santhosh J. Eapen	8th Meeting of the R & D Committee of International Pepper Community	02-03 May 2019	Kuching, Malaysia
3	Dr. C. M. Senthil Kumar	International Congress on Invertebrate Pathology and Microbial Control	28 July 01 August 2019	Valencia, Spain

E. Ph. D degree awarded

Table 23 Ph. D degree awarded			
Student	**Topic**	**University**	**Guide**
Anusree Thampi	Diversity and bioactive potential of rhizospheric actinomycetes from black pepper (*Piper nigrum* L.)	Mangalore University	Dr.R.Suseela Bhai
Karthika R.	Molecular and biochemical characterization of bacterial wilt resistance in mango ginger (*Curcuma amada* Roxb.)	Mangalore University	Dr.D.Prasath
Sreeja K.	Documentation and evaluation of fungal endophytes of black pepper (*Piper nigrum* L.)	Mangalore University	Dr.M.Anandaraj

MAJOR EVENTS 2019

Visit of Hon'ble minister of state Sri. Sanjay Shamrao Dhotre

Minister of State for HRD, Communications and Electronics & IT, Sri Sanjay Shamrao Dhotre visited the headquarters of ICAR Indian Institute of Spices Research on 13 November 2019**.** Sri Dhotre visited the various research facilities and interacted with the scientists of the institute (Fig.38). He said that ICAR IISR has made significant progress in improving the spice scenario in the country. The minister emphasised the need for intensifying research on post-harvest value addition in spices to enhance the farm incomes of the primary spice producers of the country. He said that the bio-encapsulation technology developed at ICAR IISR has the potential to make radical changes across crops under commercial cultivation. Dr. K. Nirmal Babu, Director, ICAR IISR presented the research programmes and activities of the institute.

Fig.38 Planting Nutmeg (IISR Keralashree) by Hon'ble Minister of State Sri. Sanjay Shamrao Dhotre

Vigilance awareness week

Vigilance Awareness Week (VAW) was observed from 28 October – 02 November 2019 at ICAR- IISR headquarters, Chelavoor, Kozhikode, Regional station, Appangala, Experimental Farm and Krishi Vigyan Kendra Peruvannamuzhi. The awareness week started with a pledge administered to all staff members of the institute in their respective centres at 11.00 am on 28 October. Based on this year's theme "Integrity- a way of life" various programmes were organized to promote integrity, transparency and accountability in public life and also to bring awareness among people about the harmful effects of corruption and the need for having a vigilant society to prevent corruption. Slogan writing and drawing competition, quiz and essay writing competitions were conducted for the staff and school children. As a part of this

awareness programme, a medical camp was organized at the campus for the benefit of entire staff of the institute (Fig. 39a & 39b).

The Valedictory Function of the VAW- 2019 was held on 02 November in the institute. Dr. A. Ishwara Bhat, Vigilance Officer of the institute welcomed; Dr C. M. Senthil Kumar, Senior Scientist presented various activities conducted during VAW-2019 and Dr. K. Nirmal Babu, Director of the institute gave the presidential address. Mr. Girish S. Gokarn, Deputy General Manager, SBI, Administrative Office, Kozhikode was the Chief Guest. He gave a talk on the topic "Integrity- A away of Life". He spoke on the various measures taken to promote personal integrity and explained the various steps taken to help the public when they report corruption and how to report corruption without fear.

Fig. 39a Vigilance awareness pledge taking

Fig.39b Vigilance awareness class to school children

Swachhta activities

The Swachhta Hi Sewa (11 September –02 October, 2019) programme was inaugurated by Dr. Santhosh J. Eapen, Director (i/c) and administered the Swachhta pledge to all staff members of the Institute. Dr. C. K. Thankamani, Nodal Officer, Swachhta Committee briefed the programmes proposed to be organized during the fortnight. At ICAR-IISR Experimental Farm, Krishi Vigyan Kendra, Peruvannamuzhi and ICAR-IISR Regional Station, Appangala, respective administrative heads administered Swachhta pledge to the staff.

A variety of programmes including cleaning the institute premises, laboratories, collection and segregation of plastic wastes, creating awareness among the general public, farmers and students regarding the ill effects of plastics through rally and lectures were organized during the fortnight. Literary competitions including essay writing and painting on "Challenges in Waste Management" in English and local language (Malayalam) were conducted for staff of the institute. The fortnight programmes concluded on 02 October during which Shri. C. Subramanian, the Chief Guest delivered a lecture on "Ill effects of plastics".

Fig.40 Swachhta Hi Sewa activities at ICAR IISR

The Swachhta Pakhwada 2019, programme commenced on 16.12.2019 with Pledge administered by Dr. Santhosh J. Eapen, Director (i/c), ICAR-IISR. All the staff members including contractual workers attended the pledge taking ceremony. Various activities to be conducted during the Pakhwada were highlighted by Dr. C. K. Thankamani, Nodal Officer, Swachhta Committee. At ICAR-IISR Experimental Farm, Krishi Vigyan Kendra, Peruvannamuzhi and ICAR-IISR Regional Station, Appangala, respective administrative heads administered Swachhta pledge to the staff.

Cleanliness and sanitation drive in the villages adopted under *Mera Gaon Mera Gaurav* programme (Panangad Villlage, By ICAR-IISR and Ikola village, Murgod-Post, regional Centre Madikeri) was carried out by staff members. Awareness on compost making and bush pepper propagation was carried out to the residence of IIM area residence colony at Kunnamangalam. A cleaning programme was carried out at public place Raja seat, which is one of the major tourist spots in Madikeri. A drawing competition was organised to school children's at GP School, Chelavoor and Govt. Primary School, Palur, Madikeri respectively. The valedictory program of Swachhta Pakhwada 2019 was organised on 31st December 2019 in which Dr. Mohammad Shafi, (Retired HOD Chemistry, Calicut University) delivered a lecture on “pollution due to plastic”. Dr.B.C. Narasimha, Assistant Professor, Department of Community Medicine, Kodagu Institute of Medical Sciences, Madikeri was the Chief Guest for the program organised at Regional station, Appangala.

Quinquennial review of ICAR IISR and ICAR AICRPS

The Quinquennial Review Team (QRT) of ICAR-Indian Institute of Spices Research to review the work of the IISR and AICRP on Spices for the period 2013-2018 held its first meeting during 29 July– 01 August 2019 at ICAR-IISR, Kozhikode and Regional Station at Appangala, Madikeri, Karnataka (Fig.41). The QRT was chaired by Prof.K.V. Peter, Former Vice Chancellor, KAU, Thrissur. The members of the were Dr. K.D. Kokate, Former DDG (Agrl. Ext.), Dr. V.S. Korikanthimath, Former Director, ICAR-CCARI, Goa, Dr. R.T. Patil, Former Director, ICAR-CIPHET, Ludhiana, Dr. S.R. Bhat, Emeritus Professor, ICAR-NRCPB, New Delhi and Dr. H.B. Singh, Former Head, Department of Mycology & Plant Pathology, BHU, Varanasi with Dr. Santhosh J. Eapen, Principal Scientist & Head, Division of Crop Protection, ICAR-IISR as the Member Secretary. The QRT held interactions with institutional stakeholders like Spices Board, Directorate of Arecanut and Spices Development, All India Spice Exporters Forum and World Spice Organization apart from various constituents of AICRP on spices. The final meeting of the QRT was held during 24–25 October 2019 at ICAR IISR.

Fig.41QRT team interacting with Scientist during visit to labs

Third meeting of the VIII Research Advisory Committee

The third meeting of the VIII RAC was held on 12–13 July 2019 at ICAR-IISR, Kozhikode. Prof. M.C. Varshneya, Former Vice Chancellor, Kamdhenu University, Gandhinagar, Gujarat, Chairman of VIII RAC of ICAR-IISR could not attend the meeting. Hence, the meeting was held under the Chairmanship of Dr. R.N. Pal (Former DDG (Hort.), ICAR, New Delhi and Member, RAC). The other members of the RAC were Dr. V. S. Korikanthimath, Former Director, ICAR-CCARI, Goa; Dr. Srikant Kulkarni, Former Head-Plant Pathology, UAS, Dharwad, GKVK; Dr. Suresh Walia, Emeritus Scientist, Division of Agrochemicals, ICAR-Indian Agricultural Research Institute, New Delhi; Shri. T.P. Suresh and Shri. K. K. Rajeevan (IMC members); Dr. T. Janakiram, ADG (HS-I) ICAR, KAB II, New Delhi; Dr K. Nirmal Babu, Director, ICAR-IISR, Kozhikode and Dr. J. Rema, Member Secretary, VIII-RAC.

Farmer interface meeting

Farmer Interface meeting on "Facilitating direct marketing of spices and developing an incubation model" was held at ICAR-IISR on 27 March 2019. One of the major constraints faced by primary producers of spices is their inability to leverage the market demand for realizing maximum returns from the output produced. Direct marketing of spices by the primary producer is suggested as one of the options for overcoming this constraint. However, linking the primary producer and buyer remains a challenge. In this context, the farmer interface meeting organized by ITM-BPD unit of ICAR IISR was conceived as a platform to bring together the producers, traders and other developmental stakeholders in the spices sector. Sri Nagesh S S, Chief, Agriculture, Kerala State Planning Board was the special guest on the occasion. Sri Nagesh, during his interaction, espoused the importance of aggregation of spice produce in a country like India, where the small holder producers dominate the production scenario. He expressed confidence that institutions like ICAR IISR can develop strong and robust platforms for direct marketing of spices, through which the producers share in consumer's rupee can be enhanced substantially. Dr. C Thamban, Principal Scientist, ICAR-CPCRI facilitated the farmer interaction session. The meeting was attended by progressive famers, spice traders and representatives from state agriculture department.

Fig.41 Farmer interface meeting at ICAR IISR

District level farmer's seminar

To enhance the farm income of spice growers, the creation of awareness among the primary producers of spices is the most significant and critical aspect. As a part of its efforts to spread the awareness on Spice based cropping systems, ICAR IISR organized a district level farmer's training on Spice based cropping systems for enhancing farm incomes on 28 November 2019. The seminar was inaugurated by Dr. K. Nirmal Babu, Director, ICAR-IISR. Shri. Babulal Meena, Deputy Director, DASD and Dr. K.M. Nair,

Former Principal Scientist, NBSS & LUP addressed the farmers. More than 150 farmers from different parts of Kozhikode District attended the training. Training sessions had lectures on Good agricultural practices for plant health management in spices by Ms. S. Sheela, Deputy Director, Training and Extension, Dept of Agriculture, Kozhikode; Poly house for spices: Issues and challenges by Mr. Subashbabu, Deputy Director, Farmers Training Centre, Vengeri, Kozhikode and Spice based intercropping systems for enhancing farm income by Dr. C Thamban, Principal Scientist, ICAR CPCRI, Kasargod (Fig.42).

Fig.42 District-level farmer's seminar at ICAR IISR

Certified farm advisor program

A Certified Farm Advisor Program- Module II sponsored by MANAGE, Hyderabad was organized at ICAR-IISR during 11th to 25th Nov. 2019. Twenty two state government officials from 10 different states have participated in the training program. Faculty members of ICAR-IISR delivered lectures on crop improvement, production and protection aspects of spice crops, organic farming, medicinal potential, flavours and fragrances in spices, mechanization, post-harvest handling and value addition and business initiative at ICAR-IISR. Director, ICAR-IISR gave an overview of activities of AICRPS and interacted with the participants. Outside experts from ICAR NRCSS, Ajmer and NHRDF, Coimbatore also interacted with the participants on production and protection aspects of seed spices, onion and garlic. Participants had hands on experience of pollination in turmeric and vanilla. Field visits to DASD and RARS, Ambalavayal were also organized.

KUFOS team visits ICAR-IISR

Four member team from Kerala University of Fisheries and Ocean Studies (KUFOS) consisting of Dr. Gopakumar, Dean Faculty of OST (Chairman), Dr.T.V. Sankar, Director of Research (Convener), Dr. K.P. Subash Chandar, Director SFE&CE (Member), Dr. S. Suresh Kumar, Director SOST & GC (Member) visited ICAR-IISR on October 28, 2019 for considering the organization as a Research Centre of KUFOS for Ph.D. programmes. The team members visited the laboratory and other facilities and interacted with scientists. The Director, ICAR-IISR, Dr. K. Nirmal Babu made a detailed presentation during the interaction. The team appreciated the facilities and research activities of the ICAR-IISR.

Third Dr.Y.R. Sarma memorial lecture

The Third Dr. Y.R. Sarma Memorial Lecture was organized by ICAR Indian Institute of Spices Research in association with Dr. Y.R. Sarma Memorial Trust (Fig.43). The memorial lecture was delivered by Dr. K.R.K. Reddy, Chairman & Managing Director, Sri Bio Aesthetics Pvt. Ltd., Hyderabad. The lecture on "Engineering microbiomes for sustainable crop productivity' explored the potential of manipulating microbiomes in influencing plant attributes like yield and quality. Apart from faculty members and researchers from several institutions, more than hundred research scholars from various colleges also attended the memorial lecture. Dr. Y R Sarma, former Director of ICAR-IISR, was a pioneer in spice pathology and had been the guiding force behind several highly successful research programmes at national and international level. The meeting was chaired by Dr. M Anandaraj, Former Director, ICAR IISR. Dr. K Nirmal Babu, Director, ICAR IISR and Dr. S.J. Eapen, Head, Division of Crop Protection, ICAR IISR also addressed the gathering.

Fig.43 Third Dr.Y.R. Sarma memorial lecture at ICAR IISR

Third students - scientists interface

A students - scientists interface with the theme 'Microbial Diversity - A Boon or A Bane' was organized at ICAR-IISR on 20 December 2019, by the Division of Crop Protection. The interface was inaugurated by Dr. M. Anandaraj, eminent plant pathologist and former Director, ICAR-IISR. Dr. C. Gokulapalan (KAU, Vellayani), Dr. R. Vishwanathan (ICAR-SBI, Coimbatore), Dr. A.I. Bhat & Dr. R. Suseela Bhai from ICAR-IISR delivered lectures and interacted with around 100 post graduate students from various colleges. Dr. K. Nirmal Babu, Director presided over the meeting.

INSTITUTE MANAGEMENT COMMITTEE

1	Dr. K. Nirmal Babu 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	Dr. T. Makeshkumar Principal Scientist ICAR-CTCRI, Trivandrum, Kerala	Member
6	Dr. K. Madhavi Reddy Principal Scientist ICAR-IIHR, Bengaluru, Karnataka	Member
7	Dr. A. IshwaraBhat Principal Scientist ICAR-IISR, Kozhikode, Kerala	Member
8	Dr. Vinayaka Hegde Head (Crop Protection) ICAR-CPCRI, Kasaragod, Kerala	Membeer
9	Dr. T. Janakiram ADG (HS)-II ICAR, New Delhi	Member
10	Mr. P. Krishna Kumaran Finance & Accounts Officer ICAR-CTCRI, Trivandrum, Kerala	Member
11	Administrative Officer ICAR-IISR, Kozhikode, Kerala	Member

The IMC also includes two non-official members, who are yet to be nominated by ICAR, New Delhi

RECOMMENDATIONS OF THE THIRD MEETING OF THE VIII RAC

	Recommendations	Director's comments	Council's comment
1.	Whole genome sequencing and comparative genomics of black pepper, cardamom, ginger and turmeric may be initiated with the support of external funding.	Genome sequencing and comparative genomics of spices will be taken up as part of and CABin projects (cardamom) and in collaboration with NBPGR, New Delhi (black pepper). Proposal for an externally funded project will be submitted.	Agreed
2	Chemoprofiling and metabolomics of Zingiberaceae and Piperaceae spices for identifying novel molecules may be attempted in collaboration with NIIST, Trivandrum, Kerala and NIN, Hyderabad, Telengana.	Chemoprofiling and metabolomics of Zingiberaceae and Piperaceae spices for identifying novel molecules will be carried out in collaboration with NIIST, Trivandrum, Kerala and NIN, Hyderabad, Telengana.	Agreed
3	Micro/ nano based value added products may be given importance for increasing its bio availability and stability.	Work on nano curcumin for its increased bioavailability has already been initiated. Micro encapsulation of spice based phytochemicals will be taken as a priority research.	Agreed
4	Considering the importance of spices in the cropping system, the mega project on Integrated farming system approach should be strengthened.	Integrated farming system will be strengthened by planting grafts of nutmeg, garcinia, cinnamon seedlings and bush pepper plants.	Agreed
5	Emphasis should be given on development of IPM in spices using green chemicals and bio inputs like endophytes.	IPM packages involving green chemicals and endophytes have been developed for black pepper and cardamom. Studies on endophytic fungi has been initiated in cardamom and vanilla. Research on natural molecules of plant and microbial origin has been intensified in collaboration with CSIR-NIIST, Thiruvananthapuram.	Agreed
6	Research areas on Artificial Intelligence, Sensors and ICT may be given importance in future research programmes.	Agreed	Agreed

RESEARCH PUBLICATIONS

1. Aamir Khan, Johnson George, Rahul Singh Jasrotia, Sharon Aravind, Angadi U B, Mir Asif Iquebal, Manju K P, Sarika Jaiswal, Umadevi P, Anil Rai, Dinesh Kumar (2019) Plant virus interaction mechanism and associated pathways in mosaic disease of small cardamom (*Elettaria cardamomum* Maton) by RNA seq approach. Genomics. https://doi.org/10.1016/j.ygeno.2019.11.017.

2. Agisha V N, Kumar A, Eapen S J, Sheoran N & Bhai S (2019) Broad-spectrum antimicrobial activity of volatile organic compounds from endophytic *Pseudomonas putida* BP25 against diverse plant pathogens. Biocontrol Science and Technology 29: 1069-1089.

3. Akshitha H J, Umesha K & Prasath D (2019) Morphological characterization of ginger (*Zingiber officinale*) using DUS descriptors. Indian Journal of Agricultural Sciences 89: 1744–1747.

4. Alagupalamuthirsolai M, Ankegowda S J, Murugan M, Sivaranjani R, Balaji Rajkumar M & 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.

5. Anandaraj M, Sally K M, Eapen S J, Cissin J, Rosana O B & Bhai R S (2019) 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.

6. Anusree T, Bhai R S, Ahammed Shabeer T P & Dasharath Oulkar (2019) *Streptomyces* spp from Black Pepper Rhizosphere: A Boundless Reservoir of Antimicrobial and Growth Promoting Metabolites. Journal of Biologically Active Products from Nature, 9: 1 -23.

7. Bhai R S, Lamya M, Sangeeth K P & Sreeja K (2019) Vermicompost- A suitable medium for delivering consortium of bio-inoculants into the rhizosphere of black pepper. Acta Scientific Agriculture. 3: 98-104.

8. Bhai R S, Prameela T P, Vincy K, Biju C N, Srinivasan V & Nirmal Babu K (2019) Soil solarization and amelioration with calcium chloride or *Bacillus licheniformis* - an effective integrated strategy for the management of bacterial wilt of ginger incited by *Ralstonia pseudsolanacearum.* European Journal of Plant Pathology 154 : 903–917.

9. Bijitha P K & Bhai R S (2019) *Burkholderia cepacia* strain IISR CLRB5 mediated induction of defence related enzymes and phenolic compounds to enhance the

resistance in turmeric (*Curcuma longa* L.) to *Pythium aphanidermatum*. International Journal of Environment, Ecology, Family and Urban Studies 9: 21- 32.

10. Jose A J, Leela N K, Zachariah T J & Rema J (2019) Evaluation of coumarin content and essential oil constituents in *Cinnamomum cassia* (Nees& T. Nees) J. Presl. Journal of Spices and Aromatic Crops 28: 43–51.

11. Krishna P B & Eapen S J (2019) Development of a real-time PCR based protocol for quantifying *Radopholus similis* in field samples. Journal of Spices and Aromatic Crops 28: 52-60.

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ONGOING PROJECTS

Project I: Conservation, characterization and sustainable utilization of genetic resources of spices

1. Gen. XXVIII (813): Conservation and characterisation of *Piper* germplasm (2008-2020) [Dr. K.V. Saji, Dr. M.S. Shivakumar and Dr. Honnappa Asangi]

2. Gen.XIX (813): Conservation, characterisation, evaluation and improvement of *Zingiber* and *Curcuma* sp. (2007-2020) [Dr. D. Prasath, Dr. K.V. Saji, Dr. S. Aarthi., Dr. H.J. Akshitha & Dr. Honnappa Asangi]

3. Gen. XXXIII (813): Identification of core collection, characterisation and maintenance of cardamom germplasm (2012- 2020) [Dr. Honnappa Asangi, Dr. H.J. Akshitha, Dr. S. J. Ankegowda, Dr. Mohammed Faisal Peeran , Dr. Sharon Aravind Dr. M. Balaji Rajkumar, and Dr. K. Anees]

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

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

Project II: Development of trait specific and improved varieties of spices through conventional breeding and biotechnological approaches

6. Gen XXXI (813): Breeding black pepper for high yield, quality and resistance to stresses (2012- 2017) [Dr. M.S. Shiva Kumar, Dr. K. V. Saji, Dr. R. Suseela Bhai, 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, Dr. S. Aarthi & Mr. V.A. Muhammed Nissar]

8. Gen. XXXIV (813): Induction of variability in ginger through induced mutation for yield and disease resistance (2012-2017) [Dr. D. Prasath, Dr. R. Ramakrishnan Nair & Dr. R. Suseela Bhai]

9. Gen. XXXV (813) : Genetic improvement in turmeric through seedling selection and hybridization (2013-2020) [Dr. R. Ramakrishnan Nair & Dr. S. Aarthi]

10. ICAR- CIB 2: Computational and experimental biology approaches for delineation of selected secondary metabolite pathways and antimicrobial peptides (AMPs) in

major spices (2018-2020) [Dr. P.Umadevi, Dr. T.E. Sheeja, Dr. R. Praveena, Ms. R. Sivaranjani, Dr. Dinesh Kumar, Dr. Sarika, Dr. M.A. Iquebal & Dr. U.B. Angadi (IASRI)]

11. Biotech. XIV (813): DNA fingerprinting and barcoding in spices (Dr. T.E. Sheeja, Dr D. Prasath & Dr. M.S. Shivakumar (2018 – 2023)

12. Biotech. XV (813): Identification & characterization of gene editing targets for *Ralstonia* resistance in ginger (2018-2021) (Dr P. Umadevi & Dr D. Prasath)

13. Biotech. XVI (813): Survey, identification and characterization of unique ginger and turmeric landraces endemic to North Eastern Region (NER) of India (2018-2021) (Dr. D. Prasath & Mr. V. A. Muhammad Nissar)

14. DUS project:- (Dr. K.V. Saji, Dr. J. Rema, Dr. D. Prasath, Dr. S. Aarthi, Dr. M.S. Shivakumar)

Project III: Development of resource conservation and management technologies for improving productivity of spices

15. Phy. X (813): Evaluation of black pepper and cardamom elite lines for yield and quality under moisture stress (2010–2020) [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 & Dr. S. Hamza]

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. J. Rema, Dr. R. Suseela Bhai, Dr. K.V. Saji, Dr. D. Prasath, Dr. T.E. Sheeja, Dr. P. Rajeev & Dr. Ljio Thomas, Dr. Sharon Aravind, Dr. Honnappa Asangi & Mr. V.A. Muhammad Nissar]

18. ICAR-CPPHT-4: Network project on Micronutrient management in horticultural crops for enhancing yield and quality (2014-2020) [Dr. R. Dinesh, Dr. V. Srinivasan, Dr. S.J. Ankegowda, Dr. C. Sarathambal & Dr. S. Hamza]

19. AGR. XXXI (813). Development of fertigation schedule for better productivity in black pepper (2015-2018) [Dr. C.K. Thankamani, Dr. R. Dinesh, Dr. K. Kandiannan & Dr. M. Alagupalamuthirsolai]

20. 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)

21. ICAR-CPPHT 5: Delineation of spices zone beyond boundaries using climate analogue tools in changing climate (2016-19) [Dr K.S. Krishnamurthy, Dr. K. Kandiannan, Dr. M. Alagupalamuthirsolai & Mr. K. Jayarajan]

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

Project IV: Development, refinement and demonstration of integrated cropping system for improved total factor productivity in spices

23. 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]

Project V: Development, refinement and demonstration of organic production technology of spices for improved productivity, quality and soil health

24. ICAR-CPPHT-1: Network project on organic farming (2014-2020) [Dr. C.K. Thankamani, Dr. V. Srinivasan, Dr. R. Praveena, Dr. C. Sarathambal & Dr. S. Shanmughavel]

25. 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. S.J. Anke Gowda, Dr. C.N. Biju, Dr. C.M. Senthil Kumar & Mr. Honnappa Asangi)

Project VI: Development and refinement of post harvest handling, processing and value addition technologies for minimization of post harvest losses and diversified use of spices

26. PHT VII (813): Developing energy efficient processing technologies for spices (2013-2020) [Dr. E. Jayashree & Dr. N.K. Leela]

27. ICAR-CPPHT-3: Network project on high value compounds and phytochemicals (2014-2020) (Dr. N.K. Leela, Dr. Santhosh J. Eapen, Ms. R. Sivaranjani & Dr. K. Anees)

28. KERALA State Project Establishing a value chain incubation facility for processing of spices (ginger and nutmeg) through value addition for entrepreneurship development at Indian Institute of Spices Research, Kozhikode (2017 - 2019) (Dr. E. Jayashree & Dr.K. Anees]

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

Project VII: Bio-intensive management of pests in spices

30. ICAR-CP 1. ICAR-Consortium research project on borers in network mode (2014-2019) [Dr. C.M. Senthil Kumar & Dr. M. Balaji Rajkumar]
31. 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]

Project VIII: Integrated management of fungal and bacterial diseases of spices

32. Path. XXIV (813): Surveillance, documentation and development of decision support system for pests and diseases of major spice crops (2016-2020) [Dr. C.N. Biju, Dr. Santhosh J. Eapen, Dr. R. Suseela Bhai, Dr. A. Ishwara Bhat, Dr. C. M. Senthil Kumar, Dr. R. Praveena, Dr. Mohammed Faisal Peeran, Dr. C. Sarathambal, Dr. M. Balaji Rajkumar, Dr. Lijo Thomas, C. Sellaperumal, Dr. A. Jeevalatha & Mr. K. Jayarajan]

33. Path. XXV (813): Spatiotemporal dynamics in relation to ecology and epidemiology of fungal foliar diseases in ginger and turmeric and management (2016-2020) [Dr. R. Praveena, Dr. R. Suseela Bhai, Dr. A. Ishwara Bhat, Dr. K S. Krishnamurthy, Dr. A. Jeevalatha & Dr. C. Sarathambal)

34. Path. XXVI (813): Revisiting wilt diseases of vanilla and exploitation of associated microbiome for its management (2016-2019) [Dr. Mohammed Faisal Peeran, Dr. C. Sarathambal, Dr. M. Alagupalamuthirsolai & Dr. S. Aarthi]

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

36. Path. XXVII (813): Development of microbial biostimulants for growth promotion and disease resistance in major spices (2018-2021) [Dr. C. Sarathambal, Dr. A. Jeevalatha, Dr. Mohammed Faisal Peeran & Ms. R. Sivaranjani]

Project IX: Development of diagnostic kits and integrated management viral diseases of spices

37. DST CP-I: Identification, characterization and development of diagnostics for unknown viruses associated with cardamom and ginger (2016-2020) [Dr. A. Ishwara Bhat & Dr. C. N. Biju]

38. DBT CP-VII: Characterization of episcopal and endogenous pararetroviruses infecting black pepper (2018-2021) [Dr. A. Ishwara Bhat & Dr K.S. Krishnamurthy]

Project X: Improving knowledge and skill of stakeholders for increasing production of spices

39. DBT-SS1: Distributed Information Sub-Centre (2000-2019) [Dr. Santhosh J. Eapen, D. Prasath & K Jayarajan]

40. Ext. VI (813). Capacity building and front-line intervention programmes for (spice sector development in NE states and tribal empowerment (2014-19) (Dr. P. Rajeev & Dr. Lijo Thomas)

41. Eco. III (813): Economic analysis of technology, market dynamics and policy scenario in major spice crops (2014-19) (Dr. Lijo Thomas & Dr. P. Rajeev)

42. Kerala State – CPPHT-4: Enhancing the economic viability of coconut based land use systems for land use planning in Kerala state. (2014-2019) [Dr. V. Srinivasan, Dr. R. Dinesh, Dr. R. Praveena, Dr. Lijo Thomas, Dr. S. Hamza, Dr. K.M. Prakash, Dr. P.S. Manoj, Dr. P. Ratha Krishnan & KVK, Ernakulam)

New projects

1. Evolving high yielding, biotic and abiotic stress resistant cardamom lines through selection and hybridization [Dr. H.J. Akshitha, Dr. S. J. Ankegowda, Dr. M. Balaji Rajkumar & Dr. M. S. Shivakumar]
2. Development of drought mitigating physiological strategies in black pepper [Dr. M. Alagupalamuthirsolai, Dr. K.S. Krishnamurthy, Dr. C.K. Thankamani & Dr. C. Sarathambal]
3. Integrated management of mealy bug (Pseudococcidae: Hemiptera) infesting black pepper (2019 – 2022) [Dr. M. Balaji Rajkumar and Dr. C. M. Senthil Kumar]
4. Strategic approaches for management of black pepper diseases (2019 – 2024) [Dr. C.N. Biju, Dr. A. Ishwara Bhat, Dr. R. Praveena, Dr. A. Jeevalatha, Dr. Mohammed Faisal Peeran, Dr. C. Sellaperumal & Dr. Santhosh J. Eapen]

STAFF LIST

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

ADMINISTRATIVE STAFF

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5.	Sri. V C Sunil	Assistant
6.	Sri. V VSayed Mohammed	Assistant
7.	Ms. M Seema	Upper Division Clerk
8.	Mr. P Rajeev	Upper Division Clerk

9. Mr. P T Jayaprakash — Lower Division Clerk
10. Ms. Rebeena N — Lower Division Clerk
11. Mr. P K Rahul — Lower Division Clerk

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2. Dr. E Radha — Asst. Chief Technical Officer
3. Mr. K Jayarajan — Asst. Chief Technical Officer
4. Ms.N Prasannakumari — Senior Technical Officer
5. Mr. A Sudhakaran — Senior Technical Officer
6. Mr. K Krishnadas — Technical Officer
7. Ms. P K Chandravally — Technical Officer
8. Ms. N Karthika — Senior Technician (Lab. Tech.)
9. Mr. I P Vijesh Kumar — Technical Assistant
10. Mr. O G Sivadas — Technician
11. Mr. V S Binoy — Technician
12. Mrs. Hridya K S — Technical Assistant
13. Mrs. Shajina O — Technician
14. Mr. Vishnu B — Technician

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7. Mr. A R Rasmish — Technician
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2.	Dr. S Shanmugavel	Subject Matter Specialist (T 9) (Vet. Sc.)
3.	Mr. K M Prakash	Subject Matter Specialist (T 9) (Agro.)
4.	Dr. B Pradeep	Subject Matter Specialist (T-7-8) (Fisheries)
5.	Ms. A Deepthi	Subject Matter Specialist (T-7-8) (H. Sc.)
6.	Dr. K K Aiswariya	Subject Matter Specialist (T-7-8) (Pl. Prot.)
7.	Mr. T C Prasad	Technical Officer (T-5) (Driver)
8.	Mr. C K Jayakumar	Programme Assistant (T4) (Computer)

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4.	Dr. H J Akshitha	Scientist (Spices, Plantation Medicinal & Aromatic Plants)
5.	Dr. Balaji Rajkumar	Scientist (Agricultural Entomology)
6.	Dr. M S Shivakumar	Scientist (Genetics & Plant Breeding)

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3.	Smt. B M Lalitha	Skilled Support Staff
4.	Sri. Marigowda	Skilled Support Staff

WEATHER DATA

ICAR-IISR, Chelavoor, Kozhikode				
Month	**Rainfall**		**Temperature (°C)**	
	Total Rainfall (mm)	**Rainy days**	**Max. (Mean)**	**Min. (Mean)**
January	0.2	0	31.90	20.30
February	0.0	0	33.30	23.30
March	0.0	0	33.90	24.70
April	75.8	5	34.50	25.30
May	35.0	4	34.00	26.10
June	385.8	17	32.20	24.70
July	470.6	22	29.70	23.70
August	570.2	24	29.90	24.20
September	287.6	17	27.03	24.02
October	396.6	18	30.80	22.20
November	80.4	9	33.00	23.80
December	10.8	2	32.90	23.30
Total/Mean	**2313.0**	**118**	**31.95**	**23.80**

ICAR-IISR Regional Station, Appangala, Madikeri				
Month	**Rainfall**		**Temperature (°C)**	
	Total Rainfall (mm)	**Rainy days**	**Max. (Mean)**	**Min. (Mean)**
January	0.0	0	25.37	10.50
February	3.0	1	26.42	11.90
March	0.0	0	28.22	14.28
April	76.8	5	29.00	15.17
May	34.0	4	29.60	15.44
June	220.1	14	26.93	15.18
July	566.4	28	24.65	14.59
August	1421.7	29	24.12	14.08
September	683.0	25	24.15	14.13
October	302.8	26	25.04	14.63
November	7.0	1	25.32	13.87
December	41.6	2	25.03	12.15
Total/Means	**3356.4**	**135**	**26.20**	**13.80**

ICAR-IISR, Peruvannamuzhi, Kozhikode				
Month	**Rainfall**		**Temperature (°C)**	
	Total Rainfall (mm)	**Rainy days**	**Max. (Mean)**	**Min. (Mean)**
January	0.0	0	34.61	18.65
February	0.0	0	35.84	21.30
March	12.0	2	35.98	23.15
April	84.0	7	37.20	24.67
May	115.0	11	36.40	25.15
June	561.8	24	33.70	24.63
July	1116.6	29	29.94	23.82
August	1555.2	29	29.97	23.65
September	751.4	19	31.53	24.05
October	539.8	24	32.18	23.97
November	111.2	11	34.02	23.92
December	138.0	9	34.06	23.08
Total/Mean	**4985**	**165**	**33.78**	**23.34**

Important days observed at ICAR-IISR, Kozhikode

Day	Date
National Productivity week	12-18 February 2019
National Science day	28 February 2019
International Women's day	08 March 2019
World Water day	22 March 2019
World Environment day	05 June 2019
International Yoga day	21 June 2019
Institute Foundation day	01 July 2019
Swachhata Hi Sewa	11 September to 02 October 2019
Vigilance Awareness week	28 October to 02 November 2019
World Soil day	05 December 2019
Swachhata Pakhwada	16-31 December 2019

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