वार्षिक प्रतिवेदन
AnnualReport
2018-19


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भाकृअनुप-भारतीय मसाला फसल अनुसंधान संस्थान, कोषिक्कोड

ICAR-Indian Institute of Spices Research

Kozhikode

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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)
कोषिक्कोड, केरल, भारत Kozhikode - 673012, Kerala, India

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P R E F A C E

The Institute was blessed with the visits of Dr Trilochan Mohapatra, Secretary DARE and Director General, Indian Council of Agricultural Research and also Dr A.K. Singh, Deputy Director General (Horticultural Science), ICAR. All the programmes of the institute are aimed at doubling farmers income through increased productivity, development of climate resilient spices varieties and clean and pesticide free spices safe for consumption through various approaches. Recognising the potential for channelizing CSR funds, two private firms in Telangana, Verity Pvt Ltd and Apollo Hospitals are being provided with technical support and guidance for creative use of CSR funds in spice farming initiatives. The institute in a move to support tribal welfare, organized a workshop in collaboration with AICRPS on Processing and value addition in spices in Telangana and four turmeric boilers and four turmeric polishers were distributed among tribal FPOs involved in turmeric cultivation. Institute and AICRPS together organized a seminar on Spices production technologies in Pottangi, Koraput, a pure tribal hamlet for the benefit of tribal farmers during which mother garden of spices was established at HARS, Pottangi and allspice saplings which can cover one hectare area was provided to establish a mother garden of allspice, first of its kind in the country. The institute is very committed to develop spices hub in north east. All the initiatives by the Govt. to promote spices in north east are well attended by the institute. A project on survey, identification and characterization of unique ginger and turmeric landraces endemic to North Eastern Region (NER) of India has also been initiated. Institute took up Swachhata, Hindi and Vigilance programmes with great passion and commitment.

The institute was awarded Ganesh Sankar Vidyarthi Hindi Krishi Patrika Puraskar 2018 (second prize). AICRP on spices won the prestigious Chaudhary Devi Lal outstanding AICRP award for the best AICRP for the year 2017-18. Dr R. Dinesh, Principal Scientist received NAAS Recognition award in Soil, Water and Environmental Sciences for the year 2018. Dr E. Jayashree, Principal Scientist received the Commendation Medal Award 2018 of Indian Society of Agricultural Engineers. Dr V. Srinvasan received HS Mehta Memorial Best Young Scientist award. Dr D. Prasath, Principal Scientist was awarded the Fellow of Horticultural Society of India. Many of our scientists won best paper awards in various seminars. Our ITM-BPD unit signed thirteen license agreements for technology commercialization/services during 2018-19.

In terms of research achievements, one unique germplasm accession of black pepper with ~ 30 cm spike length was registered with ICAR-NBPGR, New Delhi. Effective technology for controlling bacterial wilt in ginger was developed and was demonstrated efficiently in eight AICRP centres. In turmeric, seed set observed in inbreds offer great potential in developing hybrids with desirable traits. A promising black pepper hybrid with high yield and promising drought tolerant black pepper and cardamom genotypes are under multilocation testing. Diagnostic tools for black pepper plants infected with endogenous and episomal form of *Piper yellow mottle virus* have been developed. Climate analogues sites for small cardamom and large cardamom were identified using CCAFS climate analogues tool which helps in area expansion for increasing production and export. Organic management of cardamom with sustainable yield with minimal

pesticide residue has been developed. The institute has developed solar dryer with high efficiency for curing turmeric. Three entomopathogenic fungi were documented from insects associated with spice crops which helps in deriving biocontrol strategies. Study on rain induced natural calamity estimates indicated crop loss in terms of expected production loss at state level over previous year in spices at 25138 tons (12541.1 million Rs).

XXIX AICRPS workshop was held at Dr YSPUH & F, Solan. Eleven varieties with traits such as climate resilient and stem gall resistant coriander, high quality nutmeg, high curcumin turmeric, high quality coriander *etc.* suitable for different agro ecological zones were recommended for release during the workshop. ICAR-IISR KVK organized live telecast of Pradhan Mantri Kisan Samman Nidhi inauguration by Hon'ble PM for the benefit 1500 farmers. KVK also organised Technology week (*Tharrum Thalirum*) for the benefit of about 800 farmers. ICAR IISR organized a district level seminar on Good agricultural practices for clean and safe spices on 22 December 2018 which was inaugurated by Dr. Trilochan Mohapatra, Director General, ICAR. The institute continued to develop and support seed villages for certified seeds production of turmeric in Andhra Pradesh and Telengana. ICAR-IISR and the Department of Horticulture, Government of Telangana jointly organized a consultative meeting to formulate a strategy for productivity enhancement of turmeric and its value chain development in the state. Institute distributed soil health cards to farmers based on soil test results. Quality and disease free nucleus planting material of spices were distributed to farmers from different regions of the country. Two national facilities which were established during the last year *viz.,* Pesticide Residue Lab and Value chain incubation facility for processing of spices have started functioning.

The present production and export levels of spices indicate that we need to produce more to be competitive in global market. This requires united efforts and committed work from the spices sector as a whole (research, development, industry, farmers and the field functionaries) which can bring back the lost glory.

I place on records the encouragement and guidance given by Dr T. Mohapatra, Secretary, DARE and Director General, ICAR. I acknowledge with thanks the cooperation and support received from Dr A.K. Singh, Deputy Director General (Horticultural Science) and Dr T. Janakiram, Assistant Director General (Horticultural Science). I thank the ICAR for the financial and administrative support for carrying out various programmes. Finally, I thank the editors for bringing out this publication in time.

K. Nirmal Babu

Kozhikode
15 June 2019

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कार्यकारी सारांश

काली मिर्च

आनुवंशिक संसाधन

आईसीएआरएनबीपीजीआर ,, शिलांग, मेघालय और आईसीएआरएनबीपीजीआर ,, त्रिश्शूर, केरल के सहयोग से नागालैंड मोकोकचुंग), तुएनसांग और मोन जिलोंऔर अंडमान और (निकोबार द्वीप समूह में जर्मप्लाज़म की खोज की गई। नागालैंड के जंगलों से काली मिर्च के चालीस अक्सेशनों और अंडमान और निकोबार द्वीप समूह से अक्सेशनों का संकलन किये थे। नागालैंड से पाँच नई 17 बोहेमेरियाफोलियम .पाइपर प्रजातियाँ जैसे पी, पीमाक्रून्स ., पीपोथिफ .ोर्मे, पीराइटिडोकार्पम . .समूह से दो नई प्रजातियों जैसे पी डिफ्यूसम तथा अंडमान और निकोबार द्वीप .और पी क्लाइपिटम को काली मिर्च जर्मप्लाज़म संग्रह में जोड़ा गया। .पेडिसेल्लेटम और पी

जर्मप्लाज़म पंजीकरण

जर्मप्लाज़म से एक काली मिर्च अक्सेशन आईसी)- (0619910को आईसीएआरएनबीपीजीआर-, नई दिल्ली द्वारा अपनी विशिष्ट स्पाइक लंबाई 29.3)सेके लिए पंजीकृत किया था। (.मी.

प्रजनन

उपज का मूल्यांकन

नौ आशाजनक प्रकारों में से, संकर एचपी 117x थोमनकोड़ी ने %32.5सूखी उपज के साथ 8.90 किलोग्राम प्रति सहायक वृक्ष की उच्चतम ताजा उपज अंकित की, इसके बाद थेवम सूखी %31.2) किलोग्राम 5.1 उपज के साथ मानक/प्रति सहायक वृक्ष)। एचपी 117x थोमनकोडी की स्पाइक की लंबाई %37.5 की सबसे लंबी सूखी उपज 780 और एचपी .मी.से 21थी।

काली मिर्च में फाइटोफ्थोरा प्रतिरोध को सुदृढ करने के लिए पेप्टाइड आधारित कार्यात्मक मार्कर

उच्च 10) मात्रात्मक अभिव्यक्ति (एस) और निम्न (आर)पेप्टाइड्सके साथ पेप्टाइड्स फाइटोफथोरा (संक्रमण के खिलाफ फाइटोफ्थोरा सहिष्णु किस्म आईआईएसआर शक्ति को दो वर्गों अर्थात्, सहिष्णु और अतिसंवेदनशील में फाइटोफ्थोरा प्रतिरोध के लिए अपने सहयोग का विश्लेषण करने के लिए लिया गया था। काली मिर्च के च पेप्टाइड्स आधारित प्राइमरों की जांच की जीनप्रकारों में पां 26 ने अन्य सभी जीनप्रकारों से नारायकोडी के भेदभाव को पहचान किया। इस प्राइमर को 5 गई। पीईपी संकरण कार्य में नारायकोडी पृष्ठभूमि के तहत संततियों का चयन करने के लिए इस्तेमाल किया जा सकता है। हालांकि यह दृष्टिकोण फाइटोफ्थोरा सुदृढकरने के उद्देश्य से है, प्रारंभिक परिणामों ने सुझाव दिया कि यह जीनप्रकारों के पेप्टाइड बारकोडिंग में सहायक हो सकता है।

पाइपर प्रजातियों में पाइपरअमिड्स का अनुमान

रिवर्स चरण के उच्च प्रदर्शन तरल क्रोमैटोग्राफी की एक संशोधित विधि (एचपीएलसी-आरपी) पाइपरलोंगुमिन) आधार पर पाइपरअमिड्स के, पाइपरलोंगुमिनाइन और पाइपेरिनका (अनुमान विभिन्न*पाइपर* प्रजातियों से एकत्र किए गए फलों में किया था। पाइपरलोंगुमिनाइन और पाइपेरिन को चार स्पीसीसों से पता लगाया था, जबकि पाइपरलोंगुमिनएक संभावित , से केवलऔर नये कैंसररोधी एजेंट है *उपीलोंगम* . और *पीसरमेंटोसम* . में पाया गया था।

जीन के चित्रण के लिए आरएनए अनुक्रमण

इल्लूमिना डेटा)Hiseq)के साथ डेटा के नैनोपोर अनुक्रमण और त्रुटि सुधार, विशेष रूप से द्वितीयक चयापचयों के जैवसंश्लेषण में शामिल जीनों के बेहतर चित्रण के लिए *पाइपर नाइग्रम* और *पीलोंगम* . के फलों से अलग आरएनए नमूनों का उपयोग करके किया था। टेरपेनॉइड अग्रदूत मेवलोनेट मार्ग में शामिल जीन एन्कोडिंग प्रोटीन (एमईपी) और मीथाइलएरीथ्रिटोल फॉस्फेट (एमवीए) को*पाइपर* ट्रांसस्क्रिप्टोम में पाए गए थे। वर्ग I और वर्ग II टेरपेन्स के संश्लेषण में शामिल प्रमुख जीन भी ट्रांसक्रिप्टोम्स में पाए गए थे। अल्फा -2 गुआनाइन-ऑक्सीडेज, रोटुंडोन के जैवसंश्लेषण में प्रमुख जीन, एक ऑक्सीजनयुक्त सेस्काइटरपीन की भी खोज की गई थी। पाइपरिडाइन एल्कलॉइड बायोसिंथेसिस में शामिल प्रमुख जीन भी उत्पन्न ट्रांसक्रिप्टोम डेटा से खोजे गए थे।

पादप स्वास्थ्य प्रबंधन

***फाइटोफ्थोरा* वियुक्तियों को संचारित काली मिर्च में पेरोक्सीडेज के विभेदक प्रवर्तन**

चेक के रूप में *फाइटोफ्थोरा* प्रतिरोधी किस्म, -04पी के 24साथ सात विमोचित प्रजातियों सहित ज गतिविधि का मूल्यांकन किया था। परिणामों ने काली मिर्च अक्सेशनों के उपयोग में पेरोक्सीडे 11 संकेत दिया कि*फाइटोफ्थोरा* के प्रति काली मिर्च पौधों की जांच के लिए जैव रासायनिक मार्कर के रूप में पेरोक्सीडेस गतिविधि का उपयोग किया जा सकता है।

***कोलेट्टोट्राइकम* पर विविधता का अध्ययन**

केरल और कर्नाटक का प्रतिनिधित्व करने वाले काली मिर्च में पर्ण ब्लाइट को उकसाने वाले *कोलोटोट्राइकम* के विभिन्न वियुक्तियों के रूप से विशेषता थी, जिसमें कॉलोनी, कोनिडियल और साथ ही आशंका वाले पात्रों और उनके आयामों के संबंध में काफी परिवर्तनशीलता देखी गई। *इन प्लांटा* रोगज़नक़ के अध्ययन में संकेत दिया गया है कि तीन वियुक्तियां) 1पन्नियूर ,अतिसंवेदनशील पोषकको संक्रमित कर सकते हैं (, जो प्रमुख पीले प्रभामंडल को प्रेरित करता है। जबकि, इन विट्रो अध्ययनों से पता चला है कि संक्रमण घंटे के अन्दर हो सकता है 72, जो कि एक्यूरल इनीशियल्स के गठन के कारण होता है। इन विट्रो उत्तरजीविता अध्ययनों से पता चला है कि सभी वियुक्तियां माइक्रोस्कोलरोटिया निर्माण करने में सक्षम थे।

काली मिर्च के पीलेपन से जुड़ी *पाइथियम* प्रजातियों का चरित्रांकन

काली मिर्च से जुड़े *पाइथियम* की विविधता का अध्ययन करने के लिए, केरल और कर्नाटक के विभिन्न क्षेत्रों में एक सर्वेक्षण आयोजित किया और जड़ नमूने एकत्र किए। 12 मृदा और 92 *पाइथियम* वियुक्तियों के से प्राप्त किए और (%67) और आठ जड़ नमूनों (%94.5) मृदा नमूनों 87 इन्हें रूपवैज्ञानिक चरित्रांकन किया गया, जिसमें तीन अलगसे कॉटनीअलग कॉलोनी आकारिकी जै-, क्रिसान्तमम तथा कॉटनी एरियाल मायसेलियम के साथ *पाइथियम* प्रजातियों की पैदावार हुई थी। उन्होंने अलगग्लोबोज़ स्पोरैंजिया का / अलग विकास दर वाले टोरुलेटड-अलग मीडिया पर अलग-37-15 के पीएच रेंज और 10.0 से 4.5 उत्पादन किया और वे°C की तापमान सीमा तक बढ़ सकते हैं। इनमें से, वियुक्तियों को उनकी रोगजनकता के लिए परीक्षण किया था और सभी 10 काली मिर्च के रोगजनक थे। इन वियुक्तियों के आणविक लक्षण वर्णन ने तीन प्रजातियों जैसे *पाइथियम डेलियन्सकुकुरबिटासियरम .पी* , और एक अज्ञात *पाइथियम* स्पी .की उपस्थिति का संकेत दिया।

एन्डोजीनस और एपिसोमल पीवाईएमओवी से संक्रमित काली मिर्च पौधों का विभेदन

पोलीमरेज़ चेन रिएक्शन प)ीसीआरपीसीआर आधारित परख का (आरटी) और रिवर्स ट्रांसक्रिप्शन (एक संयोजन*पाइपर येलो मॉटल वायरस* के एन्डोजीनस और एपिसोमल के साथ रोगबाधित काली मिर्च के पौधों के विभेदन के लिए विकसित किया।

पैरारेट्रो विषाणु का चरित्रांकन

पैरारेट्रो विषाणु अर्थात) 1 पाइपर डीएनए विषाणु ,PDV- (1और PDV-2, को पीसीआर के माध्यम से काली मिर्च की किस्मों में पांच विषाणु विशिष्ट प्राइमर जोड़े का उपयोग करके पाया गया। 20 ष्टता सीधे पीसीआर उत्पादों के अनुक्रमण द्वारा पुष्ट की गई थी।पीसीआर उत्पाद की विशि

जड़ गलन और धीमी हानि रोगों के प्रति आशाजनक जीवाणुक एवं एक्टिनोमाइसेट कंसोर्टिया का खेत मूल्यांकन

केरल के कोषिकोड जिले में किसानों के भूखंडों में जैव एजेंटों के संयोजन के साथ खेत परीक्षण तीसरे वर्ष भी जारी रहा। सभी उपचार उपज में नियंत्रण के साथसाथ मृदा जनित रोगजनकों के- दमन में बेहतर पाए गए। हालाँकि, %1बोर्डो मिश्रण छिडकाव के साथ स्यूडोमोनस पुटिडा और बेसिलस मेगाटेरियम + 25बीपी)बीपी (17का उपचार अन्य उपचारों की अपेक्षा बेहतर था।

काली मिर्च के म्लानी रोगों के लिए क्षेत्रवार व्यापक एकीकृत कीट प्रबंधन

आसपास के किसानों के ख-ेतों की तुलना में *टी* + *हर्जियानम .पोचोनिया क्लैमिडोस्पोरिया*, बीएम कार्बोसल्फान से उपचारित किसी भी खेत में + एमजेड-कार्बोसल्फान और मेटालैक्सिल + सीओसी + इस परियोजना के तहत स्वस्थ रोग मुक्त रोपण सामग्री के कोई बीमारी नहीं दिखाई पडी। उत्पादन के लिए तकनीकोंको अपनाकर काली मिर्च की दो नर्सरियों की स्थापना की गई थी।

इलायची

आनुवंशिक संसाधन

नेशनल एक्टिव जर्मप्लाज़म साइट (एनएजीएस), अप्पंगला, कर्नाटक में कुल इलायची 621 बनाए जा रहे हैं जर्मप्लाजॉम अक्सेशन, जिनमें अप्पंगला से अक्सेशन शामिल हैं 423; पम्पाडुम्पारा से अक्सेशन 101; मुडिगेरे से अक्सेशनें हैं। 56 और सकलेशपुरा से 41

प्रजनन

पीईटी III में संकर शामिल थे जो उपज और कीट एवं रोगों की 1 प्रजातीय एफ-अंतर 23 तीन वर्षों के पूलित आंकड़ों से प्रतिक्रिया के लिए आयोजित किए थे।, नौ श्रेष्ठ संकरों की लघुसूची बनायी और लघुसूचित किए गए संकरों के कैप्सूल वर्णों को अंकित किया गया। नौ लघुसूचित संकरों में आईसीआरआई 4× आईआईएसआर विजेता में सबसे ताजा 1090)ग्रामऔर साथ ही प्रति पौधे (236) की कैप्सूल सूखी उपजग्रामअंकित की गई। आईसीआरआई (4× आईआईएसआर विजेता ((14के कैप्सूल ग्लोबोज़, मोटे 11.06)मिऔर रंग में धुंधला हरे रंग के होते हैं। (.मी .

जैविक खेती

रासायनिक प्रबंधन प्रणाली की तुलना में जैविक, एकीकृत प्रबंधन प्रणाली में उल्लेखनीय रूप से उच्च OC, N, P, Ca, Mg, Fe और Zn उपलब्धता अंकित की गई। जैविक पोषक तत्वों के स्रोतों में,

NC + VC ने संयुक्त रूप से FYM + NC (और (प्लॉट / किलोग्राम 0.85VC (/ किलोग्राम 0.81 12) के बाद प्रति प्लॉट (प्लॉटपौधोंशुष्क कैप्सूल अंकित किया। रासायनिक .ग्रा .कि 1.3 में (1.3) प्रबंधनकि 0.9) और जैविक प्रबंधन (प्लॉट / ग्रा.किके बाद एकीकृत प्रबंधन (प्लॉट / ग्रा. मंे उच्च ताजा कैप्सूल की उपज 1.48)किलोग्राम प्राप्त हुई। स्पिनोसाद और (प्लॉट / *लेकानिसिलियम* एंड स्पिनोनेड के साथ ट्राइक्रोडर्मा और पॉचोनिया लगाने के साथ, प्रकंद गलन की कोई गंभीर आपतन और < %5थ्रिप्स हानि के लिए निरीक्षण किये प्लॉट में प्रकन्द गलन का कोई नुकसान ध्यान में नहीं आया।

इलायची में थ्रिप्स और तना बेधक के प्रति संकरों की स्क्रीनिंग

कैप्सूल बोरर और थ्रिप्स के स्वाभाविक आपतन के लिए सात इलायची संकरों की संततियों की जांच की गई। संकरों की चुनिंदा संततियों के कैप्सूल पर थ्रिप्स और बोरर्स की प्रतिशतता क्रमशः -2.17 %8.64और %7.48-2.55थी।

वैन क्लियरिंग रोग संक्रमित इलायची के पौधे से जुड़े न्यूक्लियोरहबडोवाइरस का चरित्रांकन

पहली बार इलायची के वेन क्लियरिंग क्क्लियोरहब्डोवाइरस के संबंध रोग के साथ एक न्यू (कोके कंद्) में अध्ययन की रिपोर्ट है। इसके कारक वाइरसको सफलतापूर्वक एफिड, पैंटलोनिया कैलाडी का उपयोग करके स्वस्थ इलायची पर प्रसारित किया था। कारक वाइरस की पहचान sRNA अनुक्रमण और आरटीपीसीआर-, क्लोनिंग और अनुक्रमण के माध्यम से उसी के बाद के सत्यापन के आधार पर स्थापित की गई थी। अनुक्रमित क्षेत्र ने न्यूक्लियोहाबडो वाइरस न्यूक्लियोकैप्सिड)N), फॉस्फोप्रोटीन)P), मूवमेंट प्रोटीन)P(3, मैट्रिक्स प्रोटीन)M), ग्लाइकोप्रोटीन)G) और पोलीमरेज़)L) जीन में न्यूक्लियोरहबडोवाइरस के साथ पहचान दिखाई।

अदरक

आनुवंशिक संसाधन

खेत जीन बैंक में छः सौ अडसठ अदरक अक्सेशनों का उपयोग किया जा रहा है। जर्मप्लाज़म संग्रह को संबंधित जेनरा को नागालैंड 30 और .आठ ज़िंजीबर स्पी ,अदरक अक्सेशनों 27, मणिपुर और अंडमान एवं निकोबार द्वीप समूह से एकत्र करके समृद्ध किया गया।

चरित्रंकन

नये ईएसटीएसएसआर मार्कर का विकास-

अदरक ट्रांसक्रिप्टोम डेटा के माइनिंग के परिणामस्वरूप) सिंपल सीक्वेंस रिपीट 16790SSR) हुए और इनकी पहचान स्वदेशी में संभावित आणविक मार्कर के रूप में हुई। इसके अलावा, अनुक्रमों के कोडिंग क्षेत्र में गई थी। एसएसआर की पहचान की 4597SSR युक्त जीन अनुक्रमों के आधार पर, प्राइमर जोड़े को य 25ादृच्छिक रूप से चुना और संश्लेषित किया गया और पोलीमोरफिसम के मूल्यांकन के लिए उपयोग किया गया। छः प्राइमर जोड़े पोलीमोरफिक थे और अदरक संग्रह के 43 बीच पोलीमोरफिसम का पता चला।

उपज का मूल्यांकन

यह परीक्षण एआईसीआरपीएस सीवीटी)) वर्ष ,के दौरान आईआईएसआर 2018-2015 प्रायोगिक प्रक्षेत्र, पेरुवन्नामुषि, केरल में सात अलगअलग प्रविष्टियों और एक राष्ट्रीय चैक आईआईएसआर-वरदा के साथ किया गया। अदरक अक्सेशनों में 20.69) 247 अक्सेशन (जमा) अधिकतम उपज ,

टन/ हेक्टे.) में अंकित की गयी उसके बाद रयोजनीरो-डी- (17.75t/ha) और एसई 8681 15.81)टन/हेक्टे.) है।

उत्परिवर्तन प्रजनन

दस M1V) 102 और 5M1V (11म्यूटेंट बनाए जा रहे हैं। पाइथियम स्पी2 / 0.5 वी) ., आर 0.8 (4 / 1.25 और आर 1 /के प्रति तीन संभावित म्यूटेंट की पहचान की गई और राल्स्टोनिया सोलनसीरम 2 / 0.5 एचपी), एचपी (1 / 0.5 और एम 15 / 0.5के प्रति तीन संभावित म्यूटेंट का गुणन किया गया।

पॉलिप्लोइड का संकेत

सीमहिमा की प्रकन्द .वी. कलियों को कोलचिसिन को पोलीप्लोयिड में घंटे के लिए विभिन्न 48 %0.025 अंकुरण सांद्रता में डूबा हुआ था। अधिकतमक्कोलचिसिन में अंकित किया गया। सभी सफल पौधों को आगे के अध्ययन के लिए स्थापित किया गया है। (15)

माइक्रोर्हिज़म उत्पादन

अदरक प्रजातियों आतिरा), महिमा, वरदासोना) और हल्दी प्रजातियां (, सुरंजना, वर्णाको सूक्ष्म (हल्दी के पौधों का 1500 अदरक और 3000 में रूप से संरक्षित किया गया और नर्सरीरोपण किया गया और उसे नर्सरी में पॉली बैग में कठोर की जाएगी।

फसल अवशेषों के पोषक खनिज की गतिशीलता

एफवाईएम और राइज़ोस्फियर प्राइमिंग के साथ और उसके बिना अदरक में आमतौर पर इस्तेमाल किए जाने वाले फसल अवशेषों याग्लिसिरिडि), आइलैंथस और मिश्रित पत्तियोंके पोषक (खनिज की गतिशीलता का अध्ययन किया गया। फसल अवशेषों से NO-3N खनिज की दर अदरक के बिना उपचार पर अदरक के साथ उपचार में काफी अधिक पाई गई, जो कि राइजोस्फीयर प्राइमिंग प्रभाव को दर्शाता है। ग्लिरिसिडिया मल्च में उच्चतम NO-3N और NH-4N पाया गया। कुल N खनिजकरण की दर तब अधिक थी जब एफवाईएम या अदरक के बिना फसल अवशेषों का उपचार किया जाता था और उच्चतम तब होता है जब ग्लिरिसिडिया मल्चस का उपयोग उच्च मिट्टी में पीएचओसी , एम जोड़ और अधिक बनाने और मृदा एंजाइम गतिविधियों और माइक्रोबियल बायोमास एफवाई अदरक राइज़ोस्फियर में देखा गया था। एफवाईएम प्राइमिंग में बिना एफवाईएम की अपेक्षा सूखे अदरक उत्पादन में क्रमशः %48और %88, %100और %75N, P और K अपटेक की वृद्धि हुई। भले ही मिश्रित पत्तों के बाद ग्लिरिसिडिया में संचित नाइट्रोजन और पोटैशियम अधिक था और उसके बाद मिश्रित पत्तों में ,लेकिन पौधे द्वारा कुल अपटैक एयिलांथस में अधिक थी।

अदरक पर बाइपोलारिस रोस्ट्राटा के संक्रमण तंत्र

अदरक पर बाइपोलारिस रोस्ट्राटा के संक्रमण तंत्र पर किए गए अध्ययनों से पता चला है कि अंकुरित, अदरक के अंकुरित पत्तियों की सतह पर संचारित कोनिडिया,कोनिडिया के दोनों ध्रुवों से रोगाणु ट्यूब उत्पन्न होता है। इन रोगाणु ट्यूबों की नोक से, 15.34-9.02× 4.12– 10.57µm अन्तर का uni- और मल्टी लोबेड एप्रेसोरिया का गठन किया गया। इनसे, संक्रामक हाइफ़े सीधे एपिडर्मल कोशिकाओं या पेट के माध्यम से ऊतकों में प्रवेश करती हैं। माध्यमिक हाइप , प्राथमिक हाइप की अपेक्षा पतले है, बड़े पैमाने पर अंतर और इंट्रासेल्लुलार रूप से बढ़ते हैं, एक कॉर्टिकल सेल से अगले तक सेल की दीवारों से गुजरते हैं।

अदरक में शारीरिक और जैव रासायनिक परिवर्तन - बाइपोलारिस संपर्क

अदरक के बाइपोलारिस रोस्ट्राक्टा संपर्क के दौरान होने वाले शारीरिक और जैवरासायनिक परिवर्तन - को ग्लासहाउस स्थितियों के तहत अध्ययन किया गया। जैव रासायनिक पैरामीटर्स जैसे क्लोरोफिल त्रिम रूप से और प्रोटीन में कमी पाई गई जबकि इलेक्ट्रोलाइट लीकेज में नियंत्रण की अपेक्षा कृ संचारित अदरक के पौधों में वृद्धि हुई।

अदरक के प्रमुख रोगजनकों के प्रति पिगमेंटेड मिथाइलोबैक्टीरियम

एक नवीन फैलोस्फियर जुड़े गुलाबीरंजित-, ग्राम नकारात्मक, मोटाइल रॉड आकार के जीवाणु)GPPFM (13को जैसे पीपीएफएम से सूचीबद्ध किया था। अदरक के रोगजनकों 60*मैक्रोफोमिना फेजोलिना, स्क्लेरोटियम रोल्फसी, पाईथियम माइरोटिलम, कोलेटोट्राइकम ग्लोयियोस्पोरियोइड्स* और *फुसैरियम ऑक्सीस्पोरम* के प्रति इन विट्रो परख में %75 - 40की सीमा में प्रतिरोधक प्रभाव दिखाया। खनिज घुलनशीलता सूचकांक, IAA उत्पादन और माइकोलिटिक एंजाइमों और साइडरोफोर के उत्पादन का अध्ययन किया गया। जीवाणु को मृदा के साथसाथ पर्ण छिड़काव के रूप में प्रयोग - करने पर*इन प्लांटा* मूल्यांकन में बेहतर राइज़ोम और रूट गठन दिखाया गया। वियुक्ती)GPPFM (13को MDH (mxaF) जीन विश्लेषण द्वारा मेथिलोबैक्टीरियम के एक स्पीसीस के रूप में पहचान की जाती है और *एम .प्लाटानी* और *एमइन्नर्स* . को %96समानता दिखाई गई।

बेसिलस लिकेनिफॉर्मिस के लिए एक उपयुक्त संयोजन का विकास

बेसिलस लिकेनिफोर्मिस GAPके एक उपयुक्त संयोजन को विकसित करने के लिए 107, अदरक के जीवाणु म्लानी के प्रति एक संभावित जैवनियन्त्रण कारक, ब्रोथ कल्चर के साथ तुलना में चारकोल और टाल्क जैसे दो विभिन्न वाहक का परीक्षण किया गया। तीनों योगों ने *इन विट्रो* स्थितियों के तहत सेल व्यवहार्यता को दिनों से अधिक समय तक बनाए रखा जबकि चारकोल संयोजन ने 100 सेल दिखाई। राईजोमदिनों के बाद उच्चतम व्यवहार्य 100प्राइमिंग के रूप में रोपण (सीड कोटिंग) 45 के समय और, दिनों में मिट्टी में चारकोल का प्रयोग करने पर 90 और 60, रोग आपतन में काफी कमी हुई और पौधे की ऊंचाई, टिलर की संख्या और प्रकंद विकास में वृद्धि होती है।

अदरक के *पाइथियम मायरियोटिलम* और मृदु गलन पर सिलिकेट के कवकनाशी गतिविधि

सोडियम और पोटेशियम सिलिकेट और सोडियम मेटा सिलिकेट के ठोस और तरल रूपों के प्रभाव को *इन विट्रो* स्थितियों में *पीमाइरियोटाइलम* . की वृद्धि पर परीक्षण किया गया। सोडियम मेटासिलिकेट बकि सोडियम और पोटेशियएमएम पर कवक की वृद्धि को सीमित करता है ज 70म सिलिकेट %3 एकाग्रता पर मायसेलियल विकास को प्रतिबंधित करता है। सूक्ष्म अध्ययन से हाइपल डिस्टॉर्शन और सिकुड़न जैसी मायसेलियल मॉर्फोलॉजी में परिवर्तन का पता चला। बेटी हाइप की निरंतर वृद्धि और छिटपुट गठन को रोकना भी सिलिकेट्स के साथ देखा गया। *इन प्लांटा* अध्ययन में नियंत्रण की अपेक्षा पौधे की वृद्धि दर में समग्र वृद्धि देखी गई। सिलिकेट अणुओं वाले चुनौती वाले पौधों ने नियंत्रित करने की अपेक्षा रोग आपतन में कमी देखी गई।

अदरक में बैक्टीरियल विल्ट की आईडीएम पर खेतीगत प्रदर्शनी

अदरक में जीवाणु म्लानी के प्रबंधन पर अग्रपंक्ति प्रदर्शन नौ एआईसीआरपी केंद्रों और कर्नाटक में एक किसान खेत में किए गए। प्रत्येक स्थान में, %3कैल्शियम क्लोराइड के साथ मिट्टी की

खुदाई, बेसिलस लिकनिफॉर्मिस के साथ सीड प्राइमिंग और मृदा ड्रेंचिंग का मूल्यांकन सौर और गैर-त खेतों में किया गयासौरीकृ और प्रत्येक केंद्र के अनुशंसित पीओपी के साथ तुलना की गई। कैल्शियम क्लोराइड और बैसिलस लाइकेनफॉर्मिस दोनों के साथ संशोधित सौरीकृत प्लॉटों में पौधों का अंकुरण और स्थापना काफी बेहतर थी। सामान्य तौर पर, गैर सौरीकृत खेतों के साथ तुलना करने पर सौरीकृत खेतों ने वृद्धि और उपज में महत्वपूर्ण सुधार दिखाया।

अदरक के क्लोरोटिक फेक रोग से जुड़े परिवार, क्लोस्टरोविरिडे और टॉम्बुस्विरिडे से संबंधित वायरस की विशेषता

दो अलगअलग वाइरस-, एक जीनससे संबंधित (फैमिली क्लॉस्टरोविरिडे) एम्पीलोवाइरस ,, और दूसरी विशिष्ट स्पीसीस एक नई जीनस टॉम्बुसविरिडे परिवार से संबंधित एवं अदरक क्लोरोटिक फ्लेक रोग प्रभाव से संबंधित अध्ययन के लिए वर्तमान अध्ययन रिपोर्ट करता है जिसमें अदरक के साथ एक नई जीनस शामिल है। कारक वायरस की पहचान sRNA अनुक्रमण और आरटीपीसीआर-, क्लोनिंग और अनुक्रमण के माध्यम से उसी के बाद के सत्यापन के आधार पर स्थापित की गई थी। यह *एम्पेलोवाइरस* के आपतन की पहली रिपोर्ट है और परिवार में टॉमबसविराइडे संक्रमित अदरक में अवांछित जीनस से संबंधित वाइरस है। नई पहचान वाले जीनस के लिए जिंजीवाइरस नाम प्रस्तावित किया गया है, और *जिंजर क्लोरोटिक* फ्लेक *से जुड़े वायरस*) *1*-GCFaV- (1नाम को इस प्रजाति, जिंजीवाइरस के तहत नई प्रजातियों के रूप में प्रस्तावित किया गया है। जीनस *एम्पीलोवाइरस* के तहत नई प्रजातियों के लिए नाम, जिंजर क्लोरोटिक फ्लेक जुड़े वाइरस) 2-GCFaV- (2प्रस्तावित है।

हल्दी

आनुवंशिक संसाधन

खेत जीन बैंक में नागालैंड और अंडमान और निकोबार द्वीप समूह से एक हजार चार सौ चार *कुरकुमा* अक्सेशनों को बनाए जा रहे हैं। जर्मप्लाज़म कंजर्वेटरी को करकुमा लोंगा और छः 11 *कुरकुमा* स्पीसीस के साथ समृद्ध किया गया था।

चरित्रांकन

विभिन्न रूपात्मक लक्षणों के आधार पर हल्दी के अक्सेशनों का चरित्रांकन किया गया। प्रत्येक 150 गुणात्मक वर्ग अंकित किए गए। 10 मात्रात्मक और 12 हल्दी अक्सेशन के लिए

अतिरिक्त लंबी और मोटे हल्दी लाइनों का विकास

सेलम लोकल के चार (प्रदेश आंध्र) और म्यिदुकुर 12 के (तमिलनाडु के ईरोड एवं सेलम जिले) अक्सेशनों को एकत्र करके बहुगुणन किया गया। इसके अलावा, जर्मप्लाज्म से हल्दी के खुले 31 परागित बीजों को एकत्र किए गए और अतिरिक्त लंबी हल्दी जीनोटाइप को विकसित करने के लिए बीज पौधों की संततियों को बनाया। अंकुरित होने पर अंकुरण पाया गया, को अंकुरित बीजों 63 कियाा गया, सत्रह बीज पौधों का अन्तरण किया गया।

संकर और बीजपौधों का मूल्यांकन

चेलवूर में तीन बीज पौधों और तीन संकरों की प्रतिकृति परीक्षण ने एसएलपी ^{2}एम 3 में 2/359बेड मे । तीनों किलो ग्राम की उपज अंकित की 10.36 में 12/65 किलोग्राम ताज़े और एसएलपी 11.3 संकर औरएक बीजपौधे ने किलो से कम उपज अंकित की। चार पहली पीढ़ी के स्व परागित 10 (63 = एन 2) 65 अक्सेशन संख्या, से वर्ष में दो पुष्पित हुए। इनमें से एक में 2019-2018

लिंगी विकृत पुष्प आकृति विज्ञान था और उत्पादित सभी सात फूल सामान्य हल्दी के पौधों में उभय फूलों की तुलना में अंडाशय और स्टिग्मा के साथ एक छोटी शैली वाले मादा फूल थे।

आईआईएसआर द्वारा विकसित सौर सुखाने की मशीन का प्रदर्शन मूल्यांकन

आईसीएआरआईआईएसआर-, कोषिक्कोड द्वारा विकसित सौर ड्रायर का मूल्यांकन किया गया था और यह देखा गया कि हल्दी के लिए सुखाने का समय सौर ड्रायर के लिए थोड़ा अधिक था, क्योंकि यह सूर्य की तुलना में बहुपरत सुखाना था जो एकल परत सूख रहा है। कटे हुए हल्दी सूखने के लिए सौर सुखाने और सूरज सुखाने दोनों में दिन लगता है। विभिन्न तरीकों से सूखी हल्दी की अंतिम 7 बदलाव नहीं हुआ। ग नमी में कोई महत्वपूर्ण ुणवत्ता मूल्यांकन से पता चला कि सूर्य के सूखे हल्दी की तुलना में प्राथमिक उपापचयों की अवधारण सौर ड्रायर सूखे हल्दी में अधिक थी। कटे हुए हल्दी को सौर ड्रायर में सूखाने पर सूखे हल्दी की कुरकुमिन के लिए %4.61का अधिकतम मूल्य अंकित किया।

हल्दी के पादप परजीवी नेमेटोड के लिए सर्वेक्षण

तमिलनाडु के कोयम्बटूर, ईरोड, सेलम और विल्लूपुरम जिलों के हल्दी बढ़ते क्षेत्रों से एकत्र किए गए नमूनों में और केरल, कर्नाटक और उत्तर पूर्व से एकत्र किए गए यादृच्छिक नमूनों में रूढनॉट - र्रोइंग और क्षत ननेमटोड का उच्च आपतन देख लिया। ब ेमेटोड भी मौजूद थे। सामान्य आपतन के अन्य नेमाटोड थे *रोटेलेनक्युलस रेनफोर्मिस, हॉपोलैमस स्पीसीस* और हेलिकोटाइलेनचस स्पीसीस। क्षत नेमेटोड को कोयंबत्तूर जिले के अलंदुर और तण्णीरपंतल क्षेत्र (प्राटिलेनचस स्पीसीस), इरोड जिले के भवानीसागर और गोबीचेट्टिपालयम क्षेत्र, कर्नाटक में शिमोगा और उत्तर पूर्व क्षेत्रों में नागालैंड में देखा गया।

अदरक एवं हल्दी

शूट बोरर का मेर्मिथिड परजीविता)*कॉनोगीथेस पंक्टिफेरलिस*(

मर्मिथिड नेमाटोड परजीविता पोषक कीट आबादी में %50मृत्यु दर को पार करने वाले कॉनोगीथस पंक्टिफेरलिस में एपीज़ोटिक स्तरों तक पहुंच गया और परजीविता क्रमशः अदरक और हल्दी से एकत्र *सी पंक्टिफेरालिस* .में %80.6 से 18.2और %66.7 से 17.9तक रहा। मर्मिथिड द्वारा पोषक परजीविता का स्तर सकारात्मक रूप से वर्षा के साथ सहसंबद्ध था और अधिकतम तापमान से नकारात्मक रूप से प्रभावित था। आंशिक 18S छोटे राइबोसोमल सबयूनिट जीन क्षेत्र के आणविक विश्लेषण और अन्य मर्मिथिड अनुक्रमों के साथ फाइलोजेनेटिक विश्लेषण ने संकेत दिया कि नेमाटोड विभिन्न जनीरा से संबंधित अन्य नेमाटोड के साथ जुड़ा हुआ है और इसलिए इसे एक विशिष्ट जीन के लिए जिम्मेदार नहीं ठहराया जा सकता है।

कीटनाशकों का खुराक अनुकूलन

तीन कीटनाशक स्पिनोसाद), फ्लुबेंडियामाडे, क्लोरेंट्रानिलिप्रोल(, जो पहले के परीक्षणों में प्रभावी पाए गए और साथ ही क्लोरेंट्रानिलिप्रोले और स्पिनोसाद के छिड़काव के साथ एक उपचार किया गया, जो कि शूट बोरिंग संक्रमित अदरक और हल्दी के प्रति खुराक अनुकूलन के लिए पेरुवण्णामुषी के खेत में लगातार दूसरी बार परीक्षण किया गया। परीक्षण किए गए सबसे कम खुराक 0.3)मिली लीट /र पानीपर भी कीट के प्रबंधन में सभी कीटनाशक बहुत प्रभावी थे। वैकल्पिक रूप से (लिप्रोल और स्पिनोसाद के छिड़काव का उपचार भी कीट को नियंत्रित करने में समान रूप क्लोरान्ट्रानि

से प्रभावी था। एक किसान द्वारा विकसित वनस्पति संयोजन भी कीट को नियंत्रित करने में प्रभावी पाया गया।

अदरक और हल्दी के रोगजनकों के खिलाफ विरोधियों का मूल्यांकन।

ट्राइकोडर्मा अर्थात *ट्राइकोडर्मा एरीनेसम* (1आईआईएसआर एपी) और *टी*आईआईएसआर) *एट्रोविरिडे* . टीएल (1के दो उपभेदों को *इन विट्रो* स्थितियों के तहत *पाइथियम मायरियोथटिलम, पी* . *अफानिडेरमाटम* और *फुसैरियम ऑक्सीस्पोरम* के प्रति प्रभावी पाया गया। बैक्टीरिया के उपभेदों जैसे , *स्यूडोमोनास* स्पीसीस और *बेसिलस* स्पीसीस को *बाइपोलारिस रोस्ट्राटाकोलेटोट्राइकम* , *ग्लोयियोस्पोरियोयिड्स* और *सीकैप्सीसी* . के विकास को रोकने के लिए पाए गए।

वैनीला

आनुवंशिक संसाधन

पैंसठ *वैनिला प्लैनिफोलिया* और ग्यारह *वैनिला* स्पीसीस को पॉलीहाउस में संरक्षित किया जा रहा है। जर्मप्लाज़म संरक्षणशाला में असम और अंडमान द्वीप समूह से एकत्र किए गए छः वैनिला स्पीसीस को जोड़कर समृद्ध किया गया।

वैनिला रोगजनकों का जैविक नियंत्रण

पांच *चेटोमियम* स्पीसीस में, FVREP %56.88 ने 4और %83.73को क्रमशः *फ़ाइटोफ़्थोरा मियादी* और *कोलेलेटोट्राइकम ग्लोयियोस्पोरियोइड्स* के नियंत्रण पर प्रतिरोधक दिखाया। इसने *साइडरोफोरस* (आयरन चेलेशन), सेल्लुलस का उत्पादन किया और हाइड्रोलाइज़ स्टार्च पाया गया।

पीमियादी . के प्रति बैक्टीरियल जीवाणुओं की जांच करने पर 31, चार वियुक्तियों जैसे, VSEN7, VSEN8, VREP और 2VAREN %50 में 4से अधिक प्रतिरोधकता और तीन वियुक्तियों)VLEN2, VLEN और 3VSEP (3में *सी ग्लोयियोस्पोरियोयिड्स* .के प्रति %50से अधिक प्रतिरोधकता दिखायी। उनमें से कोई भी *एसरो .लफसी* के प्रति प्रभावी नहीं थे।

वृक्ष मसाले

आनुवंशिक संसाधन

जायफल

दक्षिण अंडमान, मध्य अंडमान, ग्रेट निकोबार और लिटिल निकोबार के विभिन्न द्वीपों का सर्वेक्षण करके *माइरिस्टिका एंडमानिका* के तीन अक्सेशन, *हॉर्सफील्डिया* स्पीसीस और नीमा स्पीसीस के चार अक्सेशन के दो अक्सेशन को एकत्र किया। एनबीपीजीआर त्रिश्शूर से भी ,*माइरिस्टिका एंडमानिका* के दो और *हॉर्सफील्डिया* और नीमा स्पीसीस में से एक एक अक्सेशन को एकत्र किया गया।

दालचीनी

अंडमान और निकोबार द्वीप समूह से दालचीनी के तीन अक्सेशन, देहरादून से *सीकैम्फोरा* . के तीन और निकोबार से दालचीनी की एक वन्य स्पीसीस को एकत्र करके जर्मप्लाज़म में जोड़ा गया। मेघालय और असम से *सिनामोमम* स्पीसीस के छः अक्सेशन एकत्र किए गए।

गार्सीनिया

अंडमान और निकोबार के विभिन्न द्वीपों से *गार्सिनिया नर्वोसा, जीकावा ., जीकिडिया ., जी . धनिकहरिनेसिस*और एक अज्ञात प्रजाति एकत्र की गई। आईसीएआरएनबीपीजीआर क्षेत्रीय स्टेशन-, त्रिशूर से *जीइंडिका* . के तीन उच्च उपज वाले अक्सेशन प्राप्त किए गए। गार्सिनिया की दो विदेशी स्पीसीस जैसे *जीस्कोम्बुर्गकियाना* . और *जीकोला* . को किसानों के खेत से एकत्र किया गया। मेघालय और असम से *गार्सिनिया*) *जीलैंसिफोलिया ., जी,पेडुंकुलाटा . जी किडिया* .और *जी* (*कोवा* . या गया।के सात अक्सेशनों को एकत्र कि

सामान्य

बेहतर प्रजातियों के केन्द्रक रोपण सामग्रियों का उत्पादन

पॉच सौ इकासी किसानों को काली मिर्च की उन्नत प्रजातियों का वितरण किया गया और मुख्यालय से कतरनों का क्रय किया गया। क्षेत्रीय स्टेशन 12000 और क्षेत्रीय स्टेशन से 70000, अप्पंगला से अदरक के बीज का लगभग 475 सकेर्स और 2885 टन बीज उत्पादित किये और इलायची के 2.0 पौधों का बहुगुणन करके वितरण किया गया॥ प्रायोगिक प्रक्षेत्र, पेरुवण्णामुषी में जायफल के आईआईएसआर विश्वश्री के पांच सौ कलमी पौधों का उत्पादन किया गया।

मसालों में डीएनए फिंगरप्रिंटिंग और बारकोडिंग

डीआरआई (MZU) और डीएएसडी , कोषिक्कोड, केरल द्वारा प्रदान किए गए नमूनों के आधार पर श्रीलंकाई काली मिर्च से वियतनाम काली मिर्च को अलग करने के लिए पॉलीमोर्फिक डीएनए मार्कर की पहचान की। डीआरआई (MZU), एफएसएसएआई, चेन्नई और डीसी (सीमा शुल्क(, मुज़फ़्फ़रपुर से कुल नमूने और सिन्थाइट इन्डस्ट्रीस लिमिटड और युनीक स्पाइसस इंडियन 41 दो नमूनों का विश-लिमिटड द्वारा दो्लेषण किया गया।

डीयुएस परीक्षण सुविधा

पीपीवी और एफआरए, नई दिल्ली द्वारा आईआईएसआर, कोषिक्कोड में डीयुएस परीक्षण केंद्र स्थापित किया गया है। वर्ष के दौरान, किसानों की काली मिर्च की प्रजातियों और छोटी (3) पर प्रारंभिक साइट अवलोकन किए गए और आगे की (6) इलायची प्रक्रिया के लिए डेटा पीपीवी और एफआरए को प्रस्तुत किया गया। इसके अलावा, सात अदरक और हल्दी की प्रत्याशी प्रजातियों 19 के लिए डीयुएस परीक्षण पूरा किया।

मसालों के कीटों और रोगों की निगरानी और प्रलेखन

निगरानी कार्यक्रम के एक भाग के रूप में, कर्नाटक और केरल में कीटों रोग आपतन के लिए / मसाला बागों का सर्वेक्षण किया गया। केरल में किए गए सर्वेक्षणों के दौरान काली मिर्च और जायफल का प्रतिनिधित्व करने वाले*फाइटोफ्थोरा* के बीस वियुक्तियों को एकत्र किया गया। काली मिर्च में शल्क (%10-2) और मारजिनल गाल थ्रिप्स (%5-3), इलायची में थ्रिप्स और प्ररोह बेधक (%10-8) ,(%20-15)अदरक में प्ररोह बेधक और लीफ (%20-15) और दालचीनी में पर्ण सुरंगक (%20-15) के कारण होने वाली हानि को कर्नाटक के कोडागु के विभिन्न बागों में आदि (%10-5) गाल थ्रिप्स

देखा गया। पादप परजीवी नेमटोड्स अर्थात, *मेलॉइडोगाइन इन्गोगिटा*, *राडोफोलस सिमिलिस* और *हेलिकोटिलीनचस* को क्षति लक्षण दिखाने वाले बेलों से संबंधित पाया गया।

मसाला फसलों के कीटाणुनाशक सूत्रकृमि और अन्य प्राकृतिक शत्रुएं

तीन कीटाणुनाशक कवक 19ईपीएफ-आईआईएसआर), आईआईएसआरईपीएफ- - (20को मसाला फसलों से जुड़ेइला ,यची में संक्रमित बसिलेप्टा स्पीसीस तथा जायफल में संक्रमित नेयेसेशिया नाइग्रा से जुड़े कीड़ के रूप में प्रलेखन किया गया। कीटाणुनाशक कवक संक्रमित बैसिलेप्टा स्पीसीस को रूपात्मक अध्ययनों के आधार पर ब्यूवेरिया स्पीसीस के रूप में पहचान की गई। अदरक ईपी-आईआईएसआर)एफ (17पर संक्रमित एक अज्ञात कैटरपिलर कीटाणुनाशक कवक को आणविक अध्ययनों के आधार पर नोमुरा रीलेई के रूप में पहचान की गई। एक अज्ञात एटिओलॉजी के *कोनोगीथस पंक्टिफरालिस* एक संक्रमित को भी अंकित किया गया।

पोचोनिया क्लैमिडोस्पोरिया पर अध्ययन

निमेटोफैगस कवक, पोचोनिया क्लैमिडोस्पोरिया के विकास को बढ़ावा देने और विरोधी गुणों को *इन विट्रो* स्थितियों के तहत अध्ययन किया गया था। यह कवक में साइडरोफोरस, अमोनिया और एबली सोलुबिलैसेर्स ज़िंक और फॉस्फेट का उत्पादन करता है। *फाइटोफ्थोरा* और *पाइथियम* का कुल दमन दोहरी परीक्षण में देखा गया।

रेडोफोलस सिमिलिस का ट्रांसक्रिपटॉमिक्स

आरसिमिलिस . के प्रतिलेख को इलुमिना सीक्वेंसिंग और डी नोवो द्वारा इकट्ठा करके व्याख्या की गयी। 62312 बीपी की औसत सीमा वाले आकार के साथ कुल 1046 बीपी से 10747-201 प्राप्त हुए। इकट्ठे हुए कोन्टिग (%73.09) यूनीजीन्स्ा्स को कार्यात्मक रूप से व्याख्या की गयी और प्रोटीन डोमेन का पूर्वानुमान किया गया। इनमें से) स्रावी / उत्सर्जन 1116ES) प्रोटीनों का पूर्वानुमान करके कार्यात्मक व्याख्या की गयी।

जैव सूचना केंद्र

केंद्र द्वारा विकसित SpiceCom डेटाबेस माननीय महानिदेशक, आईसीएआर, नई दिल्ली द्वारा लोकार्पण किया गया। किसानों के विवरण और पौधों के विभिन्न रोगों के लक्षणों के (स्पाइसफार्म) एक वेब अनुप्रयोग के विकास का आरंभ हुआ। जैव लिए एक डीएसएस उपकरण के प्रबंधन के लिए सूचना विज्ञान हेतु मेटा जीनोम डेटा विश्लेषण के लिए जैव सूचना पर एक अल्पकालिक प्रशिक्षण का आयोजन को जीनोमिक विज्ञान विभाग 2019 मार्च 22-19, केरल केन्द्रीय विश्वविद्यालय, कासरगोड के सहयोग से किया गया।

अर्थव्यवस्था

प्रौद्योगिकी प्रभाव की मान्यताहल्दी में कुरकुमिन वृद्धि पर एक अध्ययन :

घरेलू उत्पादन परिदृश्य में एक तार्किक ढाँचे का उपयोग करते हुए, कुरकुमिन मात्राएं और उच्च कुरकुमिनयुक्त प्रजातियों का विकास, उच्च कुरकुमिन उपभोग का अनुमानित आर्थिक मूल्य आदि कार्य किया गया। आर्थिक लाभों के वार्षिक मूल्य 22591)मिलियन रुपये INR) की परिमाण में

रिटर्न के स्तर को दर्शाया गया है जो कृषि अनुसंधान में निवेश से रिटर्न को मापते समय अक्सर अनसुना किया जाता है।

जर्मप्लाज्म संरक्षण का मूल्य

आईआईएसआर प्रायोगिक प्रक्षेत्र में जर्मप्लाज़म संसाधनों के संरक्षण से लाभों को मापने के उद्देश्य से, प्रायोगिक खेत में वर 32) 18-2017 से 87-1986 ्षके मूल्यों पर कुल प्रत्यक्ष 12-2011 में (635.36) निवेशमिलियन INR)किया गया था । कृषि अनुसंधान से लाभ प्राप्त करने के लिए एक सरलीकृत हेडोनिक मूल्य निर्धारण मॉडल। हमने के अंत में चार प्रमुख 18-2017 और 87-1986 काली मिर्च) फसलों, अदरक, हल्दी और जायफलके बी (च राष्ट्रीय स्तर पर क्षेत्र, उत्पादन और उत्पादकता में परिवर्तन का इस्तेमाल किया, जिनकी जर्मप्लाज़म प्रकार मुख्य रूप से प्रायोगिक प्रक्षेत्र में संरक्षित हैं। शुद्ध फसल अनुसंधान प्रभाव में पांच प्रतिशत की हिस्सेदारी में, पिछले दशक के दौरान जर्मप्लाज़म संरक्षण प्रयासों के कारण इन चार फसलों में औसत वार्षिक वृद्धिशील उत्पादन मिलियन 1159INR था।

केरल में प्राकृतिक आपदामसाला फसलों पर प्रभाव :

मसाला फसलों के प्राथमिक उत्पादकों के लिए जमीनी स्तर की स्थिति की त्वरित समझ हासिल करने के उद्देश्य से वर्षा प्रेरित प्राकृतिक आपदा के प्रभाव पर एक अध्ययन तैयार किया गया था। आपदा लघुकरण हेतु समयबद्ध हस्तक्षेप रणनीतियों को लागू करने के लिए, डेटा संग्रह का उपयोग करके नमूने में एक सरलीकृत रणनीति को अपनाया गया। 60 सामुदायिक विकास खंडों के कुल 27 ग्राम पंचायतों को इस व्यापक सर्वेक्षण के अन्दर लाया गया। व्यापक क्षेत्र सर्वेक्षणों से एकत्र किए गए जमीनी सच्चाई का इस्तेमाल कृषि विभाग के आंकड़ों से प्राकृतिक आपदा के उत्पादन प्रभाव तक पहुंचने के लिए किया गया। पिछले वर्ष की तुलना में राज्य स्तर पर अपेक्षित उत्पादन हानि के संदर्भ में फसल के नुकसान का प्रारंभिक अनुमान 12541.1) टन 25138मिलियन INR) है।

EXECUTIVE SUMMARY

BLACK PEPPER

Genetic resources

Germplasm explorations were conducted in Nagaland (Mokokchung, Tuensang and Mon districts) and Andaman and Nicobar Islands in collaboration with ICAR-NBPGR, Shillong, Meghalaya and ICAR-NBPGR, Trichur, Kerala. Forty accessions of black pepper were collected from the forests of Nagaland and 17 accessions from Andaman and Nicobar Islands. Five new *Piper* species *viz. P. boehmeriaefolium, P. makruense, P. pothiforme, P. rhytidocarpum* and *P. diffusum* from Nagaland and two new species (*P. pedicellatum and P. clypeatum*) from Andaman and Nicobar Islands were added to the black pepper germplasm repository.

Germplasm registration

A black pepper accession (IC-0619910) from the germplasm was registered with ICAR-NBPGR, New Delhi for its unique spike length (29.3 cm).

Breeding

Yield evaluation

Among the nine promising lines, hybrid HP 117 x Thommankodi recorded highest fresh yield of 8.90 kg per standard with 32.5% dry recovery followed by IISR Thevam (5.1 kg per standard with 31.2% dry recovery). HP 117 x Thommankodi had the longest spike length of 21cm and HP 780 had the highest dry recovery of 37.5%.

Peptide based functional markers to tag *Phytophthora* resistance in black pepper

Peptides with high (R) & low (S) quantitative expression (10 peptides) against *Phytophthora* infection from the *Phytophthora* tolerant variety IISR Shakthi was taken to analyze its association to *Phytophthora* resistance in two groups *viz.*, tolerant and susceptible. Five peptides based primers were screened in 26 black pepper genotypes. Pep 5 discriminated Narayakodi from all the other genotypes. This primer can be used to select the progenies under Narayakodi background in hybridisation program.Though the approach is aimed at *Phytophthora* tagging, the initial results suggested that it might be helpful in peptide barcoding of genotypes.

Estimation of piperamides in *Piper* species

Estimation of piperamides (piperlongumine, piperlonguminine and piperine) based on a modified method of reverse phase high performance liquid chromatography (RP-HPLC) was done in the berries collected from different *Piper* species. Piperlonguminine and piperine were detected in four species, whereas piperlongumine, a potential and novel anticancer agent was detected only in *P. longum* and *P. sarmentosum*.

RNA sequencing for delineation of genes

Nanopore sequencing and error correction of the data with Illumina data (Hiseq) was performed using RNA samples isolated from the berries of *Piper nigrum* and *P. longum* for better delineation of genes especially those involved in biosynthesis of secondary metabolites. Genes encoding proteins involved in terpenoid precursor mevalonate (MVA) and methylerythritol phosphate (MEP) pathways were found in *Piper* transcriptomes. Major genes involved in the synthesis of class I and class II terpenes were also found in the transcriptomes. Alpha-guanine 2- oxidase, the key gene in the biosynthesis of rotundone, an oxygenated sesquiterpene was also discovered. Major genes involved in piperidine alkaloid biosynthesis were also discovered from the transcriptome data.

Plant health management

Differential induction of peroxidase in black pepper inoculated with Phytophthora isolates

Peroxidase activity was assessed in 11 black pepper accessions including seven released varieties with the *Phytophthora* resistant line, 04-P24, as the check. Results indicated that peroxidase activity can be used as a biochemical marker for screening black pepper plants against *Phytophthora*.

Diversity studies on Colletotrichum spp.

Different isolates of *Colletotrichum* inciting leaf blight in black pepper representing Kerala and Karnataka were morphologically characterized wherein considerable variability was observed with respect to colony, conidial as well as appressorial characters and their dimensions. *In planta* pathogenicity studies indicated that three isolates could infect Panniyur 1 (susceptible host), inducing prominent yellow halo. While, *in vitro* studies showed that infection could occur within 72 h after inoculation leading to the formation of acervulus initials. *In vitro* survivability studies showed that all the isolates were capable of producing microsclerotia. Initial studies on molecular identification with two isolates of *Colletotrichum* using ITS (600 bp) and β-tubulin gene regions (approx. 400 bp) with ITS-4 and ITS-5 and Bt2aF and Bt2aR primers indicated that the ITS region was 100% similar to *C. gloeosporioides*, *C. aenigma* and *C. siamense*. The β-tubulin gene region was 100% similar to *C. gloeosporioides* and *C. fructicola*.

Characterization of Pythium species associated with black pepper yellowing

To study the diversity of *Pythium* associated with black pepper, a survey was conducted in different regions of Kerala and Karnataka and 92 soil and 12 root samples were collected. *Pythium* isolates were obtained from 87 soil samples (94.5%) and eight root samples (67%) and they were characterized morphologically which yielded *Pythium* species with three distinct colony morphology *viz.*, cottony, chrysanthemum and chrysanthemum with cottony areal mycelium. They produced torulated/globose sporangia having different growth rate on different media and can grow at a pH range of 4.5 to 10.0 and a temperature range of 15-37ºC. Out of these, 10 isolates were tested for their pathogenicity and all were pathogenic to black pepper. Molecular characterization of these isolates indicated the presence of three species *viz.*, *Pythium deliense*, *P.cucurbitacearum* and an unidentified *Pythium* sp. Upon wound inoculation to collar region, all the isolates showed collar rot leading to wilting of the

plants where *P. deliense* showed infection within three days while the other two took infection in 15 days.

Differentiation of black pepper plants infected with endogenous and episomal PYMoV

A combination of polymerase chain reaction (PCR) and reverse transcription (RT) PCR based assay was developed for differentiation of black pepper plants infected with endogenous and episomal form of *Piper yellow mottle virus.*

Characterization of pararetroviruses

Occurrence of pararetroviruses namely, Piper DNA virus 1 (PDV-1) and PDV-2, were detected in 20 varieties of black pepper through PCR using five virus specific primer pairs. The specificity of the PCR product was confirmed by directly sequencing PCR products.

Field evaluation of promising bacterial and actinomycete consortia against foot rot and slow decline diseases

The field trial with promising combinations of bio agents was continued for the third year in farmers' plots in Kozhikode district of Kerala. All the treatments were found to be better than the control in yield as well as suppression of soil-borne pathogens. However, treatment with *Pseudomonas putida* and *Bacillus megaterium* (Bp25 + Bp17) with 1% Bordeaux mixture spray was comparatively superior to other treatments.

Area wide integrated pest management of black pepper wilt diseases

No disease incidence was noticed in any plots treated with *T. harzianum* + *Pochonia chlamydosporia*, BM + COC + carbosulfan and metalaxyl-Mz + carbosulfan when compared to nearby farmers plots. Two black pepper nurseries were established under this project by adopting technologies for production of healthy disease free planting material.

CARDAMOM

Genetic resources

A total of 621 cardamom germplasm accessions are being maintained at National Active Germplasm Site (NAGS), Appangala, Karnataka which consists of 423 accessions from Appangala; 101 accessions from Pampadumpara; 41 accessions from Mudigere and 56 from Sakaleshapura.

Breeding

PET III consisting of 23 inter-varietal F1 hybrids was conducted for yield and reaction to pest and diseases. From the pooled data of three years, nine superior hybrids were shortlisted and capsule characters of shortlisted hybrids were recorded. Among the nine shortlisted hybrids ICRI 4 × IISR Vijetha recorded highest fresh (1090 g) as well as dry yield (236 g) of capsules per plant. Capsules of ICRI 4 × IISR Vijetha (14) are globose, bold (11.06 mm) and pale green in colour.

Organic farming

Significantly higher OC, N, P, Ca, Mg, Fe and Zn availability was recorded in organic and integrated management system as compared to chemical management system. Among the organic nutrient sources, NC+VC combined application recorded 1.3 kg dry capsules per 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) and organic management (0.9 kg/plot). With the application of spinosad and *Lecanicillium* andspinosad with *Trichoderma* and *Pochonia*, no major incidence of rhizome rot and <5% incidence of thrips damage on capsules was noted.

Screening of cardamom hybrid against thrips and shoot borer

Progenies of seven cardamom hybrids were screened for natural incidence of capsule borer and thrips. The incidence of thrips and borers on capsules of selected progenies of the hybrids ranged from 2.17-8.64% and 2.55-7.48%, respectively.

Characterization of nucleorhabdovirus associated with cardamom plants infected with vein clearing disease

The study for the first time reports association of a nucleorhabdovirus with vein clearing (*kokke kandu*) disease of cardamom. The causal virus was successfully transmitted onto healthy cardamom using the aphid, *Pentalonia caladii*. The identity of the causal virus was established based on sRNA sequencing and subsequent verification of the same through RT-PCR, cloning and sequencing. The sequenced region showed identities with nucleorhabdoviruses in the nucleocapsid (N), phosphoprotein (P), movement protein (P3), matrix protein (M), glycoprotein (G) and polymerase (L) genes ranging from 30-62% indicating that the virus associated with vein clearing disease of cardamom is a nucleorhabdovirus. This is the first report of occurrence of a *nucleorhabdovirus* infecting cardamom.

GINGER

Genetic resources

Six hundred and sixty eight ginger accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with 27 ginger accessions, eight *Zingiber* sp. and 30 related genera were collected from Nagaland, Manipur and Andaman & Nicobar Islands.

Characterization

Development of novel EST-SSR markers

Mining of ginger transcriptome data resulted in 16790 Simple Sequence Repeats (SSRs) and were identified as potential molecular markers in the unigenes. Also, 4597 SSRs were identified in coding region of the sequences. Based on the SSR-containing gene sequences, 25 primer pairs were randomly selected and synthesized and used for assessment of the polymorphism. Six primer pairs were polymorphic and revealed polymorphism among 43 ginger collections.

Yield evaluation

The experiment (AICRPS CVT) was conducted during 2015-2018 at IISR Experimental Farm, Peruvannamuzhi, Kerala with seven different entries and a national check IISR Varada. Among the ginger accessions, maximum yield (pooled) was recorded in Acc. 247 (20.69 t/ha) followed by Rio-de-Janeiro (17.75 t/ha) and SE 8681 (15.81 t/ha).

Mutation breeding

Ten M1V5 and 102 (M1V11) mutants are being maintained. Three potential mutants identified against *Pythium* sp. (V 0.5/2, R 0.8/1 and R 1.25/4) and three potential mutants against *Ralstonia solanacearum* (HP 0.5/2, HP 0.5/15 and M 0.5/1) were multiplied.

Induction of polyploidy

The rhizome buds of IISR Mahima were submerged in different concentrations of colchicine (0.025, 0.050, 0.075, and 0.1%) solution for 48 h to induce polyploids. Maximum sprouting was recorded in 0.025% colchicine. All the successful plants (15) have been established for further studies.

Microrhizome production

Microrhizome of ginger varieties (Athira, IISR Mahima, IISR Varada) and turmeric varieties (Sona, Suranjana, Varna) were subcultured and 3000 plantlets of ginger and 1500 turmeric were raised in protrays and are being hardened in poly bags under nursery.

Nutrient mineralization dynamics of crop residues

Nutrient mineralization dynamics of commonly used crop residue mulches (*Gliricidia*, *Ailanthus* and mixed leaves) with and without FYM and rhizosphere priming was studied in ginger. The rate of NO_3-N mineralization from crop residues applied was found to be significantly higher in the treatments with ginger over treatments without ginger, indicating rhizosphere priming effect. Highest NO_3-N and NH_4-N release was found in *Gliricidia* mulch. The rate of total N mineralization was higher when crop residues were treated without FYM or ginger and highest when *Gliricidia* mulches are used. Higher soil pH, OC buildup and soil enzyme activities and microbial biomass were seen in FYM addition and ginger rhizosphere. The FYM priming increased the dry matter production of ginger by 48% and by 88%, 100% and 75% the N, P and K uptake, respectively as compared to without FYM. Even though cumulative N and K release was higher in *Gliricidia* followed by mixed leaves, the total uptake by the plant was higher in *Ailanthus*.

Infection mechanisms of *Bipolaris rostrata* on ginger

Studies on infection mechanisms of *Bipolaris rostrata* on ginger showed that conidia inoculated on the surface of ginger leaves germinated, produced germ tubes from both the poles of conidia. From the tip of these germ tubes, uni- and multi lobed appressoria ranging between 9.02-15.34 × 4.12–10.57 µm were formed. From these, infective hyphae enter the tissues either directly through the epidermal cells or through the stomatal opening. Branched secondary hyphae, thinner than the primary hyphae, grow extensively inter and intracellularly, passing through cell walls from one cortical cell to the next. Light brown

lesions appearing on the surface of leaves are due to the growth of secondary hyphae inside the epidermal cells.

Physiological and biochemical changes in ginger - *Bipolaris* interaction

Physiological and biochemical changes occurring during the ginger - *Bipolaris rostrata* interaction were studied under glasshouse conditions. Biochemical parameters like chlorophyll and protein were found to decrease whereas electrolyte leakage increased in artificially inoculated ginger plants compared to the control.

Pink pigmented *Methylobacterium* against major pathogens of ginger

A novel phyllosphere associated pink-pigmented, Gram negative, motile rod shaped bacterium (GPPFM13) was short listed from 60 PPFMs. *In vitro* assay against pathogens of ginger *viz., Macrophomina phaseolina, Sclerotium rolfsii, Pythium myriotylum, Colletotrichum gloeosporioides* and *Fusarium oxysporum* showed inhibitory effect in the range of 40 – 75%. The mineral solubility index, IAA production and production of mycolitic enzymes and siderophores were studied. *In planta* evaluation showed better rhizome and root formation when the bacterium was applied as a foliar spray along with soil drenching. The isolate (GPPFM13) is identified as a species of *Methylobacterium* by MDH (mxaF) gene analysis and showed 96% similarity to *M. platani* and *M. inners*.

Development of a suitable formulation for *Bacillus licheniformis*

For developing a suitable formulation of *Bacillus licheniformis* GAP107, a potential biocontrol agent against bacterial wilt of ginger, two different carriers such as charcoal and talc were tested in comparison with the broth culture. All the three formulations retained the cell viability under *in vitro* conditions for more than 100 days while the charcoal formulation showed the highest viable cell count after 100 days. Application of charcoal formulation at the time of planting as rhizome priming (seed coating) and as soil application at 45, 60 and 90 days, significantly reduced the disease incidence and increased the plant height, number of tillers and rhizome development.

Fungitoxic activity of silicates on *Pythium myriotylum* and soft rot of ginger

Effect of solid and liquid forms of sodium and potassium silicate and sodium meta silicate was tested on the growth of *P. myriotylum* under *in vitro* conditions. Sodium metasilicate limit the fungal growth at 70 mM whereas sodium and potassium silicate restrict the mycelial growth at 3% concentration. Microscopic studies revealed alteration of mycelial morphology like hyphal distortion and shrinkage. Constrained growth of daughter hyphae and inhibition of sporangial formation were also observed with silicates. *In planta* studies showed an overall increase in growth rate of plant as compared to control. Challenge inoculated plants with silicate molecules showed a decrease in disease incidence as compared to the control. Among the treatments potassium silicate was found to be very effective in increasing the overall growth of the plant and limiting the disease incidence.

FLD on IDM of bacterial wilt in ginger

Frontline demonstrations on management of bacterial wilt in ginger were undertaken in nine AICRP centres and one farmer's plot in Karnataka. In each location, soil drenching with 3% calcium chloride, seed priming and soil drenching with *Bacillus licheniformis* were evaluated in solarized and non-solarized plots and compared with recommended PoP of each centre. The germination and establishment of the plants were significantly superior in solarized plots amended with both calcium chloride and *Bacillus licheniformis.* In general, solarized plots showed significant improvement in growth and yield when compared with non-solarized plots.

Characterization of the viruses belonging to the family, *Clostero viridae* and *Tombus viridae* associated with chlorotic fleck disease of ginger

The present study for the first time reports association of two distinct viruses, one belonging to the genus, *Ampelovirus* (Family Closteroviridae) and the other distinct species belonging to an undescribed new genus belonging to the family Tombusviridae with chlorotic fleck disease affected ginger. The identity of the causal virus was established based on sRNA sequencing and subsequent verification of the same through RT-PCR, cloning and sequencing. This is the first report of occurrence of *Ampelovirus* and a virus belonging to undescribed new genus in the family Tombusviridae infecting ginger. The name *Gingivirus* is proposed for the newly identified genus, and the name *Ginger chlorotic fleck associated virus-1* (GCFaV-1) is proposed as the new species under this genus, *Gingivirus*. The name, *Ginger chlorotic fleck associated virus-2* (GCFaV-2) is proposed for the new species under the genus *Ampelovirus.*

TURMERIC

Genetic resources

One thousand four hundred and four *Curcuma* accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with 11 *Curcuma longa* and six *Curcuma* sp. from Nagaland and Andaman & Nicobar Islands.

Characterization

Characterization of 150 turmeric accessions was carried out based on different morphological traits. A total of 12 quantitative and 10 qualitative characters were recorded for each turmeric accession.

Evolving extra long and bold turmeric lines

Twelve accessions of Salem Local (Erode and Salem district of Tamil Nadu) and four accessions of Mydukur (Andhra Pradesh) were collected and multiplied. Also, open pollinated seeds of 31 turmeric accessions from germplasm were collected and raised seedling progenies to evolve extra long turmeric genotypes. Germination was found to be staggered, 63 seeds germinated, seventeen seedlings were transplanted.

Evaluation of hybrids and seedlings

Replicated trial of three seedlings and three hybrids at Chelavoor recorded yield of 11.3 kg. fresh rhizomes per 3 m^2 bed in SLP 359/2 and 10.36 kg in SLP 65/12. All the three hybrids and one seedling recorded yield below 10 kg. Of the four first generation selfed progenies of Acc. No. 65 (2n=63), two flowered during 2018-2019. Among these one had distorted floral morphology and all the seven flowers produced were female, having ovary and a short style with stigma compared to the bisexual flowers in normal turmeric plants.

Performance evaluation of solar drier developed by IISR

The solar dryer developed by ICAR-IISR, Kozhikode was evaluated and it was observed that drying time for turmeric was slightly higher for solar dryer as it was multilayer drying compared to sun drying which single layer is drying. Drying of sliced turmeric was completed in 7 days in both solar drying and sun drying. There was no significant change in the dry recovery and the final moisture content of turmeric cured by different methods. Quality evaluation showed that the retention of primary metabolites was higher in solar dryer dried turmeric compared to sun dried turmeric. Curcumin content was maximum (4.61%) for solar dryer dried sliced turmeric.

Survey for plant parasitic nematodes of turmeric

High incidence of root-knot nematodes were observed in samples collected from turmeric growing areas of Coimbatore, Erode, Salem and Villupuram districts of Tamil Nadu and random samples collected from Kerala, Karnataka and North East. Burrowing and lesion nematodes were also present. Other nematodes of common occurrence were *Rotylenchulus reniformis*, *Hoplolaimus* sp and *Helicotylenchus* sp. The lesion nematode (*Pratylenchus* spp.) was observed in Alandur and Thannerpanthal region of Coimbatore District, Bhavanisagar and Gobichettipalayam region of Erode District, Shimoga in Karnataka and Nagaland in North East regions.

GINGER & TURMERIC

Mermithid parasitism of shoot borer (*Conogethes punctiferalis*)

Mermithid nematode parasitism reached epizootic levels in *Conogethes punctiferalis* exceeding 50% mortality in host insect populations and the parasitism ranged from 18.2 to 80.6% and 17.9 to 66.7% in *C. punctiferalis* collected from ginger and turmeric, respectively. The level of host parasitism by the mermithid was positively correlated with rainfall and negatively influenced by maximum temperature. Molecular analysis of the partial 18S small ribosomal subunit gene region and phylogenetic analysis with other mermithid sequences indicated that the nematode clustered with other nematodes belonging to different genera and hence could not be attributed to a specific genus. The pairwise Kimura 2-parameter (K2P) distance revealed that the closest taxon to the study nematode was an undescribed mermithid species reported to infect slugs with a K2P distance of 0.009. The results provide a basis for using this nematode as a biocontrol agent for developing integrated pest management strategies against *C. punctiferalis*.

Dose optimization of insecticides

Three insecticides (spinosad, flubendiamide, chlorantraniliprole), which were found effective in earlier trials and also a treatment with spraying of chlorantraniliprole and spinosad alternatively were tested under field conditions at Peruvannamuzhi farm for dose optimization against shoot borer infesting ginger and turmeric for the second consecutive year. All the insecticides were very effective in the management of the pest even at the lowest dose (0.3 ml/ litre of water) tested. The treatment of spraying of chlorantraniliprole and spinosad alternatively was also equally effective in controlling the insect. A botanical formulation developed by a farmer was also found to be effective in controlling the pest.

Evaluation of antagonists against pathogens of ginger and turmeric

Two strains of *Trichoderma viz.*, *Trichoderma erinaceum* (IISR AP1) and *T. atroviridae* (IISR TL 1) were found effective against *Pythium myriotylum, P. aphanidermatum* and *Fusarium oxysporum* under *in vitro* conditions. Three strains of bacteria *viz.*, *Pseudomonas* sp. and *Bacillus* sp. were found to inhibit the growth of *Bipolaris rostrata, Colletotrichum gloeosporioides* and *C. capsici*.

VANILLA

Genetic resources

Sixty five *Vanilla planifolia* and eleven *Vanilla* sp. are being maintained in the polyhouse. The germplasm conservatory was enriched with six *Vanilla* sp collected from Assam and Andaman Islands.

Biological control of vanilla pathogens

Among five *Chaetomium* sp., FVREP4 showed 56.88% and 83.73% inhibition over control of *Phytophthora meadii* and *Colletotrichum gloeosporioides*, respectively. It also produced siderophores (iron chelation), cellulase and hydrolysed starch.

On screening 31 bacterial microbes against *P. meadii*, four isolates *viz.*, VSEN7, VSEN8, VREP2 and VAREN4 showed more than 50% inhibition and three isolates (VLEN2, VLEN3 and VSEP3) showed more than 50% inhibition to *C. gloeosporioides.* None of them were effective against *S. rolfsii*.

TREE SPICES

Genetic resources

Nutmeg

Various islands of South Andaman, Middle Andaman, Great Nicobar and Little Nicobar were surveyed and collected three accessions of *Myristica andamanica*, two accessions of *Horsfieldia* spp. and four accessions of Knema spp. Two accessions of *Myristica andamanica* and one accession each of *Horsfieldia* and *Knema* species were also collected from NBPGR, Thrissur.

Cinnamon

Three accessions of cinnamon from Andaman and Nicobar Islands, three accessions of *C. camphora* from Dehradun and a wild species of cinnamon from Nicobar were collected and added to the germplasm. Six accessions of *Cinnamomum* spp. were collected from Meghalaya and Assam.

Garcinia

Garcinia nervosa, G. cowa, G. kydia, G. dhanikhariensis and an unidentified species were collected from various Islands of Andaman and Nicobar. Three high yielding accessions of *G. indica* were obtained from ICAR-NBPGR Regional Station, Thrissur. Two exotic species of Garcinia *viz., G. schomburgkiana* and *G. kola* were collected from farmer' field. Seven accessions of *Garcinia* (*G. lancifolia, G. pedunculata, G. kydia* and *G. cowa*) were collected from Meghalaya and Assam.

GENERAL

Production of nucleus planting materials of improved varieties

Improved varieties of black pepper were distributed to 581 farmers and 70000 cuttings were sold from main campus and 12000 from Regional Station. Around 4 tons of ginger and 6 tons of turmeric seed material were produced and distributed. About 2885 suckers and 475 seedlings of cardamom were multiplied and distributed from Regional Station, Appangala. Five hundred nutmeg grafts of IISR Vishwasree were produced from Peruvannamuzhi.

DNA fingerprinting and barcoding in spices

Identified polymorphic DNA marker for distinguishing Vietnam pepper from Sri Lankan pepper based on samples provided by DRI (MZU) and DASD, Kozhikode, Kerala. A total of 41 samples from DRI (MZU), FSSAI, Chennai and DC (customs), Muzaffarpur and two samples each from Synthite Industries Ltd and Unique Spices Indian Ltd were analysed. Fingerprinting facility was extended to AICRPS centres for varietal release of five turmeric, three ginger, three fenugreek and four coriander samples.

DUS testing facility

The DUS testing centre has been established at IISR, Kozhikode by the PPV&FRA, New Delhi. During the year, preliminary on-site observations on the farmer's varieties of black pepper (3 nos.) and small cardamom (6 nos.) were taken up and the data submitted to PPV&FRA for further processing. Also, completed DUS test for seven ginger and 19 turmeric candidate varieties.

Surveillance and documentation of pests and diseases of spices

As a part of surveillance programme, spices plantations were surveyed for the incidence of pests/diseases in Karnataka and Kerala. Twenty isolates of *Phytophthora* representing black pepper and nutmeg were collected during the surveys conducted in Kerala. Damages due to scales (3-5%) and marginal gall thrips (2-10%) in black pepper, thrips (8-10%) and shoot borer (15-20%) in cardamom, shoot borer (15-20%) in ginger and leaf miner (15-20%) and leaf gall damage (5-10%) in cinnamon were observed in different gardens of Kodagu,

Karnataka. Plant parasitic nematodes *viz.*, *Meloidogyne incognita*, *Radopholus similis* and *Helicotylenchus* were found associated with vines exhibiting declining symptoms.

Entomopathogens and other natural enemies of spice crops

Three entomopathogenic fungi (IISR-EPF-19, IISR-EPF-20) were documented from insects associated with spice crops, *Basilepta* sp. infesting cardamom and *Saissetia nigra* infesting nutmeg. The entomopathogenic fungus infecting *Basilepta* sp. has been identified as *Beauveria* sp based on morphological studies. The entomopathogenic fungus infecting an unknown caterpillar infesting ginger (IISR-EPF-17) has been identified as *Nomuraea rileyi* based on molecular studies. An infected *Conogethes punctiferalis* of unknown etiology wasalso recorded.

Studies on *Pochonia chlamydosporia*

The growth promoting and antagonistic properties of the nematophagous fungus, *Pochonia chlamydosporia*, was studied under *in vitro* conditions. The fungus produces siderophores, ammonia and ably solubilizes zinc and phosphate. Total suppression of *Phytophthora* and *Pythium* was noticed in dual plate assays.

Transcriptomics of *Radopholus similis*

The transcriptome of *R. similis* was sequenced by Illumina sequencing and *de novo* assembled and annotated. A total of 62312 unigenes (73.09%), ranging in size from 201–10747 bp with a mean contig size of 1046 bp, were obtained. The assembled contigs were functionally annotated and protein domains were predicted. Out of these, 1116 excretory/secretory (ES) proteins were predicted and functionally annotated.

Effect of spice essential oils on *Aspergillus* spp.

Allspice leaf essential oil at 0.04% concentration completely inhibited *Aspergillus flavus* (IISRaf1), the mycotoxin producing fungus, within seven days of incubation by the poisoned food technique. Significant reduction in radial growth and biomass of *A. flavus* was also noticed with allspice leaf essential oils ranging from 0.02 to 0.03%.

BIOINFORMATICS CENTRE

The SpiceCom database developed by the Centre was launched by Hon. DG, ICAR, New Delhi. Initiated development of a web application for managing the details of farmers (SpiceFarm) and a DSS tool with images for symptoms of various diseases of plants. A short-term training on ‘Bioinformatics for metagenome data analysis’ was conducted from 19-22 March 2019 with the support of Department of Genomic Science, Central University of Kerala, Kasaragod.

ECONOMICS

Valuation of technology impact: A study on curcumin enhancement in turmeric

Using a logical framework of domestic production scenario, curcumin content and extent of varietal spread of high curcumin varieties, the approximate monetary value of higher

curcumin consumption was worked out. The magnitude of the annual value of the monetary benefits (Rs 22591 million INR) indicate the levels of returns which are often unheeded while measuring the returns from investments in agricultural research.

Value of germplasm conservation

In an exercise aimed at measuring the benefits from conservation of germplasm resources at IISR Experimental farm, the total direct investment incurred at the experimental farm from 1986-87 to 2017-18 (32 years) at 2011-12 prices was worked out (635.36 million INR). A simplified hedonic pricing model for valuing gains from the agricultural research. We used the change in area, production and productivity at the national level between the biennium ending 1986-87 and 2017-18 for four major crops (black pepper, ginger, turmeric and nutmeg) whose germplasm lines are mainly conserved in the experimental farm. At five per cent share in pure crop research effect, the average yearly incremental production in these four crops attributable to germplasm conservation efforts during the last decade was valued at 1159 million INR.

Natural calamity in Kerala: impact on spice crops

A study on impact of the rain induced natural calamity was designed with an objective to gain a quick understanding of the ground level situation for primary producers of spice crops. To implement time bound intervention strategies for calamity mitigation, a simplified strategy was adopted in the sampling used for data collection. A total of 60 village panchayats across 27 Community Development Blocks were covered under the extensive survey. The ground truth collected from the extensive field surveys were used to firm up the data from agricultural department to arrive at the production impact of the natural calamity. The initial estimates of crop loss in terms of expected production loss at state level over previous year in spices amounted to 25138 tonnes (12541.1 million INR).

PROGRAMMES OF NATIONAL IMPORTANCE

Institute is conducting all the programmes of national importance with commitment and fervour. Swachhta and Vigilance activities are taken up with great spirit and sincerity. For tribal upliftment and value chain development in turmeric in tribal areas of Vishakhapatnam, the institute has provided facilities for processing of turmeric for tribal FPOs. Similarly in Pottangi, the tribal hamlet of Koraput, Odisha, the institute is establishing mother garden of spices for spreading spices to the entire Koraput region. The institute is involved in promotion of spices cultivation in north east to develop it as a quality production hub. We are tapping solar energy for our routine requirement of electrical energy. For enhancing spices production and doubling farmers income, spices cultivation as intercrops in young orchards and plantations is encouraged. Soil test based fertilizer recommendations for each crop is being advocated and the soil health cards are issued. Recycling of organic wastes and making institute plastic free are given priority.

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

- To extend services and technologies to conserve genetic resources of spices as well as soil, water and air of spices agroecosystems.
- To develop high yielding and high quality spice varieties and sustainable production and protection systems using traditional and non-traditional techniques and novel biotechnological approaches.
- To develop post harvest technologies of spices with emphasis on product development and product diversification for domestic and export purposes.
- To act as a centre for training and technology upgradation of spices and to coordinate national research projects.
- To monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of the farming community.
- To serve as a national centre for storage, retrieval and dissemination of technological information 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 2460.20 lakhs during the year, which included 21.40 lakhs under the Network Project on High value compounds under institute grant.

Resource generation: Institute earned a total revenue of 100.71 lakhs through sale of planting materials, biocontrol agents, training, publications and consultancy services *etc*.

Staff

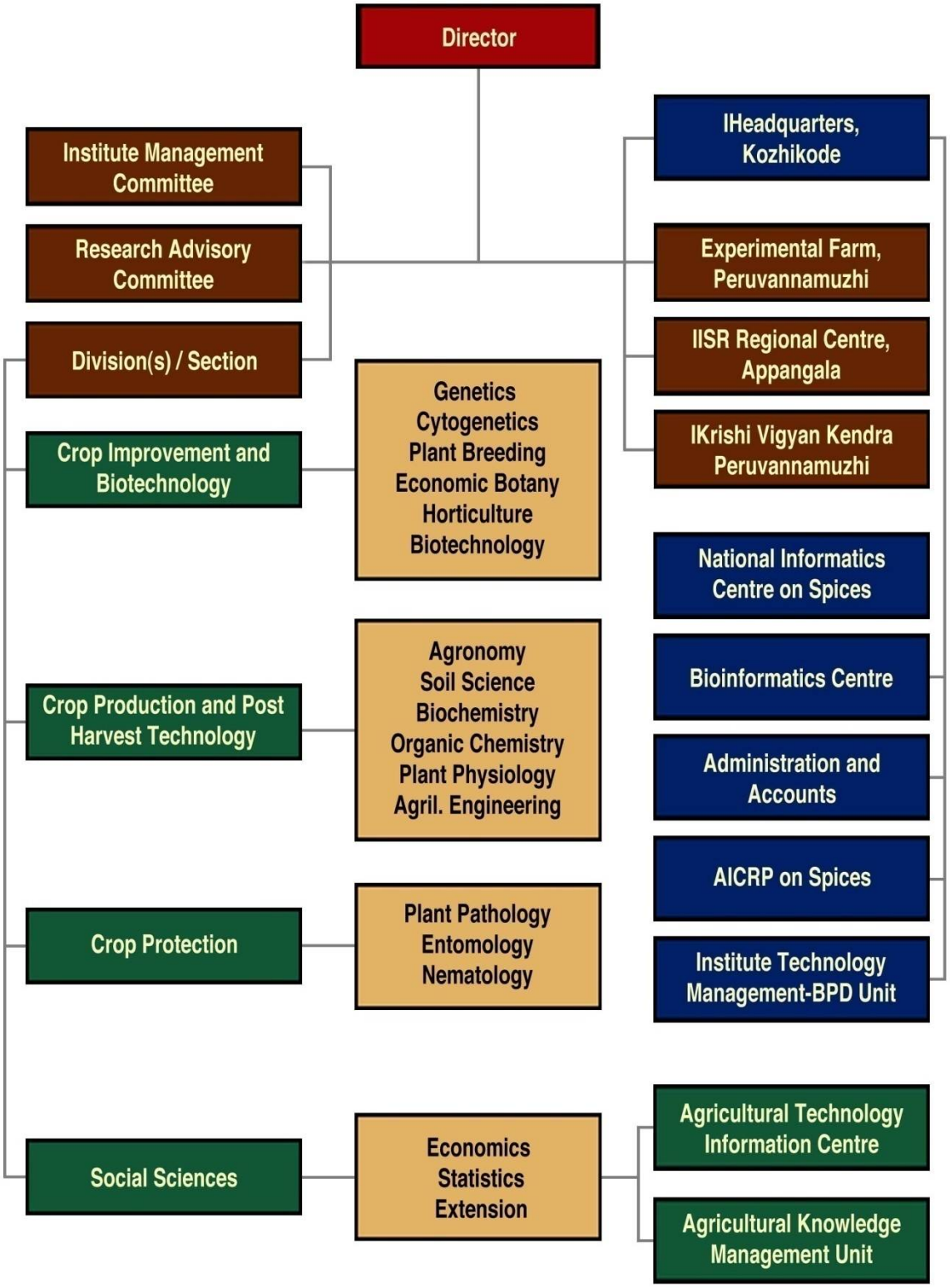
The institute has a sanctioned strength of 45 scientific, 24 administrative, 35 technical and 61 supporting staff, of which 38, 15, 24 and 9 of scientific, administrative, technical and supporting staff, respectively are in position. The KVK has a sanctioned strength of 1 scientific, 2 administrative, 11 technical and 2 supporting staff.

Staff position of the Institute

Category	Sanctioned	Position			Total	Vacant
		Kozhikode	Peruvannamuzhi	Appangala		
Scientist	45	32	0	06	38	07
Technical	35	14	07	03	24	11
Administration	24	13	0	02	15	09
Supporting	61	02	01	06	09	52
Total	165	61	08	17	86	79

Staff position of KVK

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



Organizational chart of ICAR-Indian Institute of Spices Research, Kozhikode

PAST ACHIEVEMENTS

Black pepper

Germplasm collections obtained over the years through explorations are being maintained at ICAR-IISR, Chelavoor; Experimental Farm, Peruvannamuzhi as well as in other alternate sites *viz.*, Appangala and Chettalli of Karnataka for developing improved varieties for yield, quality, abiotic and biotic stresses. About 3466 accessions are maintained at the nursery. The genetic stock has lead to the release of nine improved varieties such as Sreekara, Subhakara, Panchami, Pournami, PLD-2, IISR Thevam, IISR Girimunda, IISR Malabar Excel and IISR Shakthi. Two 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, were registered with NBPGR, New Delhi. Endangered species *viz. P. barberi* and *P. hapnium* were located and collected from Sabari hills. Microsatellites developed for *Piper* species were successfully used to detect polymorphism in black pepper cultivars. Germplasm catalogue consisting of characterization and evaluation data of 530 accessions was prepared. 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, 21 plants being resistant to *Phytophthora*, two plants susceptible and the rest showing moderate resistance. Putative transgenic black pepper plants with osmotin gene conferring resistance to drought and *Phytophthora capsici* have been developed. *In vitro* and *in vivo* propagation methods were standardized. Plantlets developed through micropropagation were established in farmers' field in Kerala and Karnataka.

The adoption of site-specific soil fertility management helped in increasing the yield of black pepper by 76-97% over control. Soils from all all the Panchayats of Kerala state have been analysed for their physico-chemical properties and nutrient advisory cards have been generated for distribution to farmers. The spacing, nutrient and water requirements were standardized for different soil types of pepper growing regions. Irrigating pepper vines once in a fortnight from March to May months at the rate of 50 L $vine^{-1}$ enhanced yield substantially. High production technologies and mixed cropping systems were developed for increasing productivity. Organic production technology for black pepper has been standardized. Crops such as ginger, tapioca, coleus, amorphophallus and hybrid napier were found suitable for intercropping in black pepper gardens that are more than 15 years old. Intercropping medicinal plants (*Vetiveria zizanoids* and *Alpinia calcarata*) in juvenile black pepper garden was found to be profitable with a B: C ratio of 2.3. Cost effective method for production of disease-free rooted cuttings was developed. A machine was fabricated in collaboration with CIAE, Coimbatore centre which is capable of mixing, pulverizing, sieving, and filling of potting ingredients in poly bags at desired quantity. 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. 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) are 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. Phytoplasma with phyllody symptoms was most closely related to members of aster yellows group (16Sr I) of Phytoplasma. Integrated strategies involving cultural methods, biocontrol agents, plant products and resistant varieties were developed for the management of pests and diseases including nematodes that resulted in substantial increase in yields and pesticide free produce.

Large scale multiplication of biocontrol agents such as *Trichoderma* and *Pseudomonas* 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. The presence of β-1, 4 endoglucanase, a major secretory cellulose enzyme in nematodes, was located in *R. similis* through EST analysis. 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 40 µL 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 formulation 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 PGPR by encapsulation has been developed and non-exclusively licensed 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. Among the new chemicals tested i*n vitro* against *P. capsici*, Acrobat 50 showed 100% inhibition at 50 ppm concentration. Profiling and activity prediction of biochemical compounds using *in silico* tools were completed for *Pseudomonas putida* BP 25 and *Bacillus megaterium* BP 17. 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 production 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, Illumina - Solexa GA II. ITS region of *R. similis* was amplified with universal primers. 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. *Karshika Sankethika Darshanam* and Media Meet were organized to mobilize mass media support for sharing Agro-Information. Video film on Augmenting black pepper production – a success story (Malayalam, English, Hindi) was produced.

Cardamom

Germplasm collections obtained over the years through explorations are being maintained at IISR Regional Station, Appangala, Karnataka and IC numbers have been obtained for all the available germplasm. 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 and dendrogram of similarity was prepared. 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. Cardamom accessions APG 257, APG 414 and APG 434 were found to be promising for drought tolerance.

A procedure for total RNA isolation and detection of CdMV through reverse transcription–polymerase chain reaction (RT-PCR) using primers designed for the conserved region of coat protein was standardized. 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. Phenotypic and genetic characterization revealed that the causative organism is *R. solanacearum* biovar 3 phylotype 1. Multiplex-PCR based phylotyping, 16s rDNA & recN gene sequence based comparison and MLST based comparative genetic analysis further revealed that the strain is 100% similar to the ginger strain of *R. solanacearum*.

Ginger

Germplasm repository at ICAR-IISR is the largest with several unique collections. 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. Cross specific amplification of rice microsatellites was successfully done in ginger. 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.

Post harvest technologies for processing and technologies for preparation of value added products such as salted ginger 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. Ginger strain of *R. solanacearum* infected turmeric, cardamom, *C. aromatica, C. zedoaria, Kaempferia galanga, Zingiber zerumbet* and tomato. Indian mango ginger, *Curcuma amada* was free from bacterial wilt even under inoculated conditions. The species of *Pythium* causing ginger rhizome rot 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 collected over the years have been conserved in the field gene bank and were 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. Open pollinated seedling progenies generated over the years are being evaluated for their yield and quality characters.

Molecular genetic fingerprints of sixteen *Curcuma* species using RAPD and ISSR markers revealed high degree of polymorphism among the accessions. 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.

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. Processing with or without boiling or different drying methods did not lead to variation in oil, oleoresin and curcumin

contents. The optimum spacing, nutrient and water requirement were standardized for different soils and organic farming system was developed for turmeric.

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. Lamda cyhalothrin 0.0125% was more promising in reducing the percentage of shoots infested by the shoot borer. The improved varieties and technologies were disseminated to farmers and other agencies through publications and demonstrations. The adoption of released varieties like IISR Prathiba in Andhra Pradesh, Karnataka and Tamil Nadu were studied. A novel soil pH based micronutrient mixtures for enhancing growth, yield and quality of turmeric, ginger, black pepper and cardamom were developed. Video film on success story of a 'Prathiba' grower was produced.

Tree spices

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

Four species of Garcinia *viz., G. kydia* (Kuji Thekera), *G. lancifolia* (Rupohi Thekera), *G. pedunculata* (Bor Thekera) and *G. xanthochymus* (Tepor Tenga) were located in Meghalaya, Assam and Nagaland. Hot water extraction and solvent extraction (methanol/chloroform -1:1) of *G. gummigutta* and *G. tinctoria* yielded 50% butter with yellow colour and pleasant aroma.

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* × *V. tahitensis*, *V. tahitensis* × *V. planifolia* and selfed progenies of *V. tahitensis* were established *ex vitro*. Chromosome number analysis of two interspecific hybrids between *V. planifolia* and *V. tahitensis* showed 2n=30 in one (PT-5) and 2n=32 in other (PT-17).

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

Paprika

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

RESEARCH ACHIEVEMENTS 2018-19

BLACK PEPPER

Genetic resources and characterization

Three thousand four hundred and sixty six accessions are maintained at germplasm nursery at the experimental farm, Peruvannamuzhi, Kerala. Also, improved varieties and examples varieties were planted under protected condition for conservation. A field gene bank of core set of black pepper germplasm collection comprising 80 accessions are planted at Kozhikode campus on *Ailanthus* standards.

Characterization of germplasm for qualitative and quantitative traits was initiated. Twenty germplasm accessions were screened for *Phytophthora* resistance and another set of 20 accessions are under screening. Collection no. 7548, an unique germplasm accession having very long spike has been registered at NBPGR, New Delhi (INGR 19024).

Exploration program along with ICAR-NBPGR, Shillong was conducted and three districts *viz.*, Mokokchung, Tuensang and Mon districts of Nagaland were surveyed during the exploration. The explored area lies in Nagahills and Patkai range belonging to Arakan mountain range. Around 40 accessions were collected. Six new species were added to the germplasm. Some of the new species collected and conserved from Nagaland are *Piper acutistigmum, P. boehmeriaefolium, P. diffusum, P. makruense* (Fig 1a), *P. pothiforme* and *P. rhytidocarpum.*

Another exploration was carried out to Andaman and Nicobar Islands in collaboration with ICAR-NBPGR, Trichur, Kerala. Survey was conducted in parts of Andaman Islands and great Nicobar and 17 *Piper* accessions were collected. The new additions to the germplasm are *P. pedicellatum* (Fig 1b) and *P. clypeatum* (Fig 1c). Besides, the other *Piper* species collected from A & N Islands are *P. sarmentosum, P. betle* and four unidentified species.

a) P. makruense b) *P. pedicellatum* *c) P. clypeatum*

Fig. 1. *Piper* spp. collected during exploration trip

Breeding

Four promising lines constituting three hybrids i.e. HP117 × Thommankodi, HP 1411, HP 780 and 1 open pollinated progeny OPKM were shortlisted for AICRPS trial PEP/CI/3.7 CVT 2018 on black pepper- Series IX.

Molecular biology

Quantification of piperamides in different Piper *species*

Piperine-type alkaloids or alkamides or piperamides have been isolated commonly from species belonging to the genus *Piper* (Piperaceae) and they include, piperlognumine, piperlonguminine. Piperlongumine (PL), a natural product derived from the fruit of *Piper longum*, and was found to selectively cause apoptosis in numerous cancer cell lines as well as cancerous tumors in animal models. Piperlonguminine (PLM) was reported to have good antioxidant properties**.** In the attempt made for estimation and quantification of the presence of these alkaloids in different *Piper* species, Piperlonguminine and piperine were detected in four species analyzed whereas piperlongumine was detected only in *P.longum* and *P. sarmentosum* which are closely related species.

Data mining for the prediction of genes involved in piperinebiosynthesis

Piperine is formed from piperidine and piperoyl-CoA. Piperidine is formed from L-lysine and piperoyl-CoA is derived from cinnamoyl-CoA precursor via acetate/shikimic acidpathway. The DAP pathway is found in plants for the synthesis of lysine and genes for 10 enzymes of this pathway were identified from black pepper berry transcriptome. Six genes involved in tropane, piperidine and pyridine alkaloid biosynthesis were identified. Eighteen Phenylpropanoid biosynthesis related genes were also identified from black pepper.

Identification of genes involved in rotundone biosynthesis in black pepper

Recent findings describe (−)-rotundone as an oxygenated sesquiterpene responsible for the peppery aroma in grapes, wines, herbs, and spices. The genes responsible for alpha-guaiene and the key enzyme, guaiene 2-oxidase were identified from the black pepper berry transcriptome by sequence similarity searches.

Identification of terpene synthase genes

Similarity search in the transcriptome data of *Piper nigrum* and *P. longum* was performed with specific terpene synthase gene sequences from UNIPORT and candidate gene sequences of different terpene synthase genes identified. Twelve sequences with similarity to alpha-phellandrene synthase, beta-pinene synthase, alpha-pinenesynthase, myrcene synthase, alpha-terpineol synthase. *etc.* were found and different conserved motifs, DDXXD, DXDD, DDXXD, RR(x8)W *etc.* were found in the deduced amino acid sequences of these genes.

Impact of rainfall on spiking intensity and fruit setting

Monthly Rainfall data of 2018 was collected from 50 different locations in Karnataka. Total rainfall ranged from 1625 mm to 4550 mm. Amount of pre monsoon rainfall (Jan-May) ranged from 350 to 550 mm. Pre monsoon rainfall distribution was good in many locations. July and August rainfall was high and also continuous which lead to incidence of *Phytophthora* foot rot disease.

Spiking intensity and berry setting was recorded in these 50 different locations (Madikeri, Virajpet, Somwarpet, Sakleshpur, Mudigere, Chikkamagaluru, Puttur and Sirsi). Spike

intensity ranged from 12.2 to 25.4 per 0.5 square meter canopy area with a mean of 20.2. Berry set percentage ranged from 59.24 to 76.07 per cent with a mean of 69.32 per cent. Low berry set per cent was recorded in low rainfall area and less managed plantations. Over all crop in Karnataka was good in many locations due to good distribution of rain and also irrigation.

Influence of altitude and management practices on yield of black pepper

Surya Kiran estate in Hattihole, Somwarpet Taluk has altitude ranging from 891 m (2923 ft) to 1168 m (3832 ft) above MSL. Pepper vines grown at 1040 m and above were not yielding well even though they flower in July and August and all the spike fall due to anthracnose and lack of bisexual flowers. To initiate flowering in May, shade regulation was done in February and vines were irrigated from March 10 onwards at 10-15 days interval. This intervention resulted in flowering and fruit setting in May-June. With prophyactic spray of carbendazim 2 g/litre in April and 1% Bourdeaux mixture in May, spike shedding was fully contained. Spiking intensity was recorded at different heights and the number of spikes per square meter of the canopy ranged from 30.75 (1087 m MSL) to 59.0 (891 m MSL) with a mean of 40.73. Spike length (cm) ranged from 10.64 (926 m MSL) to 17.4 cm (1018 m MSL) with a mean of 13.36 cm. Number of berries per spike ranged from 51.8 (926 MSL) to 84.7 (1078 MSL) with a mean of 71.4. Vines above 1100 m MSL were young and not in bearing stage. The data clearly indicated that good pepper crop could be harvested at higher altitudes (1078 MSL; 3536 feet) by adopting early shade regulation and irrigation.

Site specific nutrient management

Application of gypsum as an amendment to correct the sub soil acidity in combination with lime (dolomite + gypsum) significantly improved the pH of the surface (0-15 cm) and sub surface soil (15-30 cm) in black pepper (Fig. 2). Imposing site-specific nutrient management has shown significant increase in soil pH depth wise as compared to farmers practice. Significant increase in soil available P, K, Ca, Mg, Zn and Cu was observed in adopted plots as compared to farmers practice. The adoption of site-specific soil fertility management has helped in increasing the yield of black pepper over control (farmers practice). Similar increase in yield was observed in demonstration plots at various farmers plots (15-30%). Even though the quality of the produce did not show any significant increase, the best management practice (BMP) treatments showed higher values of bulk density as compared to farmers practice.

Development of fertigation schedule for better productivity

The experiment was initiated during 2015 to standardize drip fertigation schedules for three black pepper varieties *viz.*, IISR Thevam, IISR Girimunda and IISR Shakthi and to determine its influence on soil nutrient dynamics, yield and quality with following treatments:

T1- Drip irrigation @ 8 litres of water daily from September-May: 50 RDF, fertigation in 24 splits during 6 months; T2- Drip irrigation @ 8 litres of water daily from September -May: 75 RDF, fertigation in 24 splits during 6 months; T3- Drip irrigation @ 8 litres of water daily from September -May: 50 RDF in 40 splits during 10 months; T4- Conventional irrigation @ 10 litres of water daily from September -May: 100 RDF in 3 equal splits; basal in June, II in

September and III in February (control); T5- Drip irrigation @ 8 litres of water daily from September-May: 75 RDF in 40 splits during 10 months; T6- Drip irrigation @ 8 litres of water daily from February-April: 100 RDF in 3 equal splits; basal in June, II in September and III in February.

Results indicated that the nutrient status was improved in all the plots in which fertigation was carried out compared to control. Flowering was initiated in IISR Thevam and IISR Girimunda. Better lateral production and yield was observed in the variety IISR Girimunda (15 kg) followed by IISR Thevam (12 kg).

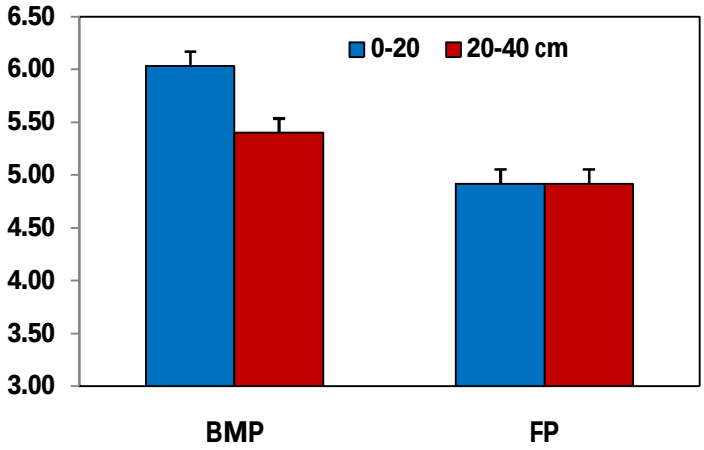


Fig. 2. Effect of best management practice (BMP) as compared to farmers practice on soil pH in black pepper

New RP-HPLC method for quantification of piperamides in *Piper* species

A new RP-HPLC method was developed to analyze quantitatively the three piperamides namely piperlongumine, piperlonguminine and piperine in major *Piper* species. Piper species selected for the study were *P. nigrum*, *P. longum*, *P. chaba*, *P. sarmentosum*, *P. thomsonii*. The results showed a marked variation in the concentration of these piperamides in the five species analyzed. Piperlonguminine and piperine was detected in four species analyzed whereas piperlongumine was detected only in *P. longum* and *P. sarmentosum* which are closely related species. The concentration of piperine was highest in *P. nigrum* (29.3 mg g^{-1}) followed by *P. chaba* (26.4 mg g^{-1}). Piperlongumine was found to be at 1.7 mg g^{-1} concentration in *P. sarmentsoum* and 1.2 mg g^{-1} in *P. longum*. The concentration of piperlonguminine was highest in *P. chaba* and *P. nigrum* (2.1 mg g^{-1} in each species)

Foot rot

Molecular differentiation of P. capsici *and* P. tropicalis *isolates*

PCR assay was standardized to amplify *Cox I*, intergenic and *Cox II* region of *Phytophthora* spp. (approx. 2300 bp region) using FM75 and FM83/77 primers and sequenced using four primers *viz.*, FM75, IgCoxF, FM84 and FM83. The cox region of isolate 05-06 was 99% similar to *P. capsici* isolate P10386 (GU221957), P1319 (GU221958) and AY129166 (from *Capsicum annuum*). The *Cox I* gene analysis could differentiate *P. capsici* and *P. tropicalis* isolates. Phylogenetic analysis of *Cox I* region of six isolates of *Phytophthora* from national

repository indicated that three isolates (99-162, 05-06, 06-09) belong to *P. Capsici* while the remaining isolates (97-55, 98-93, 98-02) belong to *P. tropicalis*.

Peroxidase activity as an indicator of resistance to Phytophthora

Since peroxidase is a precursor for lignin biosynthesis, peroxidase activity was taken as an indicator for screening plants for resistance to *Phytophthora* infection. Four accessions and seven released varieties of black pepper were screened for peroxidase activity keeping the *Phytophthora* resistant line 04-P24 as a reference standard.Out of these, Acc. 7731 and 7583 showed higher peroxidase activity when compared to other accessions and released varieties tested.

Field evaluation of promising bacterial/actinomycete consortia

The field trial in a farmer's plot at Venappara (Kozhikode District, Kerala) with four different varieties of black pepper (IISR Thevam, IISR Shakthi, IISR Girimunda and IISR Malabar Excel) raised by incorporating two different actinomycetes spp. combinations *viz.*, *Streptomyces* spp. Act 5+9, *Streptomyces* spp. Act 2+9 in comparison with *Trichoderma harzianum* + *Pochonia chlamydosporia* combination was continued. No diseases were observed in the trial plot and the variety IISRThevam produced the maximum lateral branches.

In another field trial wherein promising combinations of bioagents *viz.*, *Pseudomonas putida* (Bp 25) + *Bacillus megaterium* (Bp17), *P. putida* (Bp 25) + *Curtobacterium luteum* (TC 10) were compared with *T. harzianum* + *P. chlamydosporia*, soil samples were collected and analyzed for *Phytophthora*, *Pythium* and nematodes. All the bioagent combinations were found to suppress the disease incidence and significantly improved the yield. However, the treatment with *T. harzianum* + *P. chlamydosporia* recorded the maximum pepper yield which was on par with TC10+BP 25 (Table 1).

Table 1. Effect of bioagents on yield of black pepper – Pooled data of 2016-18

Treatment	Yield of 10 plants (kg fresh)			
	2016	2017	2018	Average
P. putida (Bp25) + *B. megaterium* (Bp17)	6.63	3.33	17.17	9.04^{B}
P. putida (Bp 25) + *Curtobacterium luteum* (TC 10)	16.33	15.23	14.23	15.27^{A}
T. harzianum + *P. chlamydosporia*	17.01	22.67	14.33	18.0^{A}
Control	6.43	7.67	5.67	6.59^{B}

Values in the last column followed by a common letter are not statistically different

Rejuvenation of black pepper plantation by adopting GAP

Field demonstration trials were taken up at three locations for the rejuvenation of declining black pepper plantations due to foot rot and yellowing. The demonstration was taken up by replanting the affected plantation and also by attempting to rejuvenate the existing plantation with proven crop protection technologies. New planting was done at two locations (Kodagu

and Kozhikode) whereas rejuvenation was attempted in a declining pepper plantation in Kodagu. The treatments being demonstrated are: (1) combination of actinobacteria - Act 1+5+9 (Act 1 & 9 against *Phytophthora* and Act 5 against *Radopholus similis*) @ 50 ml /vine along with 1% Bordeaux mixture spray 1% and (2) *T. harzianum* + *P. chlamydopsoria* @ 50 g/vine each along with 1% Bordeaux mixture spray.

Field demonstrationof integrated disease management

The demonstration plots at Muthappanpuzha (Kozhikode District, Kerala) for foot rot management using chemical and biological means are being maintained by giving required inputs and also by taking observations regularly. As in previous years, there was no incidence of any diseases in these plots compared to adjacent plots where foot rot incidence was quite serious during the year. The two model nurseries established in Kozhikode District (Omasserry and Muthappanpuzha), continued to produce disease-free rooted cuttings. During 2016-18, a total of 34,662 rooted cuttings were produced from the nursery at Omasserry.

Anthracnose disease

Characterization of Colletotrichum *isolates*

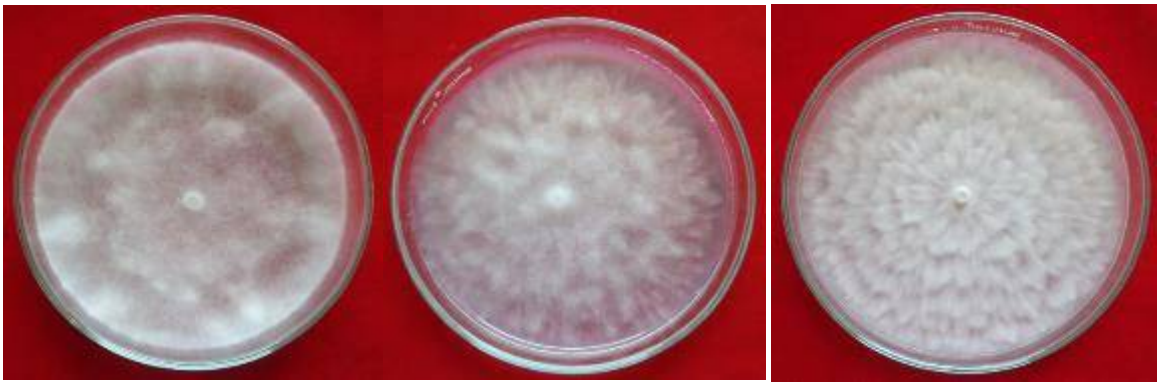
Colletotrichum isolates associated with post-monsoon leaf blight in black pepper representing Kerala and Karnataka were morphologically characterized based on colony, conidial as well as appressorial characters. *In planta* pathogenicity studies indicated that, three isolates could infect Panniyur 1 (susceptible host) by inducing prominent yellow halo 10 days after inoculation. While, *in vitro* studies showed that, infection could occur within 72 h post inoculation with the formation of acervulus initials. Vegetative compatibility studies among selected isolates representing Kerala and Karnataka indicated that, isolates 2 and 4 (representing Kerala) were more compatible with other isolates. Survivability studies under *in vitro* conditions showed that, all the isolates were capable of producing microsclerotia, indicating their survival potential. Molecular characterization of two isolates of *Colletotrichum* representing Chelavoor and Peruvannamuzhi was attempted using ITS (600 bp) and β-tubulin gene regions (400 bp) with ITS-4 and ITS-5 and Bt2aF and Bt2aR primers. The ITS region was 100% similar to *C. gloeosporioides, C. aenigma* and *C. siamense*. Whereas, the β-tubulin gene region was 100% similar to *C. gloeosporioides* and *C. fructicola*.

Yellowing disease

Characterization of Pythium *species*

To study the diversity of *Pythium* spp. associated with yellowing of black pepper, a survey was conducted in different black pepper growing tracts of Kerala and Karnataka and 92 soil and 12 root samples were collected from yellowing affected black pepper vines. *Pythium* species with three distinct colony morphology, *viz.*, cottony, chrysanthemum and chrysanthemum with cottony areal mycelium could be isolated from 87 soil samples (94.5%) and eight root samples (67%). The isolated *Pythium* spp. were characterized morphologically and pathogenically. Isolates showing different colony morphology were tested for pathogenicity and all of them were found pathogenic to black pepper. Molecular characterization of the isolates revealed the occurrence of three species *viz., Pythium deliense, P. cucurbitacearum* and *Pythium* sp. (Fig. 3). Upon wound inoculation to collar

region, all the isolates showed collar rot leading to wilting of the plants where *P. deliense* showed infection within three days while the other two took infection in 15 days. Among the 76 isolates, 80% were of *P. deliense* associated with yellowing of black pepper.



P. deliense *P. cucurbitacearum* *Pythium* sp.

Fig. 3. Colony morphology of three species of *Pythium* infecting black pepper

Viruses

Differentiation of black pepper plants with endogenous and episomal Piper yellow mottle virus

Complete genome sequencing of *Piper yellow mottle virus* (PYMoV) showed that it is about 7.5 kb in size and has four open reading frames (ORFs). As the badnavirus, PYMoV, is known to occur both in episomal and endogenous (integrated) forms in black pepper, a method to distinguish plants infected with episomal and endogenous form of PYMoV using PCR and RT-PCR approaches was developed. Total DNA and RNA isolated from black pepper plants were subjected to PCR and RT-PCR. Plants that test positive in both PCR and RT-PCR will have episomalPYMoV while plants positive only in PCR will have only endogenous form of PYMoV.Initial results of DNA-PCR and RT-PCR done using known infected symptomatic plants belonging to black pepper var. Thekkan and Panniyur 1 showed positive reaction for all four ORFs both in PCR and RT-PCR confirming occurrence of episomalPYMoV in these plants. The utility of the method was then used to screen asymptomatic plants of different varieties of black pepper that showed plants with both endogenous and episomal form of PYMoV.

Characterization of pararetroviruses (Piper DNA virus 1 and Piper DNA virus 2) *in black pepper*

Studies using next generation sequencing of PYMoV infected black pepper identified two new pararetroviruses that showed homology to members of the genus, *Tungrovirus* and *Badnavirus*. Characterization of these pararetroviruses is important as the exact identity and whether they represent endogenous or episomal form of the virus is not known. The two new pararetroviruses are tentatively named as *Piper DNA virus 1*(PDV 1) and *Piper DNA virus 2* (PDV 2). During the period under study, occurrence of PDV-1 and PDV-2 in 20 different cultivars and varieties of black pepper was studied through PCR using three and two sets of primers derived from the known regions of PDV-1 and PDV-2, respectively. The specificity of the amplicons was confirmed by cloning and sequencing of the PCR products.

Plant parasitic nematodes

Transcriptome mining of Radopholus similis *for novel targets*

The *de novo* assembled contigs were functionally annotated and protein domains were predicted. Out of these, 1116 excretory/secretory (ES) proteins were predicted and functionally annotated of which 162 (8.5%) proteins were mapped to 38 CAZyme families. The ES proteins were further checked for their homology with genomes of 32 non-target organisms comprising of fungi, nematodes, insects, vertebrates and plants. Around 109 ES protein sharing homology with these non-target species were discarded. The non-homologous ES proteins were further screened against RNAi phenotypes in *Caenorhabditis elegans* and 170 ES proteins were identified. Out of these, 20 target genes were short-listed based on literature survey for RNAi studies.

Studies on Pochonia chlamydosporia

The growth promoting and antagonistic properties of the nematophagous fungus, *P. chlamydosporia*, were studied under *in vitro* conditions. The fungus produces siderophores, ammonia and ably solubilizes Zn and P. Total suppression of *Phytophthora* and *Pythium* was noticed in dual plate assays. A semi-selective medium was developed for enumeration of *P. chlamydosporia* colonies. Bioassay guided fractionation of culture filtrates is in progress.

CARDAMOM

Genetic resources and characterization

A total of 621 cardamom germplasm accessions are being maintained at National Active Germplasm Site (NAGS), Appangala, Karnataka which consists of 423 accessions from Appangala; 101 accessions from Pampadumpara; 41 accessions from Mudigere and 56 from Sakaleshapura.

Oil and oleoresin estimation of 24 germplasm accessions was done. Oil content ranged from 5.10% (IC 349466) – 7.15% (IC 349478) and oleoresin content ranged from 4.49% (IC 547212) – 6.05% (IC 349335).Shortlisted accessions IC349333, IC349334, IC349358 and IC349376 (from field observations against rhizome rot) were evaluated by challenge inoculation under pot conditions. Two rounds of inoculation with *Pythium vexans* and *Rhizoctonia solani* at 30 days intervals was carried out. None of the accession showed rhizome rot symptoms even after profuse flooding. Further inoculations are in progress.

Breeding

Twenty three inter-varietal F1 hybrids were evaluated for yield and reaction to pest and diseases. From the pooled data of three years, nine superior hybrids were shortlisted and capsule characters of shortlisted hybrids were recorded. Among the nine shortlisted hybrid progenies, the progeny number 14 of ICRI 4 × IISR Vijetha recorded highest fresh (1090 g) as well as dry yield (236 g) of capsules per plant. Capsules of ICRI 4 × IISR Vijetha (14) are globose, bold (11.06 mm) and pale green in colour (Fig. 4).

Fig. 4. Capsule characters of ICRI 4 × IISR Vijetha (14)

Shortlisted hybrids PV 2 × IISR Vijetha (1), Mudigere 3 × IISR Vijetha (5), ICRI 4 × IISR Avinash (2), ICRI 4 × IISR Vijetha (14), Mudigere 1 × IISR Vijetha (1) and Mudigere 1 × IISR Vijetha (2) from field observations against rhizome rot were evaluated by challenge inoculation under pot conditions. Three rounds of inoculation with *Pythium vexans* and *Rhizoctonia solani* at 30 days intervals was carried out. None of the accession showed rhizome rot symptoms even after profuse flooding. Further work is in progress.

Evaluation of cardamom elite lines for yield and quality under moisture stress

Six genotypes of cardamom (IC 349537, IC 584058, GG × NKE-12, IC 584078, CL 668, HS 1, IC 584090) with one check (Appangala 1) were evaluated for drought tolerance under AICRP (Spices). Mositure stress was imposed in summer from February to April in stress block by withholding irrigation. The control block was irrigated by sprinkler (25 mm) once in 12-15 days interval. Soil moisture, gas exchange parameters, growth and yield data were recorded. Plant height, number tillers, panicle length and yield reduced under moisture stress. Accession IC 584058 recorded 400.34 kg/ha capsule yield in control and undermoisure stress it recorded 278.78 kg/ha, followed by that accession IC 584090 which recorded 307.32 kg/ha in control and 166.33 kg/haunder stress. Accession IC 584058 recorded 80 per bold capsules (>7mm) and synchrony in flowering and harvesting can be completed in four rounds. Essential oil content ranged from 6.81 to 8.18% and oleoresin content ranged from 3.61 to 5.55%.

Drought management

Anti transpirants such as kaolin 2%, kaolin 2% + 0.5% MOP, spray lime 1.5%, Spray lime 1.5% + 0.5% MOP and Miracle 3ml/litre were sprayed in February 2019. Physiological parameters such as Photosynthetic rate, stomatal conductance, transpiration rate, canopy temperature, chlorophyll fluorescence and yield parameters were recorded. Results indicated that lime 1.5% recorded higher photosynthetic rate with lower leaf temperature which helps the plants to maintain better water status under stress conditions.

Ideal shade concept for better productivity

Cardamom variety Appangala 1 was grown under different shade treatments (75% & 50% shade and open irradiance) to evaluate the effect of different light intensities on growth,

physiological parameters, yield, quality and pest incidence. Compared with open irradiance, physiologically active tillers, per cent of capsule setting and capsule yield per plant were highest in plants under 50% shade. The highest photosynthetic rate, stomatal conductance, transpiration rate, chlorophyll fluorescence and lowest canopy temperature were observed in plants subjected to 75% shade. Oleoresin content was highest in plants under open irradiance and no significant difference was observed in essential oil content of capsules among the treatments. The insect pest incidence in different light intensities showed that, the borer (*Conogethes punctiferalis* Guen.) damage on shoots was highest in plants under 75% shade. Intriguingly, no significant difference was observed in thrips and borer damage on capsules. Hence, it is suggested that 50% shade could be optimum for cultivation of small cardamom under both field and controlled conditions.

Rapid screening method for drought tolerance in small cardamom seedlings

An attempt was made develop a rapid screening method for moisture stress tolerance in small cardamom seedlings (variety-Appangala 1) using PEG-6000. Four different concentrations of PEG-6000 (5, 10, 15 and 20 per cent) along with a control (distilled water) were used. Significant differences were observed for seedling survival and root/shoot ratio at different concentrations of PEG-6000 ($p<0.05$). PEG-6000 concentration above 15% reduced seedling survival almost by 50%. However, at 15% PEG-6000, a significant increase in scavenging enzyme activity and total phenols content were recorded. Hence, 15% PEG-6000 appears to be an ideal concentration for moisture stress tolerance screening of small cardamom genotypes.

Organic farming

Under the network project on organic horticulture, trials on nutrient management of cardamom were initiated. Higher soil availability of major, secondary and micronutrients was recorded in FYM, vermi compost (VC) and neem cake (NC) combined application as compared to single application. Significantly higher OC, N, P, Ca, Mg, Fe, Zn availability was recorded in organic and integrated management system as compared to chemical management system. Among the organic nutrient sources, NC+VC combined application recorded 1.3 kg dry capsules per plot (of 12 plants) followed by FYM + NC (0.85 kg/plot) and VC (0.81 kg/plot). Integrated management yielded significantly highest fresh capsule yield (1.48 kg/plot) followed by chemical management (1.3 kg/plot) and organic management (0.9 kg/plot). With the application of spinosad and *Lecanicillium* and spinosad with *Trichoderma* and *Pochonia* no major incidence of rhizome rot and less than 5% incidence of thrips damage was noticed on capsules. Enzyme activities like dehydrogenase, acid phosphatase, alkaline phosphatase, and phosphodiesterace were higher under organic management as compared to chemical management.

Fig. 5. Field view of cardamom applied with different organic nutrient inputs

Identification of climate analogues sites for small and large cardamom

Identification of climate analogues sites for small cardamom and large cardamom was carried out using CCAFS climate analogues tool. For identification of climate analogues sites, efficient producing zones were identified based on relative yield index and relative spread index. These efficient zones were used as reference sites for identifying the climate analogues sites under changing future climate using CCAFS climate analogues tool. Accordingly, for small cardamom, 236 taluks located in 104 districts and for large cardamom, 234 taluks located in 112 districts were identified as climate analogues sites considering their future climate under changing climate scenario.

Viral diseases

Transmission of the Nucleorhabdovirus *causing vein clearing disease* (kokkekandu) *of cardamom*

Cardamom plants naturally infected with vein clearing *(kokke kandu)* disease showing typical symptoms collected from Hassan District, Karnataka was used for the study. Aphid species, *Pentalonia caladii* maintained in healthy cardamom plant was used for transmission studies. The identity of the aphid species was confirmed through PCR and sequencing of cytochrome oxidase subunit 1 (COI) gene. Sequence analysis of the COI gene of aphid showed 100% identity with *Pentalonia caladii* (GenBank accession number GU140254) confirming identity of the species. Aphids were allowed to feed on infected cardamom plants for 24 h to acquire the virus. The viruliferous aphids were then transferred to healthy seedlings of cardamom raised from seeds under insect-proof glass house conditions for a week and later killed. Of the eighteen cardamom plants inoculated, eight plants showed typical vein chlorosis symptoms within one month after inoculation indicating transmission of the virus through aphid. In another study, seeds collected from virus infected cardamom plants were also sown and plants raised under insect-proof conditions to check if the causal virus is seed transmitted. None of the plants raised from seeds that were collected from the virus infected plant showed any symptoms indicating that the virus is not transmitted through seeds.

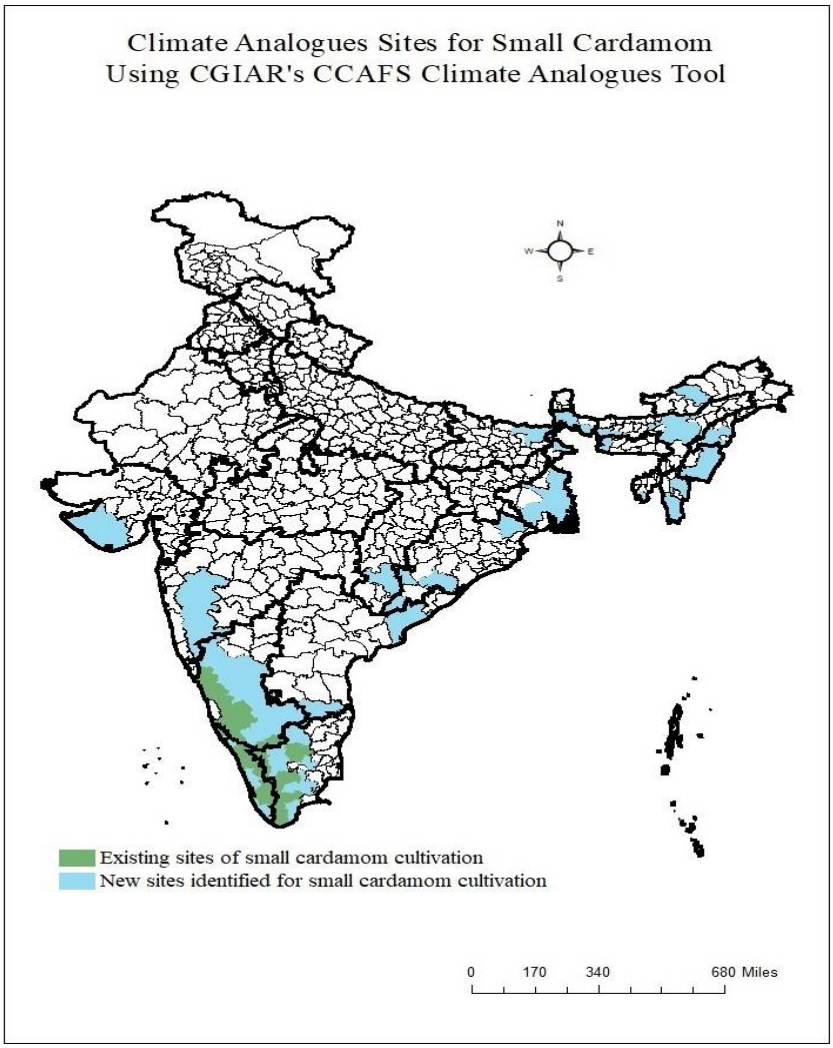


Fig. 6. Climate analogues sites for small cardamom

Cloning, sequencing and sequence analyses of *Nucleorhabdovirus* infecting cardamom

The total RNA extracted from aphid transmitted cardamom plants when subjected to RT-PCR using specific primers designed based on NGS contig sequence showed presence of the expected product (Fig. 7). The products were cloned and sequenced. Alignment of the sequences produced more than 9000 nucleotides. The BLAST N and BLAST X search of the sequence showed identities with nucleorhabdoviruses in the N (nucleocapsid), P (phosphoprotein), P3 (movement protein), M (matrix protein), G (glycoprotein) of nucleorhabdoviruses. The ORFs are separated by intergenic regions (IGR), bases 1253 to 1383, 2158 to 2342, 3396 to 3579 and 4489 to 4813 in the sequence. The 3610 bp sequenced region corresponds to partial L (polymerase, 1202 aa) (from 3 to 3608 nt).

The nt and aa sequences of the present virus isolate (tentatively named as *Cardamom vein clearing virus*, CdVCV) shared maximum identities in the L (58-62% and 57-64%), N (57-61 and 50-59%), G (51-61% and 49 to 56%), M (44-51% and 22-34%), P3 (47-49% and 31-40%) and P (41-45% and 15-22% with BCaRV, DYVV and SYNV compared to other nucleorhabdoviruses such as EMDV, MIMV, MMV, MSFV, PhCMoV, PYDV, RYSV and TaVCV. Similarly, when IGR sequences were compared, CdVCV showed identities ranging

from 31 to 61% with BCaRV, DYVV and SYNV. Further analysis of the sequence using cNLS Mapper revealed that all CdVCV encoded proteins contain mono- or bipartite nuclear localization signal (NLS). Phylogenetic analysis of the putative aa sequence of L proteins of

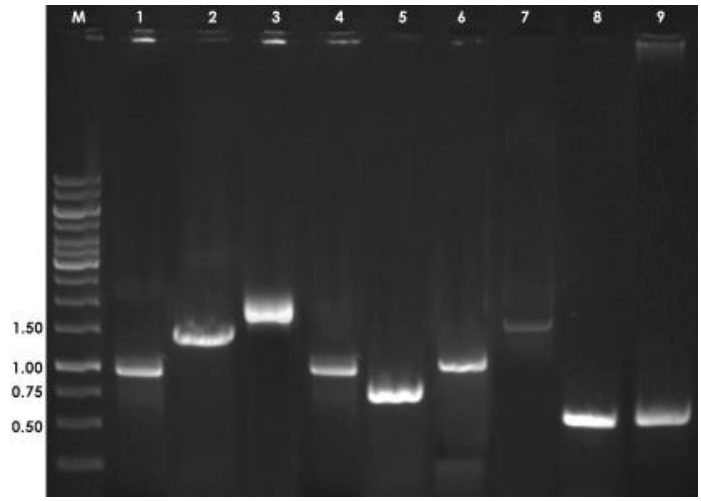


Fig. 7. Agarose gel electrophoresis of RT-PCR products obtained with nine primer sets used for the amplification of the *Nucleorhadovirus* genome from cardamom. Lane M: Marker; Lanes 1-9: RT-PCR products obtained with primers targeted to different regions of the virus

CdVCV and other nucleorhabdoviruses revealed closeness of CdVCV with BCaRV, DYVV and SYNV that formed a cluster clearly separated from other nucleorhabdoviruses (Fig. 8). Phylogenetic tree for all other five proteins also showed similar topology grouping CdVCV, BCaRV, DYVV and SYNV in a single cluster. This is the first report of occurrenceof a *Nucleorhabdovirus* infecting cardamom.

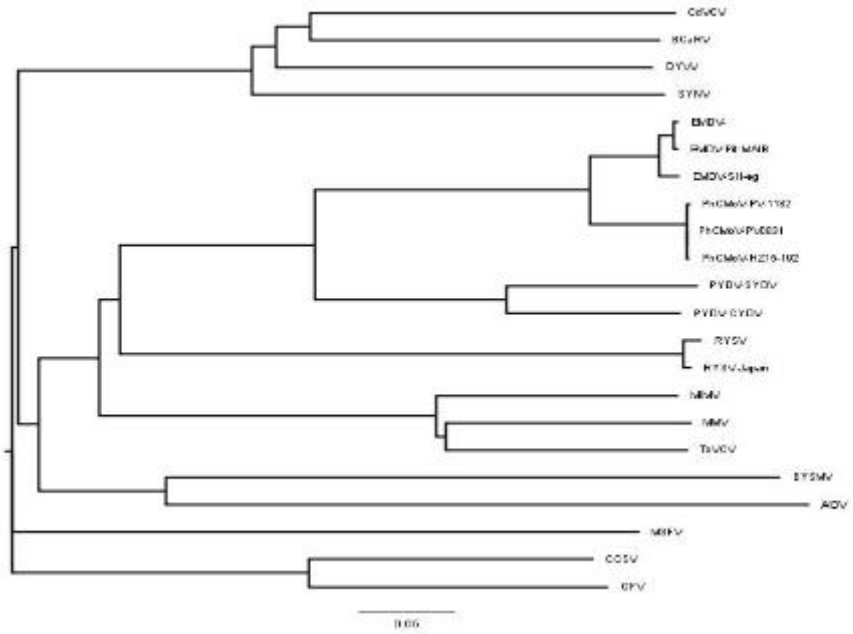


Fig. 8. Phylogenetic tree drawn based on the amino acid sequence of the polymerase gene of the *Cardamom vein clearing virus* (CdVCV) with other nucleorhabdoviruses

GINGER

Genetic resources

Six hundred and sixty eight ginger accessions have been maintained in the field gene bank. The ginger germplasm conservatory was enriched with 27 ginger accessions, eight *Zingiber* sp. and 30 related genera collected from Nagaland, Manipur and Andaman & Nicobar Islands.

Fig. 9. *Etlingera fenzlii* collected and added to the germplasm repository

Characterization

A total of 43 ginger accessions collected from different locations of North East India were genotyped using selected 30 SSR markers. Among them, eight primers produced polymorphic bands.

Development of novel EST-SSR markers

Mining of ginger transcriptome data resulted in 16790 Simple Sequence Repeats (SSRs) and was identified as potential molecular marker in the unigenes. Also, 4597 SSRs were identified in coding region of the sequences. Based on the SSR-containing gene sequences, 25 primer pairs were randomly selected and synthesized and used for assessment of the polymorphism. Six primer pairs were polymorphic and revealed polymorphism among 43 ginger collections.

Yield evaluation

The experiment (AICRPS CVT) was conducted during 2015-2018 at IISR Experimental Farm, Peruvannamuzhi, Kerala with seven different entries and a national check IISR Varada. Among the ginger accessions, maximum yield (pooled) was recorded in Acc. 247 (20.69 t/ha) followed by Rio-de-Janeiro (17.75 t/ha) and SE 8681 (15.81 t/ha) (Table 2).

Mutation breeding

Ten M1V5 and 102 M1V11 mutants have been maintained. Three potential mutants identified against *Pythium* sp. (V 0.5/2, R 0.8/1 and R 1.25/4) and three potential mutants against *Ralstonia solanacearum* (HP 0.5/2, HP 0.5/15 and M 0.5/1) were multiplied.

Induction of polyploidy

The rhizome buds of cv. Mahima were submerged in different concentrations of colchicine (0.025, 0.050, 0.075, and 0.1%) for 48 h to induce polyploids. Maximum sprouting was

recorded in 0.025% colchicine. All the successful plants (15) have been established for further studies.

Table 2. Yield performance of ginger genotypes

Genotype	Fresh yield (t/ha)			
	2015/16	2016/17	2017/18	Mean
Acc. 247	28.78	15.83	17.45	20.69
Acc. 578	23.98	8.29	14.50	15.59
SE 8640	23.40	14.46	8.25	15.37
SE 8681	23.80	16.75	6.88	15.81
SE 86131	18.29	10.31	11.63	13.41
SE HP9	18.49	15.71	8.25	14.15
SE 26-04	13.44	9.24	10.11	10.93
Rio-de-Janeiro	12.50	22.75	18.00	17.75
IISR Varada	17.23	10.95	11.63	13.27
Mean	17.23	10.95	11.63	13.27

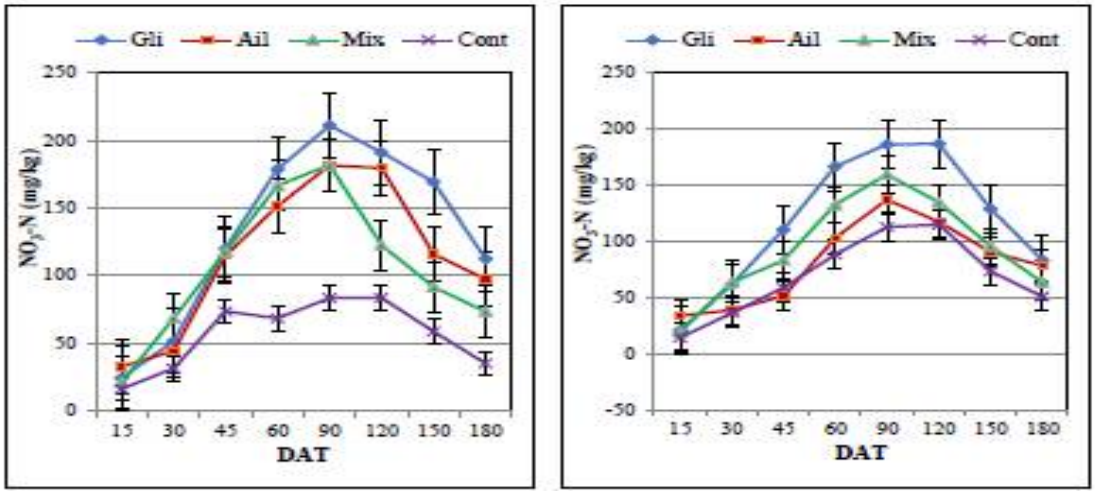
Nutrient mineralization dynamics of crop residues

Nutrient mineralization dynamics of commonly used crop residue mulches (Gliricidia, Ailanthus and mixed leaves) with and without FYM and rhizosphere priming was studied in ginger (Fig. 10). The rate of NO_3-N mineralization from crop residues was found to be significantly higher in the treatments with ginger over treatments without ginger, indicating the positives of rhizosphere priming effect. Highest NO_3-N and NH_4-N release was found in Gliricidia mulch. The application of FYM and presence of ginger decreased the cumulative and net release and mineralization rate of NH_4-N and the total N mineralization rate. The rate of total N mineralization was higher when crop residues are treated without FYM or ginger and highest when Gliricidia mulches are used. Almost 10 times higher net P release was observed between with FYM and without FYM treatment. Among mulches, net P release was higher in Ailanthus. Higher soil pH, OC buildup and soil enzyme activities were seen in FYM addition and ginger rhizosphere. More MBC was observed in the treatments with Ailanthus. The FYM priming increased the dry matter production of ginger by 48% and by 88%, 100% and 75% the N, P and K uptake, respectively as compared to without FYM. Even though cumulative N and K release was higher in Gliricidia followed by mixed leaves, the total uptake by the plant was higher in Ailanthus, which might be due to the prolonged release of N, P and K from Ailanthus and extended supply of these essential nutrients till 90-160 DAT for ginger during its critical growth period.

Anti oxidant and anti diabetic activity of ginger extracts

Ginger (IISR Varada) was powdered and subjected to the sequential extraction with petroleum ether, methanol and water and the percentage of 6-gingerol and 6-shogaol present in each of the sequential extract was quantified by HPLC analysis. Antioxidant activity using DPPH assay and IC_{50} values of the extracts were estimated and compared with that of standard 6-gingerol, 6-shogaol, butylated hydroxyl anisole (BHA) and curcumin and found that, among the sequential extracts, the petroleum ether extract had better activity. Antioxidant activity was also estimated by phosphomolybdenum assay. Anti-diabetic enzyme

assay of the standard 6-gingerol, 6-shogaol, 1:1mixture of 6-gingerol and 6-shogaol was carried out using α-glucosidase and compared with that of curcumin, DMC and BDMC.



(a) (b)

Fig. 10. Changes in NO_3 N availability due to application of mulches (a) with FYM; (b) without FYM

Bacterial wilt

Development of a suitable formulation for Bacillus licheniformis

Two different materials- charcoal and talc - were tested as carriers for *B. licheniformis* GAP107 formulation. *In vitro* and *in planta* studies were conducted in comparison with the broth culture for comparing their suitability and efficacy. All the three formulations retained the viability under *in vitro* conditions for more than 100days with the charcoal formulation maintaining the viability beyond 100 days. On evaluating the three formulations under greenhouse conditions, all the formulations enhanced the soil properties such as OC, N, P and K contents. However, application of charcoal formulation at the time of planting as rhizome priming (seed coating) and as soil application at the time of planting and at 30, 45, 60 and 90 days significantly enhanced the growth of the plants and reduced the disease incidence.

FLD on IDM of bacterial wilt of ginger

The effect of soil solarization, soil amendment with 3% calcium chloride and *Bacillus licheniformis* was demonstrated in eight AICRP centres, a farmer's plot in Chamarajanagar, Karnataka State and at Chelavoor campus of the Institute. In each centre, the main treatments were with solarization and without solarization. The sub treatments included (1) soil drenching with 3% calcium chloride, (2) seed priming and soil drenching with *Bacillus licheniformis* and (3) recommended practice of each centre. The germination, establishment, growth and yield of plants were significantly superior in solarized plots amended with both calcium chloride and *Bacillus licheniformis*.Significantly higher growth and yield were obtained with *B. licheniformis*treatment followed by calcium chloride atSASRD, Nagaland. However, at Solan, and Sikkim, treatment with calcium chloride resulted in significantly higher growth and yield.

Fungal diseases

Evaluation of Trichoderma *spp. against pathogens*

Under *in vitro* conditions, two strains of *Trichoderma viz., Trichoderma erinaceum* and *T. atroviride* were found to be effective against *Pythium myriotylum, P. aphanidermatum* and *Fusarium oxysporum* and bacteria *viz., Pseudomonas* sp. and *Bacillus* sp. isolates were found to inhibit the growth of *Bipolarisrostrata, Colletotrichum gloeosporioides* and *C. capsici*. The effective isolates of *Trichoderma, Trichoderma erinaceum* (IISR AP1) and *T. atroviride* (IISR TL 1) isolated from Andhra Pradesh and Telangana soils were coded and maintained in the biocontrol repository of ICAR-IISR.

Fungitoxic activity of silicates on Pythium myriotylum

Three silicon sources (solid and liquid forms of sodium and potassium silicate and sodium meta silicate) were tested under *in vitro* conditions for their effect on *P. myriotylum* and *Macrophomina phaseolina*. Sodium meta silicate limit the fungal growth at 70 mM whereas sodium and potassium silicate restrict the mycelial growth at 3% concentration. Microscopic studies revealed alteration of mycelial morphology like hyphal distortion and shrinkage. *In planta* studies showed an overall increase in growth rate of plant as compared to control. Challenge inoculated plants with silicate molecules showed a decrease in disease incidence as compared to the control. Among the treatments potassium silicate was found to be very effective in increasing the overall growth of the plant and arresting the disease incidence.

Isolation, characterization and evaluation of pink pigmented Methylobacterium

Potential of native Pink-Pigmented Facultative Methylotrophs (PPFMs) were isolated from ginger phyllosphere by leaf imprint technique and screened against major fungal pathogens of ginger *viz., Macrophomina phaseolina, Sclerotium rolfsii, Pythium myriotylum, Colletotrichum gloeosporioides* and *Fusarium oxysporum* (Fig. 11). Among the 60 PPFMs evaluated, seven showed higher inhibitory activity against the target pathogens. However, only one isolate (IISRGPPFM13) showed uniform growth at various temperatures. The isolate was studied for its abilities for mineral solubility, production of IAA, siderophores and hydrolytic enzymes like cellulase, pectinase, lipase, amylase and chitinase. On *in planta* evaluation for growth, better rhizome and root formation was obtained when the bacterium was applied as soil drenching cum foliar spraying. Methanol utilization potential of the isolate was confirmed by mxaF gene analysis where the sequence showed>95% similarity towards *Methylobacterium platani* and *M. inners*. Further, 16SrRNA gene sequence showed 98.96% similarity to *M. komagatae*, and this isolate can be proposed as a novel species of the *Methylobacterium* genus.

Leaf blight disease

Infection mechanisms of Bipolaris rostrata

The studies on infection mechanisms of *Bipolaris rostrata* on ginger showed that conidia inoculated on the surface of ginger leaves germinated, produced germ tubes and germ tube formation was found to occur from both the poles of conidia. Initially conidia were found to increase in size and later the end cell of one pole started bulging followed by formation of a small vesicle at the pole of the conidia. This vesicle was found to elongate to form a tube like

structure called the germ tube and later from the tip of germ tubes, uni- and multi lobed appressoria developed with size ranging between 9.02-15.34 µm × 4.12–10.57 µm (Fig. 12). Infection hyphae were formed from this and entered the tissues either directly through the epidermal cells or through the stomatal opening. Having established an infection in epidermal cells and the fungus produced secondary hyphae. The secondary hyphae were branched, thinner than primary hyphae and grew extensively inter and intracellularly, passing through cell walls from one cortical cell to the next. Later light brown lesions appeared on the leaves, due to the growth of secondary hyphae inside the epidermal cells.

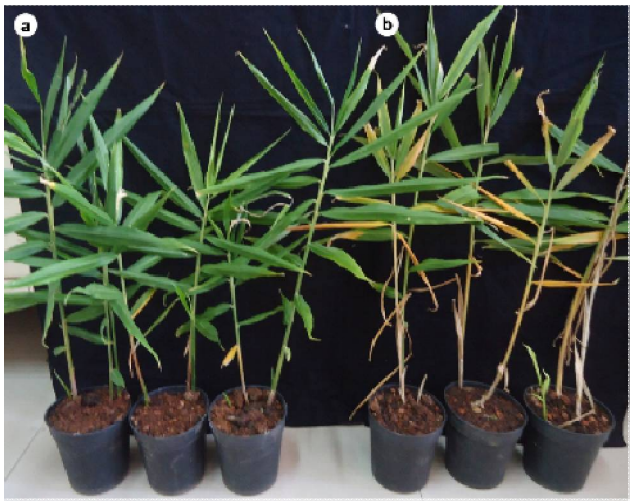


Fig. 11. Effect of *Methylobacterium* against *Pythium myriotylum* infecting ginger (a) *Methylobacterium* treated (b) Control with *Pythium* alone

Physiological and biochemical changes during ginger-* Bipolaris rostrata *interaction

Physiological and biochemical changes occurring during the *ginger- Bipolaris rostrata* interaction were studied under glasshouse conditions. Biochemical parameters like chlorophyll and protein were found to decrease whereas electrolyte leakage increased in artificially inoculated ginger plants compared to the control. Electrolyte leakage was found to increase rapidly from 15.7% at the time of inoculation to 44.61% on 5th day of inoculation. Chlorophyll 'a' (chl a) content showed a decrease from 1.91 mg/g at the time of infection to 0.84 mg/g, 5 days after inoculation (DAI). Similarly, there occurred a decrease in chlorophyll 'b' (chl b) content where it reduced from 0.62 mg/g at inoculation time to 0.31 mg/g at the 5 DAI.

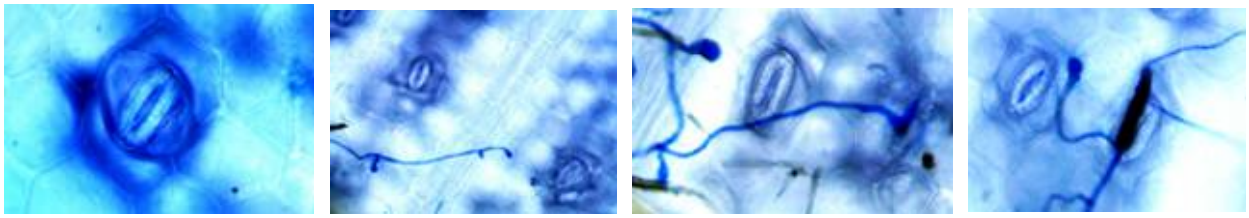


Fig. 12. Different stages in the conidial germination and infection by *Bipolaris rostrata*

In vitro *and field screening of fungicides*

The fungicides tebuconazole (0.1%), carbendazim + mancozeb, cymoxanil + mancozeb and hexaconazole were found to be effective under *in vitro* conditions. The most effective chemicals (tebuconazole 0.1% and carbendazim + mancozeb 0.2%), along with biocontrol agents (*Trichoderma harzianum*, *Bacillus amyloliquefaciens* and apoplastic bacteria) were tested against ginger foliar diseases under field conditions. Seed treatment and three foliar sprays with tebuconazole (0.1%) at 15 days' interval were found to be effective in managing foliar diseases of ginger.

Viral disease

Characterization of the virus belonging to the family Tombusviridae and Closteroviridae associated with ginger chlorotic fleck disease

The total RNA extracted from chlorotic fleck infected ginger plants when subjected to RT-PCR using specific primers designed based on NGS contigs sequence representing different genomic regions gave expected products. The products were cloned and sequenced. Alignment of the sequences produced 4086 nucleotides. The BLAST N and BLAST X search of the sequence showed identities of 41 to 47% identity with members of panicoviruses and machlomoviruses in the family, Tombusviridae. Similarly, comparison with different open reading frames (ORFs) such as polymerase, polymerase readthrough, coat protein and movement protein also revealed low identity ranging from 30 to 52% in the nucleotide and 8 to 42% in the deduced amino acid sequence with genera such as *Panicovirus*, and *Machlomovirus*. Similarly, subjecting these plants to RT-PCR using specific primers designed based on NGS contig sequence showed presence of the expected products (Fig. 13). Multiple alignment and per cent sequence identity of the virus isolate with corresponding sequences of different ampeloviruses showed that the present isolate shared 30 to 57% identity with different species of ampelo viruses (Closteroviridae family). The exact taxonomic identity of the virus will be known only when complete genome sequence of the virus is determined.

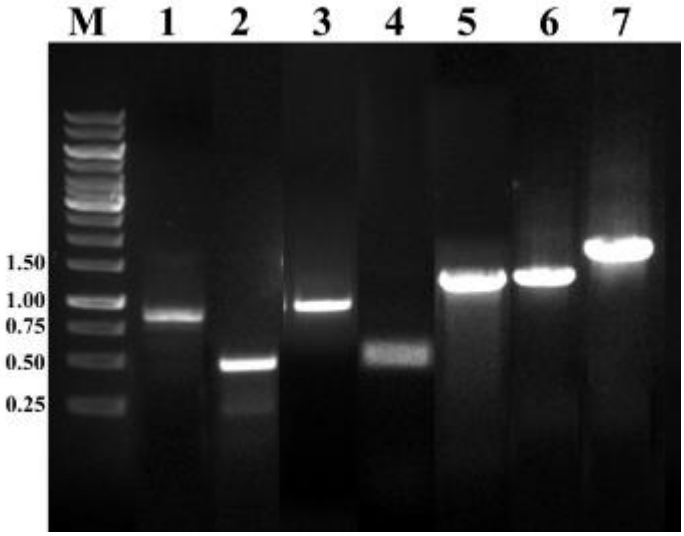


Fig. 13. Agarose gel electrophoresis of RT-PCR product obtained with seven primer sets used for the amplification of the virus belonging to the family, Closteroviridae

TURMERIC

Genetic resources

One thousand four hundred and four *Curcuma* accessions are being maintained in the field gene bank. The germplasm conservatory was enriched with eleven *Curcuma longa*, six *Curcuma* sp. from Nagaland and Andaman & Nicobar Islands.

Characterization

One hundred and fifty turmeric accessions were characterised based on different morphological traits. A total of 12 quantitative and 10 qualitative characters were recorded for each turmeric accession.

Evolving extra-long and bold turmeric lines

Twelve accessions of Salem Local (Erode and Salem districts of Tamil Nadu) and four accessions of Mydukur (Andhra Pradesh) were collected and multiplied. Also, open pollinated seeds of 31 turmeric accessions from germplasm were collected and raised seedling progenies to evolve extra-long rhizome turmeric genotypes. Germination was found to be staggered, 63 seeds germinated and seventeen seedlings were transplanted.

Maintenance of seedling progenies, hybrids and inbreds of turmeric

First generation seedlings (224 Nos), mother genotypes (23 Nos), second generation seedlings (378 Nos), third generation seedlings (34), first generation inbreds (42 Nos), second generation inbreds (6 Nos), third generation inbreds (402) and inter-varietal hybrids (4 Nos) were maintained. One hundred and forty F_2 hybrids of H1 (30), H2 (110), and nine open-pollinated progenies of high curcumin line SLP 389/1 were also maintained. Additionally, intercross hybrids (38), back cross hybrids (8), OP progenies of two inter-varietal hybrids (34) and 75 somaclones were also maintained.

Replicated trials of promising seedlings and hybrids of turmeric in the field

Replicated trial involving three hybrids and three seedlings were laid out at Chelavoor and Peruvannamuzhi. Yield was better in Chelavoor compared to Peruvannamuzhi. SLP 359/2 and SLP 65/12 produced mean yield of > 10.0 kg per 3 m^2 bed at Chelavoor. Curcumin content was above 5% in SLP 359/2 and 389/1-OP-1 (Table 3).

Table 3. Yield, dry recovery and curcumin content of the seedlings and hybrids

Identity	Yield* (kg/3 m^2 bed)		Dry recovery (%)		Curcumin content
	Chelavoor	Peruvannamuzhi	Chelavoor	Peruvannamuzhi	Chelavoor
Hybrid-1	8.9	6.03	24.0	20.25	2.83
Hybrid-2	9.7	5.73	23.0	20.05	2.62
Hybrid-3	6.0	2.83	25.3	22.50	2.47
SLP 65/12	10.4	6.10	23.0	20.00	3.08
SLP 359/2	11.3	7.16	18.7	17.40	5.40
389/1-OP-1	8.7	5.60	22.3	21.80	5.66

*Mean of three replications

Chromosome number analysis of seedlings, hybrids and inbreds of turmeric

Among the 20 third generation inbreds analyzed, 9 showed 2n=84, 6 showed 2n=86, 2 showed 2n=87 and 1 each showed 2n=90, 2n=91 and 2n=132. Among the seedlings 6 showed 2n=84 and 1 showed 2n=86. An intercross hybrid (Hybrid 2 x Hybrid 3) showed 2n=82.

Self-pollination studies

Self-pollination was performed in 33 third generation inbreds of 138/11/1 and two first generation inbreds of Acc. 65 and SLP 359/2. Fruit and seed set were observed in 18 of them. Additionally, self- pollination was performed in 10 OP seedlings and six of them produced seeds. All selfed seeds were sown and germination is in progress in most of them (Table 4). More than 1100 selfed seedlings were transferred to bags as on date. One of the first generation inbreds of Acc. 65 (Acc. No.65--I_1-2) was found to have only female flowers. Self pollination in IISR varieties *viz.*, Suguna, Sudharsana, Suvarna and IISR Pragati and other triploid commercial varieties *viz.*, Roma, Reshmi, Rajendra Sonia, Suranjana and Narendra Haldi did not result in any seed set.

Multiplication of first generation inbreds of 69/5/22 and self-pollination

Eight first generation inbreds were multiplied in pots and self-pollination was performed. Seed set was observed in five of them and germination started in one.

Cross pollination

Six cross combinations between inbreds resulted fruit set in two combinations. Four cross combinations between commercial cultivars failed to produce any fruit set. Thirty-five hybrid seedlings were established in bags as on date. Pollen fertility based on stainability was tested in 10 third generation inbreds of 138/11/1. Five inbreds showed pollen fertility above 90%.

Towards identification of a candidate PAL gene involved in curcumin biosynthesis

Using a comparative transcriptome approach a *PAL* gene transcript showing significant correlation with curcumin levels as well as with *CLPKS 11* and *CURS I* (bait genes) was identified (Fig. 14). Tissue-specific qPCR analysis of *PAL* gene showed maximum expression in rhizomes and pseudostems followed by leaf and root.

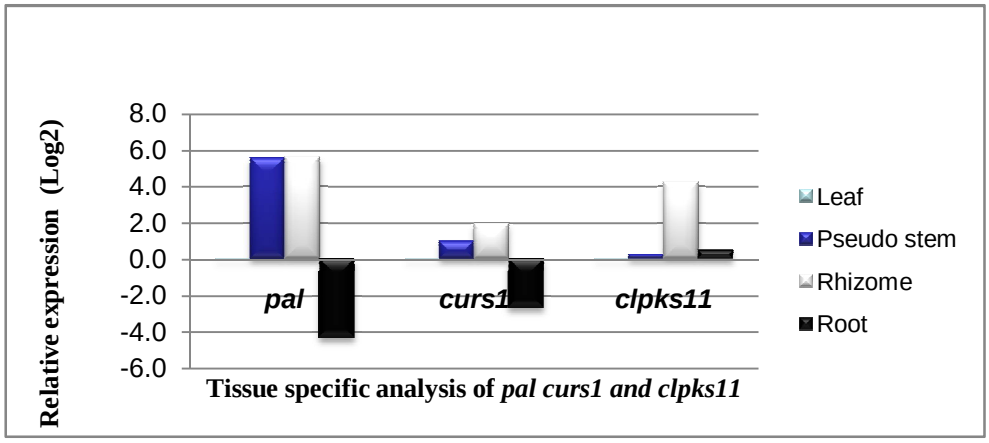


Fig. 14. Tissue specific analysis of PAL, CURS1 and CLPKS11 in four month old IISR Prathibha

Table 4. Self-pollination in inbreds

Identity of inbred	Number of flowers pollinated	Number of fruits set	Number of seeds	Number of inbred seedlings established
138/11/1/I_1-12-I_2-1-I_3-1	52	-	-	-
138/11/1/I_1-12-I_2-1-I_3-5	117	1	8	
138/11/1/I_1-12-I_2-1-I_3-6	16	-	-	-
138/11/1/I_1-12-I_2-1-I_3-9	13	-	-	-
138/11/1/I_1-12-I_2-2-I_3-23	33	3	19	2
138/11/1/I_1-12-I_2-2-I_3-25	40	-	-	-
138/11/1/I_1-12-I_2-2-I_3-26	14	-	-	-
138/11/1/I_1-12-I_2-2-I_3-29	43	-	-	-
138/11/1/I_1-12-I_2-2-I_3-30	55	8	64	30
138/11/1/I_1-12-I_2-2-I_3-56	63			-
138/11/1/I_1-12-I_2-2-I_3-64	19	3	22	3
138/11/1/I_1-12-I_2-2-I_3-81	39	2	12	3
138/11/1/I_1-12-I_2-2-I_3-83	119	36	530	193
138/11/1/I_1-12-I_2-2-I_3-86	43	4	19	4
138/11/1/I_1-12-I_2-2-I_3-93	34	-	-	-
138/11/1/I_1-12-I_2-2-I_3-118	200	2	12	3
138/11/1/I_1-12-I_2-2-I_3-129	45	-	-	-
138/11/1/I_1-12-I_2-2-I_3-142	83	4	32	11
138/11/1/I_1-12-I_2-2-I_3-148	19	-	-	-
138/11/1/I_1-12-I_2-2-I_3-153	100	17	114	4
138/11/1/I_1-12-I_2-2-I_3-157	13	1	4	
138/11/1/I_1-12-I_2-2-I_3-160	87	16	99	49
138/11/1/I_1-12-I_2-2-I_3-359	51	11	103	9
138/11/1/I_1-12-I_2-2-I_3-360	36	2	11	
138/11/1/I_1-12-I_2-3-I_3-1	72	17	132	8
138/11/1/I_1-12-I_2-3-I_3-3	49	7	37	1
138/11/1/I_1-12-I_2-3-I_3-4	6	-	-	
138/11/1/I_1-12-I_2-3-I_3-5	28	12	80	34
138/11/1/I_1-12-I_2-3-I_3-6	14	-	-	
138/11/1/I_1-12-I_2-3-I_3-7	22	-	-	
138/11/1/I_1-12-I_2-3-I_3-8	33	-	-	
138/11/1/I_1-12-I_2-4	59	1	3	
SLP 359/2-I_1-1	70	-	-	
Acc. No.65--I_1-1	24	-	-	

Total 354

Identification of MYB transcription factors involved in curcumin biosynthesis

RNA seq and differential analysis in a high curcumin variety, IISR Prathibha and a low curcumin accession, Acc. no. 200 identified 20 full length R2R3 MYB transcripts putatively correlating with curcumin content. Most of these were down regulated under high curcumin levels and a few of them had repressor motifs and their expression could be correlated in qPCR analysis. The selected MYBs were docked to confirm their interaction with the cis regulatory regions of the novel gene *CLPKS 11* involved in curcumin biosynthesis. Based on

Patch Dock a good interaction of MYBs with the promoter is indicated by a minimum Atomic Contact Energy (ACE). Our results indicate a plausible interaction of the candidate MYB with the novel gene *CLPKS11* putatively involved in curcumin biosynthesis (Fig. 15).

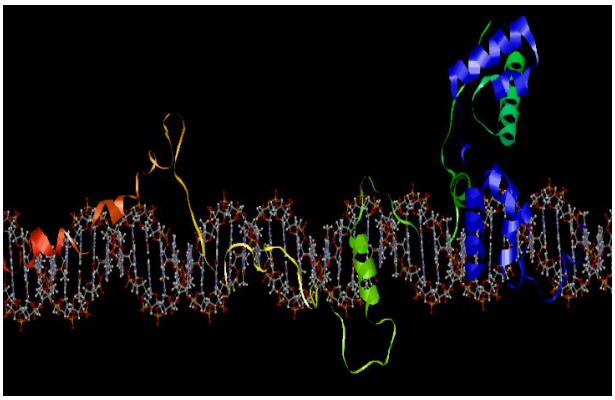


Fig. 15. Patch dock analysis of putative MYB with promoter regions *CLPKS11* gene

Organic farming

Under Network project on organic farming, eleven varieties of turmeric were tested under five treatments *viz.*, organic 100%, organic 75%, INM (75% org + 25% chemical), INM (50% org + 50% chemical) and 100% chemical for yield and quality. Integrated nutrient management (75:25 & 50:50) recorded highest fresh rhizome yield of turmeric (23.8 t/ha-30.2 t/ha) followed by organic and chemical management systems. IISR Pragati recorded highest yield (30.2 t/ha) under INM 75:25 followed by Kanthi (21.6 t/ha) and Sudarshana (19.8 t/ha) under similar management systems. Under fully organic (both 100 & 75%) management systems also IISR Pragati (26.2 t/ha), Suguna (24.6 t/ha) and Kanthi (21 t/ha) varieties yielded higher fresh rhizomes as compared to other varieties. Among the varieties, significantly higher oil content was noticed in IISR Prathibha, IISR Alleppey Supreme and Kanthi. The varieties IISR Prabha, IISR Pragati, and IISR Kedaram recorded higher oleoresin content. Highest curcumin content was recorded in IISR Pragati followed by IISR Prabha and IISR Kedaram.

Integrated organic farming system model

Farming system model plot with spices, fodder and vegetables was established at Chelavoor farm. Fodder grasses (700 kg), tapioca (70 kg), cowpea (12 kg), banana (80 kg) and milk (4358 L) were produced under integrated farming system. In addition, 12 tons of cow dung was obtained from the 3 cows during the year and used for recycling through composting and FYM preparations. In IFS, a profit of Rs 1.08 lakhs was obtained from one acre land.

Zn solubilizing bacteria on mycorrhiza development

To achieve maximum benefit from PGPR, the influence of promising in turmeric rhizosphere was studied for possible interactions. Zn solubilizing bacteria (ZnSB2-*B. megaterium* and *Glucanacetobacter diazotrophicus*) was co-inoculated with AMF (*Glomus irregularis* aka *Rhizophagus irregularis*) in soils under turmeric. Zn was applied as ZnO and $Zn_3(PO_4)_2$. The results indicated accelerated spore production and colonization when *R. irregularis* was applied in conjunction with ZnO and ZSB2 (ZnO + ZSB2 + AMF) or $Zn_3(PO_4)_2$ and ZSB2 [$Zn_3(PO_4)_2$ + ZSB2 + AMF] compared to ZnO + AMF alone.

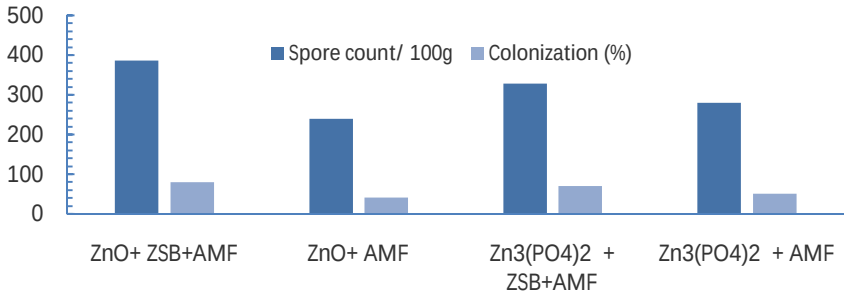


Fig. 16. AMF (*R. irregularis*) – ZSB (*B. megaterium*) interaction on AMF spore production and percent colonization in soils under turmeric

ZnO effects on soil bacterial community structure in turmeric rhizosphere

The soil samples spiked with nZnO (<100 nm) had relatively lower average Shannon diversity index and Simpson's Evenness Index compared to the control soil and those exposed to bZnO. The total bacteria in the soil was quantified by measuring the amount of 16S rRNA gene targets per g of dry soil. The results revealed marked decrease in bacterial population in soils exposed to nZnO and soil exposed to 250 ppm bZnO. Conversely, the effect was insignificant in soils exposed to 50 ppm bZnO.

Perceptible shifts in class level microbial community composition was observed in soils due to different treatments (Fig. 17). The control soils had a relative abundance of Sphingobacteria, Actinobacteria and Gemmatimonadetes. A major reversal was observed in soils exposed to 50 and 250 ppm nZnO, where both abundance and richness in the class level community composition showed a drastic decrease. These soils showed abundance of Gamma proteobacteria, indicating the resilience of this class of bacteria to nZnO. Similar decrease was observed in soils treated with bZnO, though the degree of shifts in the class level community composition was not quite as extreme as in soils treated with nZnO.

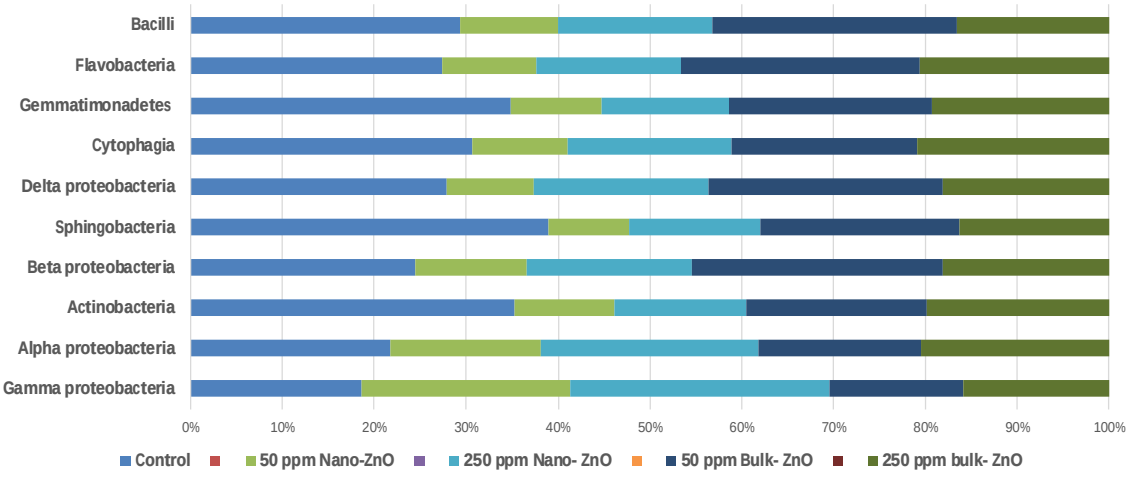


Fig. 17. Class level bacterial community composition in soil spiked with nZnO and bulk ZnO

Performance evaluation of solar drier

The solar dryer was installed at IISR, Experimental farm, Peruvannamuzhi. It consists of 20 rectangular solar collectors of size 2 × 1m covered with glass for trapping solar radiations. The unit is capable of heating air to a temperature of more than 100^{o}C, depending on the intensity of the solar radiation. The drying chamber consists of 20 trays each with a capacity 2.5 kg.

Turmeric variety (IISR Prathibha) was cured by four different methods such as i) slicing to 5mm thickness, ii) traditional water boiling for 60 minutes, iii) steam cooking for 60 minutes in TNAU boiler iv) cooking for 60 minutes in solar cooker developed by ICAR-IISR. Cured turmeric rhizomes were dried in the solar dryer and under open sun. Drying of sliced turmeric was completed in 7 days in both solar drying and sun drying. Turmeric cured in TNAU boiling unit recorded maximum drying time of 12 days for both solar drying and sun drying methods. There was no significant change in the dry recovery and the final moisture content of turmeric cured by different methods.

Quality evaluation showed that the retention of primary metabolites were higher in solar dryer dried turmeric compared to sun dried turmeric. Essential oil content of solar dryer dried turmeric was higher compared to sun dried turmeric with maximum value of 6.40% for sliced turmeric. Turmeric cured by all the heat treatments reported the lowest essential oil content of 5.20% when subjected to sun drying. Curcumin content of dried turmeric recorded a maximum value of 4.61% for solar dryer dried sliced turmeric. Lowest curcumin content (3.89%) was reported for sun dried turmeric cured in solar cooker. Highest oleoresin content was also observed in sliced turmeric.

Screening of turmeric accessions against diseases

Natural incidence of rhizome rot and foliar diseases was recorded in 165 germplasm accessions of turmeric during July 2018 to January 2019. Among the different germplasm accessions, mean per cent disease index for rhizome rot varied between 0-23.41, whereas the mean per cent disease intensity of foliar diseases ranged from 0-17.59.

Plant parasitic nematodes

Survey for nematodes of turmeric

Surveys were conducted in turmeric growing areas of Coimbatore, Erode, Salem and Villupuram districts of Tamil Nadu and 52 soil and rhizome samples were collected. Random samples were also collected from Kerala, Karnataka and North East. High incidence of root-knot nematodes was observed in these samples, followed by burrowing and lesion nematodes (Fig. 18). Root knot nematode population was comparatively high wherever turmeric was intercropped with banana, especially at Thanneerpanthal region in Coimbatore District. The lesion nematodes (*Pratylenchus* spp.) were observed in Alandur and Thannerpanthal region of Coimbatore District, Bhavanisagar and Gobichettipalayam region of Erode District, Shimoga in Karnataka, Nagaland in North East regions. High population of lesion nematode, *Pratylenchus* spp was recorded in Thanneer Panthal region (3.2/g soil) in Coimbatore and Gobichettipalayam (4.7/g soil) in Erode from turmeric.

Fig. 18. Field symptoms of nematode infestation in turmeric. (*Left*) Root knot nematodes and (*Right*) Lesion nematodes

VANILLA

Collection and conservation of germplasm

The germplasm conservatory was enriched with six *Vanilla* sp. collected from Assam resembling the morphological features of *V. borneensis* and five collections from Andaman Island.

Fig. 19. Germplasm collection at Andamans; *V. andamanica* collected from Andamans

Conservation of vanilla germplasm

Sixty five accessions of *Vanilla planifolia,* 7 *Vanilla* spp. from Andamans, one each of *Vanilla pilifera, Vanilla aphylla, Vanilla tahitensis* and *Vanilla wightiana,* totalling 76 accessions are conserved at ICAR IISR, Chelavoor farm under protected condition.

Wilt diseases

Characterization of Chaetomium *spp.*

Five *Chaetomium* spp. isolated from different parts of the healthy vanilla plants were microscopically observed for theirperithecial and ascosporial characters bearing densely hairy, egg-shaped fruiting bodies (perithecia) containing asci, which in turn enclose 4-8 brown spores (ascospores). The length of perithecia ranged between 180-120 µm and width ranged between 134-152 µm. The length of ascospore ranged between 9-12 µm and width in the range of 6-8 µm. The isolates were tested for their ability to produce various growth

promoting substance such as H_2S, siderophores, starch hydrolysis and cellulase production activities. All the isolates were able to hydrolyze starch while none of them were able to produce H_2S. All the isolates except FVLEp2 and FVAREn1 produced siderophores and cellulose, respectively.

In vitro *screening of microbial antagonists against major pathogens*

Chaetomium isolates were screened under *in vitro* conditions against two major pathogens of vanilla -*Phytophthora meadii* and *Colletotrichum gloeosporioides*. Among the isolates, FVREP4 showed maximum reduction in growth of pathogens by 56.88 and 83.73% for *P. meadii* and *C. gloeosporioides*, respectively.

Endophytic and epiphytic bacteria isolated from healthy vanilla plant parts were screened against *P. meadii* and the inhibition ranged from 0.0 to 53.0%. Among the isolates tested, VSEN7 and VAREN4 showed maximum (>50%) inhibition of the pathogen. However, none of them showed more than 50.0% inhibition of *Sclerotium rolfsii*, causing stem rot.

In vitro *screening of fungicides against major pathogensof vanilla*

Four fungicides *viz.*, propioconazole (45% EC), hexaconazole (5% EC), carbendazim 12% + mancozeb 63% (WP) and metalaxyl 8%+ mancozeb 64% (WP) were tested at five different concentrations (500, 1000, 1500, 2000 and 2500 ppm) against *P. meadii*, *S. rolfsii* and *C. gloeosporioides*. All the fungicides showed 100% inhibition of *P. Meadii* and *C. Gloeosporioides* at 500 ppm concentration while the fungicides - propioconazole (45% EC) and hexaconazole (5% EC) showed 100 % inhibition of *S. rolfsii* at 1500 ppm only.

TREE SPICES

Nutmeg

Collection and conservation of germplasm

Various islands of South Andaman, Middle Andaman, Great Nicobar and Little Nicobar were surveyed and collected three accessions of *Myristica andamanica*, two accessions of *Horsfieldia* spp. and four accessions of Knema spp. Two accessions of *Myristica andamanica* and one accession each of *Horsfieldia* and *Knema* species were also collected from NBPGR, Thrissur.

Conservation of treespices germplasm

The nine new accessions of nutmeg arebeing maintained in the nursery for establishment. The germplasm of tree spices collected during earlier surveys were planted at Chelavoor and Peruvannamuzhi campus for conservation. All the field planted germplasm are well maintained in the germplasm repository at Chelavoor and Peruvannamuzhi campus.

Evaluation of nutmeg germplasm

The germplasm of nutmeg consisting of bold nut types, thick mace types, high yielding types, monoecious types, unique types, farmers varieties, *etc.* were maintained. Data on yield and

yield attributing characters of all the accessions of nutmeg maintained at Chelavoor were recorded this year also for identifying elite lines.

Conservation and evaluation of monoecious nutmeg

Monoecious nutmeg plants collected from various parts of the country are being evaluated at Chelavoor campus. All the plants have established and the growth of the seedlings is good. Few of the seedlings progenies of monoecious trees planted at Chelavoor campus are early bearing and haveflowered and fruited. The yield data is being recorded.

Evaluation of elite lines having high myristicin and elemicin in nutmeg and mace oils

Grafts of four short listed elite lines namely, A9/4-3(IC-537153), A9/4-11(IC-537153), A4/17 (IC-537043) and A9/20 (IC-537169) having high myristicin and elemicin in nutmeg and mace oils were planted for field evaluation at Chelavoor. All the plants have established and the growth is good. Flowering and fruit set has been observed in a few grafts and the morphological and yield data were recorded.

Evaluation of elite lines having low myristicin, elemicin and safrole and high sabinene in nutmeg

Grafts of four short listed elite lines A4-22 (IC-537048), A9-69 (IC- 537218), A9-71 (IC 537220), A9-95 (IC-537244) and A9-102 (IC- 537251) having low myristicin and high sabinene in nutmeg and mace oils were planted in Chelavoor campus for evaluation. Flowering and fruit set has been observed in a few plants and the morphological and yield data were recorded.

Evaluation of a nutmeg variant with yellow coloured mace

The seedlings of the nutmeg variant with yellow mace was planted in the field for evaluation. All the plants have established. The budded plants planted in the conservatory has flowered and fruited and data on fruit characters and yield was recorded. Among the 12 seedlings 4 flowered and out of that one was female and other three males.

Evaluation of nutmeg for its suitability for high density planting

The experiment on studying the suitability of the nutmeg for high density planting with plagiotropic grafts of nutmeg variety IISR Viswashree at Chelavoor campus. The spacing adopted were 4m × 2m, 4m × 3m, 4m × 4m, 4m × 5m, 4m × 5m (Control, no pruning). All the plants have established and the plants have been trained to grow erect by giving support. Around 30.0% of the plants have flowered and set fruits. A similar experiment was laid out at Peruvannamuzhiand the grafts were pruned and trained by giving support to fit in to the high density system.

Integrated nutrient management in nutmeg

Application of coir pith compost 2 kg during May, soil application of recommended nutrients (120: 108:300 NPK g/plant) in 2 splits during June and September, foliar spray of micro nutrients (0.5%) and spraying of benzyl adenine (BA 10 ppm) during June and September recorded maximum canopy spread in north south (193 cm) and east west

direction (255 cm) followed by application of vermicompost 2 kg per plant and recommended nutrients, (163 cmnorth south and 153 cmeast west direction, respectively) during 2018-19.

Cinnamon

Germplasm collection

A collaborative germplasm exploration trip was undertaken to various parts of South Andaman, Great Nicobar and Little Nicobar along with ICAR-NBPGR RS, Thrissur and ICAR- CIARI, Port Blair and collected three accessions and a wild species of cinnamon. One of the cinnamon accessions was found to be tolerant to salinity.

Antidiabetic activity

Earlier studies indicated promising *in vivo* antidiabetic potential methanol extract of cinnamon. By column chromatography the extract was fractionated and promising fraction was identified and further purified. Antidiabetic potential of the fractions was determined by α-glucosidase inhibitory activity (Fig. 20) and compared with that of authentic standard acarbose.

Molecular docking using α-glucosidase, dipeptidyl peptidase, protein tyrosine phosphate, free fatty acid receptor, peroxisome proliferator-activated receptor and reported chemical constituents of cinnamon was carried out and epicatechin and procyanidin B5 were identified as probable candidates with antidiabetic potential.

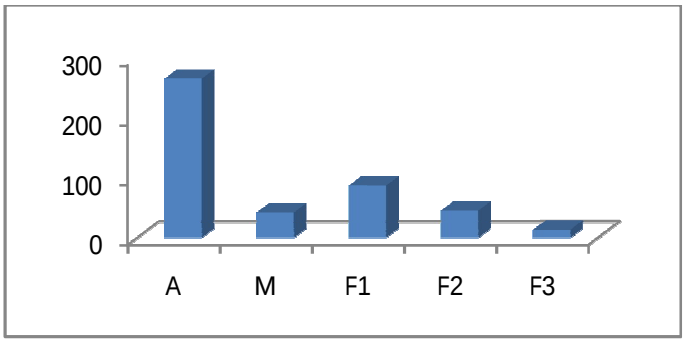


Fig. 20. α-Glucosidase inhibitory activity (IC_{50}) of acarbose and cinnamon fractions

Allspice

Germplasm collection

High yielding trees of allspice were identified and 5 accessions were collected from the farmer's field in Wayanad district of Kerala.

Quantification of flavonoids

Sequential extraction of allspice berries was carried out in hexane, chloroform, methanol and water. Total phenol content and flavonoids were estimated and found that chloroform extract had highest phenolic content and methanol extract had highest flavonoids.

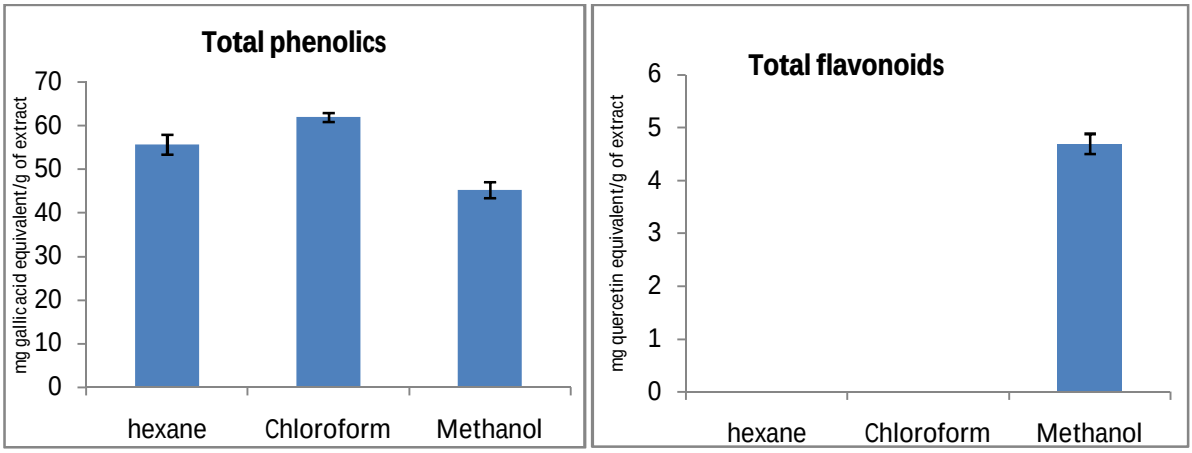


Fig. 21. Total phenols and flavonoids in allspice berry extracts

Inhibitory effect of *Pimenta dioica* leaf essential oil on *A. flavus*

Radial growth and biomass of *A. flavus* (IISRaf1) reduced significantly in response to various concentrations of allspice leaf essential oil (EO) ranging from 0.01 to 0.04%. At 0.03%, growth was reduced to about half as that of the control. The Probit analysis of allspice leaf EO showed LD50 and LD90 values of 0.026% and 0.038% respectively. The EO at 0.04% concentration able to inhibit spore germination by 100%.

Detection of antifungal compound by agar overlay method

The TLC separation leaf EO showed the presence of seven bands with RF values of 0.15, 0.32, 0.43, 0.52, 0.70,0.76 and 0.80 when eluted with solvent system comprising of toluene and ethyl acetate (9.3: 0.7 ratio) (Fig. 22). A clear colourless inhibition zone against pink background around the place where eugenol was separated in agar overlay assay was seen (Fig. 23).

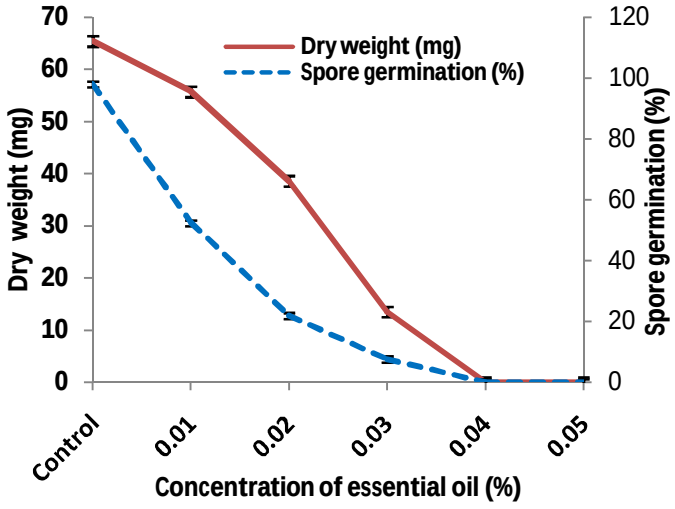


Fig. 22. Effect of *P. dioica* leaf oil on spore germination of *A. flavus*

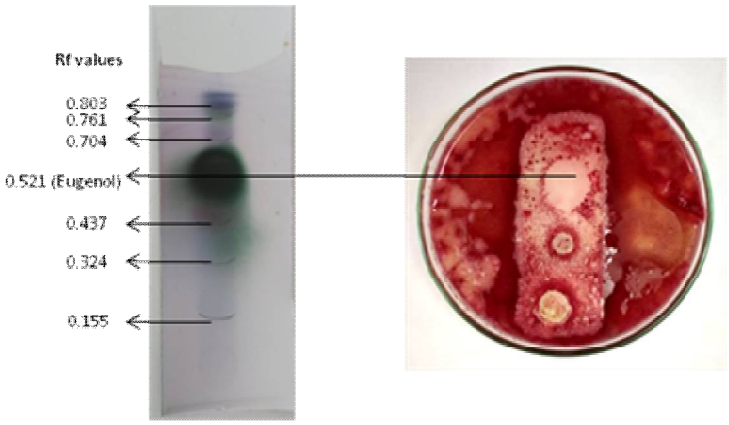


Fig. 23. Thin layer chromatography with agar overlay assay of leaf oil against *A. flavus*

Clove

Germplasm collection

One clove accession and two *Syzigium* species were collected during the exploration to Andaman and Nicobar islands

Garcinia

Germplasm collection

In an exploration trip to Andaman and Nicobar Islands, three accessions of *Garcinia nervosa*, 10 accessions of *G. speciosa*, One accession of *G. dhanikariensis*, five accessions each of *G. cowa and G. Kydia* were collected. Three high yielding accessions of *G. Indica* and one accession of *G. dhanikariensis* were obtained from NBPGR Regional Station, Thrissur. In addition to this, two exotic species of Garcinia *viz; G. schomburgkiana* and *G. kola* were collected from farmer's field in Kerala.

SPICES

Surveillance and documentation of pests and diseases of spices

Eleven black pepper plantations representing Kodagu (9), Karnataka and Palakkad (2), Kerala were surveyed for the occurrence of pests and diseases. As a part of surveillance programme, more than 30 cardamom and black pepper plantations were also surveyed for the incidence of pests/diseases in Malnad regions of Karnataka. Five isolates of *Phytophthora* and 10 isolates of *Colletotrichum gloeosporioides sensu lato* were collected during the surveys undertaken in Karnataka. Twenty isolates of *Phytophthora* representing black pepper and nutmeg were collected during the surveys conducted in Kerala. In black pepper, plant parasitic nematodes *viz.*, *Meloidogyne incognita*, *Radopholus similis*, *Pratylenchus reniformis* and *Helicotylenchus* were found associated with vines exhibiting declining symptoms. Soil enzyme activity of samples collected from Kodagu (Karnataka), Palakkad and Idukki (Kerala) indicated that, fluorescein diacetate (FDA) hydrolysis rate was high (45.8 FDA µg

fluorescein g^{-1} h^{-1}) in the sample collected from the rhizosphere of organically cultivated black pepper representing Agali (Palakkad) region.

Entomopathogens and other natural enemies of spice crops

Four entomopathogenic fungi were documented from insects associated with spice crops, *Basilepta* sp. (IISR-EPF-19) infesting cardamom, *Saissetia nigra* infesting nutmeg (IISR-EPF-20), *Aspidiotus destructor* (IISR-EPF-21) and *Protopulvinaria* sp. (IISR-EPF-22). The entomopathogenic fungus infecting *Basilepta* sp. has been identified as *Beauveria* sp. based on morphological studies. The entomopathogenic fungus infecting an unknown caterpillar infesting ginger (IISR-EPF-17) has been identified as *Nomuraea rileyi* based on molecular studies.

Association of arbuscular mycorrhizal fungi in different spice crops

Association of arbuscularmycorrhizal (AM) fungiwith spice crops was investigated inblack pepper, turmeric, ginger and cardamom by collecting soil and root samples from different locations. The AM fungal spores were separated from the soil by wet sieving and decanting technique and identification of AM spore was carried out based on morphotaxonomic criteria using INVAM. Based on our observation, most of the spices possess AM fungal spores as a regular component of the soil microflora. Among the recovered AM fungal spore population *Glomus* species was dominant in most of localities. This might due to the high sporulation capacity and high viability of the *Glomus* species, while, others were scanty due to the longer reproductive times (Fig. 24).

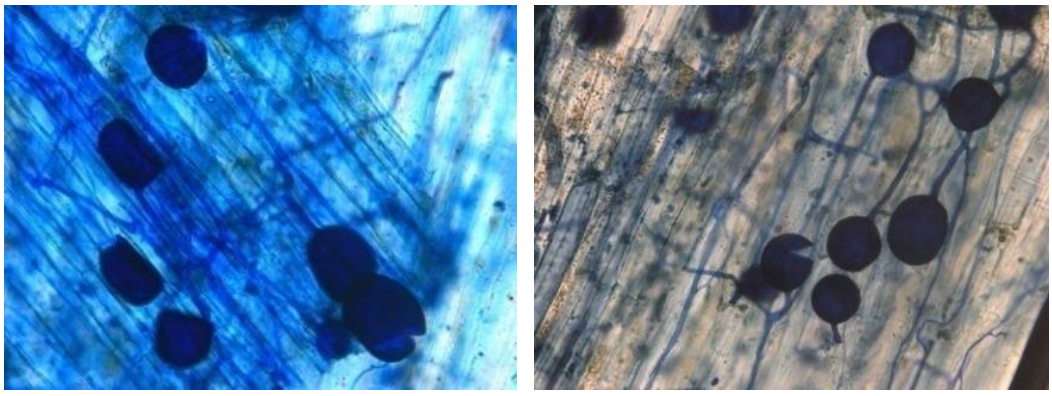


Fig. 24. Natural occurrence of AM fungi in spice crops: (*left*) in turmeric and (*right*) in black pepper

Mermithid parasitism of shoot borer

Mermithid nematode, parasitic to larvae of *Conogethes punctiferalis*, a serious pest of ginger and turmeric, was recorded under field conditions at Peruvannamuzhi in Kerala. Parasitized larvae of *C. punctiferalis* were pale, sluggish and appeared similar to non-parasitized larvae in their shape and size. The number of post-parasitic nematodes that emerged from a single larva ranged from 1 to 5 nos. The nematodes exit the host larvae either through the anal opening or through the epicranial suture of the larval head (Fig. 25 a, b).

Freshly emerged post-parasitic nematodes were creamy or pale white. The length of the post-parasitic nematodes ranged from 2.5 to 21.4 cm (average length: 9.0 ± 0.5 cm) and was

indirectly proportional to the extent of host parasitism by the nematodes. The post-parasitic nematodes had a tail like appendage present at the posterior end and with a blunt end anterior head tip (Fig. 25 d, e). Immediately after emergence of the parasites, the host larva turned dark, became flat, deprived of its contents and died **(**Fig. 25 c). Mortality of *C. punctiferalis* due to mermithid parasitism during the crop periods ranged from 18.2 to 80.6% and 17.9 to 66.7% in ginger and turmeric, respectively. The infection reached epizootic levels during July to September, leading to more than 50% mortality in *C. punctiferalis*. The level of host parasitism by the mermithid was positively correlated with rainfall and negatively influenced by maximum temperature. Molecular analysis of the partial 18S small ribosomal subunit gene region and phylogenetic analysis with other mermithid sequences available in the GenBank indicated that the nematode clustered with other nematodes belonging to different genera and hence could not be attributed to a specific genus. The pairwise Kimura 2-parameter (K2P) distance revealed that the closest taxon to the study nematode was an undescribed mermithid species reported to infect slugs with a K2P distance of 0.009. The results provide a basis for using this nematode as a biocontrol agent for developing integrated pest management strategies against *C. punctiferalis*.

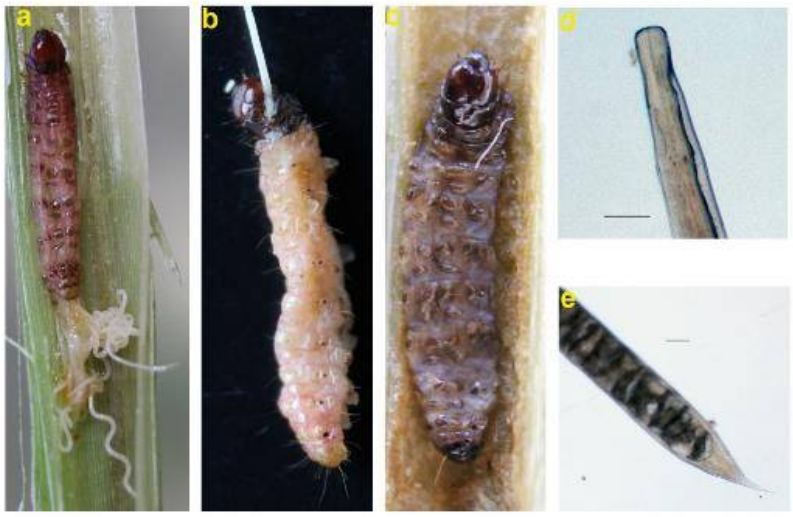


Fig. 25. (a) Egression of post-parasitic mermithid nematodes through the anal opening (b) Exit of a mermithid nematode through the epicranial suture (c) Dead *Conogethes punctiferalis* larva upon exit of mermithid nematodes (d) Head of postparasitic juvenile (scale bar: 99.5 µm) (e) Tail region of postparasitic juvenile with papillae (scale bar: 102 µm)

Dose optimization of insecticides for shoot borer

Three insecticides (spinosad, flubendiamide, chlorantraniliprole), which were found effective in earlier trials and also a treatment with spraying of chlorantraniliprole and spinosad alternatively were tested under field conditions at Peruvannamuzhi farm for dose optimization against shoot borer infesting ginger and turmeric for the second consecutive year. All the insecticides were very effective in the management of the pest even at the lowest dose (0.3 ml/ litre of water) tested. The treatment of spraying of chlorantraniliprole and spinosad alternatively was also equally effective in controlling the insect.

Nutritional quality of industrial waste of spices

Nutritional quality of acetone/methanol/water extracts of spent turmeric and cinnamon was determined. Various biochemical assays *viz.*, protein estimation, carbohydrate content, fat content and total phenol content were carried out and a considerable reduction of these biochemical constituents was observed in the spent spices.

Carbohydrate content of turmeric had reduced by 24.9% due to acetone extraction and in the case of cinnamon 38.2% reduction was observed due to methanol extraction and 33.5% reduction due to water extraction (Fig. 26 a). The protein content of turmeric was reduced by 60.7% due to acetone extraction. While in the case of cinnamon 76% reduction was observed due to both water and methanol extraction. However, the protein concentration in both cinnamon and turmeric was high for the purpose of adding it as an ingredient in feed formulations. Fat content of turmeric was reduced by 93.55% due to acetone extraction and in the case of cinnamon 90.42% reduction was observed due to methanol extraction and 76.71% reductionby water extraction. The crude fibre content of turmeric was reduced only by 10.25% due to acetone extraction. In the case of cinnamon, fibre content was about 5% before extraction with methanol/water while it was 35% after extraction (Fig. 26 b). The study has also shown that, due to solvent/water extraction of both turmeric and cinnamon, the tannin content was reduced to a low level (2.51% and 5.15%).

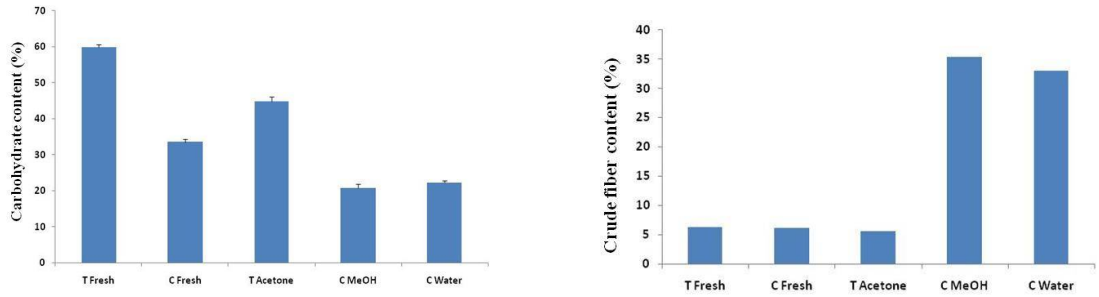


Fig. 26. Carbohydrate content (%) of spent spices and crude fibre content (%) of spent spices

Production of nucleus planting materials of improved varieties of spices

Improved varieties of black pepper were multiplied at main campus, Kozhikode and Regional Station (RS), Appangala and distributed to 581 farmers (531 from MC and remaining from RS). Totally, 70000 cuttings were sold from main campus and 12000 from Regional station. Around 4 tonnes of ginger and 6 tonnes of turmeric seed material were produced and distributed. About 2885 cardamom suckers and 475 seedlings were multiplied and distributed from Regional station, Appangala. Five hundred nutmeg grafts of IISR Vishwasree were produced at Experimental farm, Peruvannamuzhi.

Microrhizome of ginger varieties (Athira, IISR Mahima, IISR Varada) and turmeric varieties (Sona, Suranjana, Varna) were subcultured and 3000 plantlets of ginger and 1500 turmeric raised in protrays and being hardened in 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. The bioagent *Bacillich* and is being distributed to ginger farmers. Growth improvement and disease suppression was observed in both calcium chloride and bioagent treatments. Twenty selected released varieties and cultivars were tested with polymorphic primers to identify and develop variety specific markers.

Fig. 27. FLD on soil solarization to control bacterial wilt of ginger in field

Establishment of a DNA fingerprinting and barcoding facility at the Central Facility of ICAR-IISR

A facility for DNA fingerprinting was established and is presently undertaking fingerprinting of released varieties of the institute, identification of country of origin of black pepper and also developing profiles of major and minor spices (coriander, fennel, fenugreek *etc.*) from various centres of AICRPS for facilitating varietal registration.

ECONOMICS AND IMPACT ASSESSMENT

Valuation of technology impact: A study on curcumin enhancement in turmeric

Curcumin is one of the most discussed active ingredient in turmeric which is known for its several medicinal properties and pharmacological applications. A salient point to consider in the measurement of impact of high curcumin varieties would be the change in curcumin consumption among the general population arising from availability of high curcumin varieties for common culinary purposes. Using a logical framework of domestic production scenario, curcumin content and extent of varietal spread of high curcumin varieties, the approximate monetary value of higher curcumin consumption was worked out. The magnitude of the annual value of the monetary benefits (Rs 22591 million INR) indicated the levels of returns which are often unheeded while measuring the returns from investments in agricultural research.

Value of germplasm conservation

Agricultural research is considered to be one of the public goods. In an exercise aimed at measuring the benefits from conservation of germplasm resources at IISR Experimental farm, the total direct investment incurred at the experimental farm from 1986-87 to 2017-18 (32 years) at 2011-12 prices was worked out (635.36 million Rupees). A simplified hedonic pricing model for valuing gains from the agricultural research. We used the change in area,

production and productivity at the national level between the biennium ending 1986-87 and 2017-18 for four major crops (black pepper, ginger, turmeric and nutmeg) whose germplasm lines are mainly conserved in the experimental farm. At five per cent share in pure crop research effect, the average yearly incremental production in these four crops attributable to germplasm conservation efforts during the last decade was valued at 1159 million Rupees.

Natural calamity in Kerala: impact on spice crops

A study on impact of the rain induced natural calamity was designed with an objective to gain a quick understanding of the ground level situation for primary producers of spice crops. To implement time bound intervention strategies for calamity mitigation, a simplified strategy was adopted in the sampling used for data collection. A total of 60 village panchayaths across 27 Community Development Blocks were covered under the extensive survey. The ground truth collected from the extensive field surveys were used to firm up the data from agricultural department to arrive at the production impact of the natural calamity. The summary of initial estimates of crop loss in terms of expected production deficit at state level over previous year is presented (Table 5) which indicates initial estimates of crop loss in terms of expected production loss at state level over previous year in spices to 25138 tons (12541.1 million Rupees).

Table 5. Crop loss estimates in spices in Kerala due to floods during 2018

Crop	Area affected (ha)	Production loss in 2018-19 (tons)	Value (million INR)
Black pepper	26613	10700	4027
Cardamom	15655	6600	6795
Nutmeg	4400	2749	1018
Clove	160	13	9.3
Ginger	1030	4100	605
Turmeric	395	976	86.8
Total		**25138**	**12541.1**

BIOINFORMATICS CENTRE

The SpiceCom database developed by the Centre was launched by Hon. DG, ICAR, New Delhi. Initiated development of a web application for managing the details of farmers (SpiceFarm) and a DSS tool with images for symptoms of various diseases of plants. A short-term training on 'Bioinformatics for metagenome data analysis' was conducted from 19-22 March 2019 with the support of Department of Genomic Science, Central University of Kerala, Kasaragod.

AGRICULTURAL TECHNOLOGY INFORMATION CENTRE 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 visit the institute from time to time. Total number of farmers visited during the year was 2553 and that of students was 1219.
- Following the severe natural calamity leading to loss of crops, life and property in August 2018 multi disciplinary teams of scientist carried out spot surveys in major spice growing tracts of Calicut, Malappuram, Wayanad, Idukki, Thrissur and Eranakulam districts to assess the direct damage caused to spice crops. The report on assessment of damage was submitted to Kerala state government and ICAR.
- The two day State Level Seminar and Agricultural Exhibition sponsored by Mission for Integrated Development of Horticulture (MIDH) and Directorate of Arecanut and Spices Development (DASD), Kozhikode in collaboration with ICAR-Indian Institute of Spices Research (IISR), Kozhikode was held at ICAR-IISR Experimental farm, Peruvannamuzhi, Kozhikode during 26–27 October 2018. Around three thousand farmers participated.
- District level seminar sponsored by MIDH on Good agriculture practices for production of clean and safe spices was held at ICAR- IISR on 22 December 2018 and 300 farmers participated in the seminar.
- District level seminar Sponsored by MIDH on Recent Advances in Production and Processing of spices at High Altitude Research Station, OUAT, Pottangi on 1 March 2019 in which 100 farmers participated.
- District level seminar on Scientific and technological interventions for improving production and quality of major spices (cardamom, ginger, black pepper) was held on 21.03.2019 at ICAR-IISR Regional Station, Appangala (sponsored by Directorate of Arecanut and Spices Development, Kozhikode).
- The institute participated in 8 major national/state level exhibitions, the main events being National Horticulture Fare held at ICAR-IIHR, Bangalore in November 2018, VAIGA National Expo on Value addition organized by Kerala State Government at Thrissur in December 2018 and Agriculture Science Congress at New Delhi in March 2019.
- A total of eleven on-campus training courses were conducted in which 263 extension officials/ farmers participated. These programmes were sponsored by various state department agencies One of the major programme was the Certified Farm Advisor Training Programme sponsored by MANAGE, Hyderabad organized by IISR during 21 Janauary-4 February 2019 in which 19 extension field officers representing six states attended the training programme.

Revenue generation through sale of technology products

The revenue generation through the sale of planting material and other technology products registered an increase of 20% over previous year. The total revenue generated was Rs 4321401/- of which micronutrient mixtures (Rs 1405750) and quality planting material (Rs 1324655/-) had the major share. Other items were farm produce, Bacillich, Pochonia, biocapsules of *Trichoderma* & PGPR, Institute publications *etc*.

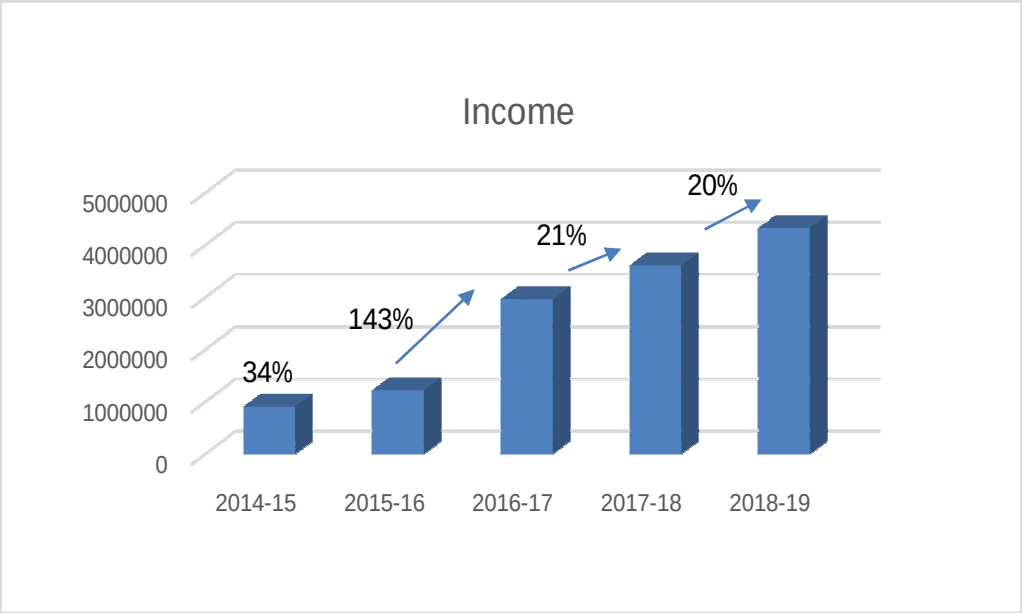


Fig. 28. Increase in ATIC income over years

ICAR-ALL INDIA COORDINATED RESEARCH PROJECT ON SPICES

The XXIX Workshop of ICAR-All India Coordinated Research Project on Spices was held during 4-6 October 2018 at Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, Himachal Pradesh. The workshop was inaugurated by Dr. Hari C. Sharma, Hon'ble Vice Chancellor, Dr. YSPUH & F, Solan on 4 October 2018. In his inaugural address he opined that advanced biotechnological tools may be utilized for crop improvement and to enhance secondary metabolite content in spices. Dr. K. Nirmal Babu, Director, ICAR-IISR & Project Coordinator (AICRP on spices), Kozhikode highlighted the importance of spices in Indian economy and research accomplishments made in spices. Dr. Gopal Lal, Director, NRC for Seed Spices, Ajmer and Dr. Rakesh Gupta, Dean, College of Horticulture, Dr. YSPUH & F, Solan were the Guest of Honour and offered felicitations. During the inaugural session the "Best AICRPS Centre Award 2017-18" was presented to Pepper Research Station, Panniyur (KAU), Kerala. Thirteen booklets/pamphlets on spices production technologies from different AICRPS centres were released during the occasion. Eleven varieties covering different spices crops such as ginger, turmeric, nutmeg, coriander and fenugreek suitable for different growing regions were recommended for release during the workshop. Six different technologies covering black pepper, cardamom, coriander and fennel were also recommended during the occasion.

Fig. 29. Inaguration of the workshop and presentation of Best AICRPS centre award to PRS, Panniyur

Table 6. Varieties recommended for release during the workshop

S. No	Crop	Name of variety	Developer	Area of adoption/ recommended for	Salient features
1	Ginger	Solan Giriganga	Dr. Y.S. Parmar University of Horticulture & Forestry, Solan	Western and eastern Himalayan regions and lower gangetic plain region of India.	Plumpy and bold rhizomes with high dry matter recovery of 21.01%, essential oil -1.45%, oleoresin – 4.69%, crude fibre 4.47% and < 10% incidence of rhizome rot.
2	Turme-ric	TCP 129 (Uttar Rangini)	UBKV, Pundibari	Middle gangetic plain region, West Bengal, Bihar and Tamil Nadu	Tolerant to leaf spot and leaf blotch, 5.1% curcumin content and high dry recovery (26.51%)

3	Nut-meg	Konkan Sanyukta	Dr. B.S.K.K.V, Dapoli	Western plateau and hill region of Maharashtra	Monoecious nutmeg bearing 500 fruits per plant per year with bold nuts (9.20 g), 1.07 g mace wt, high nut (27%) and mace oil (17.75%).
4	Cori-ander	Ajmer Coriander -3	ICAR-NRC on Seed Spices, Ajmer	Central plateau and hill region, Rajasthan	High volatile oil (0.55%) with high linalool (75.42%), high (13.09 q ha^{-1}) and stable yield
5	Cori-ander	Rajendra Dhania 3	Dr. RPCAU, Dholi	All coriander growing regions of the country	Climatic resilient variety with high yield (14.09 q ha^{-1}) and high oil (0.52%)
6	Cori-ander	JD (SI)-1	JNKVV, Jabalpur	Western Himalayan region, MP	High oil type (0.67%) with high yield potential (14.14 q ha^{-1})
7	Cori-ander	Chhattisgarh Sri Chandra-hansini Dhania-2	IGKV, Raigarh	All coriander growing regions of the country	Climatic resilient variety suitable for both leafy and seed purpose, moderately resistant to powdery mildew and aphids
8	Turme-ric	NDH-8 (Narendra Saryu)	ND University of Agriculture & Technology, Kumarganj	Middle gangetic plain region. Uttar Pradesh	High curcumin variety (5-6%), more number of primaries with yield advantage of 10%
9	Cori-ander	Gujarat Coriander -3	(CRSS), (SDAU), Jagudan	Gujarat plains and hills region	High quality, high volatile oil (0.52%), high linalool (72.16%) and high yield potential (16.94 q ha^{-1})
10	Fenu-greek	Ajmer Fenugreek 5	ICAR-NRC on Seed Spices, Ajmer	Central plateau and hill region, Rajasthan	High quality & high yield (17.21 q $ha^{-1)}$, high antioxidant content (66.428 mg/ BHTE/ ppm), suitable for green leaf production under protected condition in summer
11	Cori-ander	Ajmer Coriander 2	ICAR-NRC on Seed Spices, Ajmer	Central plateau and hill region, Rajasthan	Tolerant to stem gall resistance, high linalool content (71.7%), early maturing type

KRISHI VIGYAN KENDRA

KVK conducted total 84 trainings covering agriculture and allied fields benefiting 3057 farmers, rural youth, extension functionaries and students. It includes, two OJTs for sixty two students, paid training on Breeding and culture of ornamental fishes, Horticorp's bee keeping trainings. Training for 45 Kutumbasree members on planting material production and nursery establishment funded by District Kutumbasree unit, Kozhikode; Friends of coconut training funded by CDB and one month Gardeners training funded by SHM were also organised. As mass awareness programmes, District level seminar on "Scientific cultivation of tapioca" in association with CTCRI, Trivandrum; world soil day seminar on soil health; workshop on "After flood management of Soil and Plants" for extension functionaries of ATMA & Dept. of Agriculture, Kozhikode; Productivity week seminar on "Tropical tubers cultivation"; Live telecast of Pradhan Mantri Kisan Samman Nidhi inauguration by Hon'ble PM were organized for the benefit of total 1500 farmers.

KVK also organised four days Technology week – 2019 for the benefit of about 800 farmers. An open day on National Agriculture Education day observed on which 447 students, 53 teachers of eleven schools visited the KVK demonstration units and labs. Expert lectures were delivered by KVK staff on 'Doubling farmers' income' during Kisan Kalyan Divas organised by ATMA at all the 12 blocks of Kozhikode on 2nd May, 2018. Fourteen Front Line Demonstrations and five On Farm Trials on technology assessment and refinement in 149 farmers' fields were carried out in Naduvannur and Ulleri Panchayats. Among these, technologies on seed production of Pragati turmeric, Varada ginger, Kasturi turmeric, Estrus synchronization and Fixed time breeding in goat, cows, FFS on apiary and value added products using honey were received very well by the stakeholders.

KVK-IISR participated in two exhibitions, arranged two exhibitions and reached the interior area stakeholders through mobile sales unit visits, SMS services, etc. During the period, two radio talk/ interview, two TV programmes and one soil health camp were attended. Nine popular articles, two handouts, one booklet were published. Total 5609 farmers, 1037 students of Kozhikode district, 489 farmers from other districts and 89 farmers from other states visited KVK.

Fig. 30. Training class on honey production and Kutumbasree workers participation in a training

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

The ITM-BPD unit expanded its activities during the year. Thirteen new licenses for different technologies were issued during the year out of which six were for ginger and turmeric varieties, four for micronutrient technology and one each for seed coating, mobile app based instant analysis of turmeric quality and *Trichoderma*. Total revenue from technology commercialization was 18.50 lakhs and Rs. 12.47 lakhs was earned through sale of planting materials, spices and other products during the year. The unit participated in 12 exhibitions in different places of the country during the year. It also organised/participated as an invitee in various training programmes across the country. The unit organized visit of Dr. Saji Gopinath who heads Kerala Startup Mission. He addressed our scientists and discussed about the future collaboration of IISR with KSUM and signing of MOA. The unit also organized a farmer interface meeting on "Facilitating direct marketing by spice farmers and developing an incubation model" on 27 March 2019 at ICAR IISR. Sri S S Nagesh, Chief-Agriculture, Kerala State Planning Board was the chief guest on the occassion.

Fig. 31. (a) Signing of MoA between Parasite breeding station, Kozhikode and ICAR-IISR for licensing '*Trichoderma harzianum* (b) Dr. Sheeba, ICAR-IISR incubatee gifting spice based innovative products to Kerala Governor during Krishi Unnati Mela at Thrissur

New business initiatives

ITM-BPD unit ventured into spice based product development owing to the increasing demand for sophisticated finished products from oils and oleoresins and health and wellness care products. The major products launched are 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 and insect repellent spray. The major spice based food products developed are dry ginger coffee, ginger sorbet, turmeric infused honey, health mix and masala tea. Some of the other products targeted are developing pain reliever balm, homemade lotion and body wash, cough drops, turmeric tonic, spice flavoured cakes and puddings *etc.*

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, 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-mail, webserver etc., were also done. The Personnel Management Information System Network of ICAR (PERMISnet II) and Project Information & Management System of ICAR (PIMS-ICAR) were updated. The repair and maintenance of computers and audio visual support to various activities were also facilitated through AKMU. Apart from this AKMU assists to analyze and interpret geographical data using ArcGIS & DIVA GIS and statistical analysis of scientific data using SAS and other statistical software and developing mobile applications.

Mobile Application

The institute has developed a Mobile App (Android) ICAR-IISR Ginger. This mobile app is to help farmers by getting relevant information quickly. With click of a button, they can get the information on cultivation, management, varieties, plant protection etc. It is a bilingual (English & Hindi) application which can be downloaded free from Google play store.

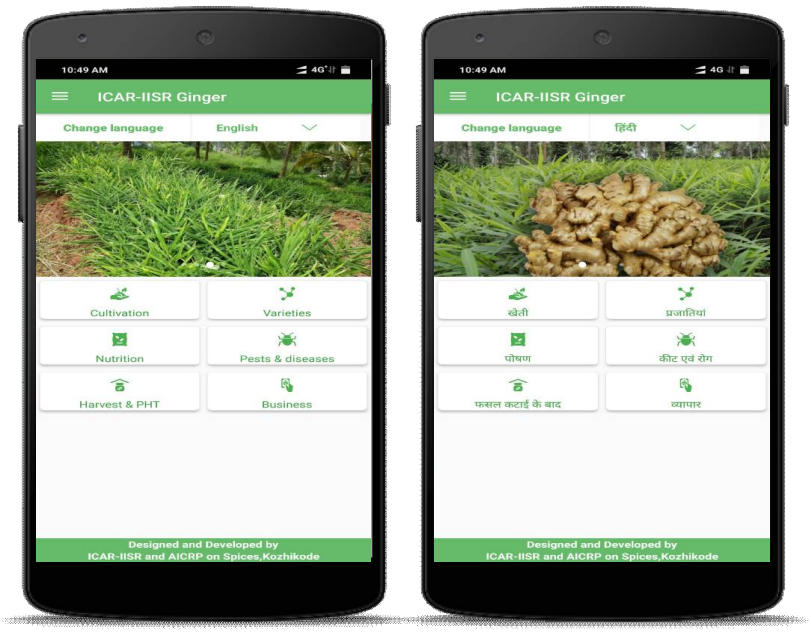


Fig. 32. A snap shot of Ginger mobile application

HINDI CELL

OLIC meeting

The Official Language Implementation Committee (OLIC) of the institute met four times during the year. The first meeting was held on 26 June 2018. The other meeting were conducted on 26 September 2018, 31 December 2018 and 13February 2019. The OLIC meetings under the chairmanship of Dr. K. Nirmal Babu, Director, periodically reviewed the official language implementation activities of the institute.

Workshops conducted

Four Hindi workshops on noting and drafting were conducted during 2018-19. Resource persons from Hindi teaching scheme and other public sector organizations handled the sessions. The workshops were conducted on 28 June, 2018, 15 September, 2018, 15 December, 2018 and 6 February, 2019.

Hindi Week celebration

Hindi Week was celebrated from 14 – 22September 2018 with various Hindi competitions like Hindi Word Power, Caption Writing, Hindi Reporter, Hindi Noting and Drafting, Pick and Speak, Hindi Song etc. The valedictory function of the Hindi Week was held on 22 September, 2018. Mr. Jitendra Gupta, Post Master General, Kozhikode was the Chief Guest of the function. A Hindi skit titled "Budi kaki" based on noted novelist, Sri Premchand's story was presented by the students of Zamorin's Guruvayurappan College during the valedictory function.

Meetings and trainings attended

S. N	Particulars of the meeting / training	Personnel
1	61st meeting of TOLIC, 26 April, 2018, Kozhikode	Dr. S J Eapen, Dr. Lijo Thomas
2	62nd meeting of TOLIC, 26 September, 2018, Kozhikode	Dr. K Nirmal Babu, Dr. Lijo Thomas, Smt N Prasannakumari
3	Five days Hindi Translation Training conducted by Central Translation Bureau hosted by TOLIC, Kozhikode, 3-7 December, 2018	Smt. N Prasannakumari
4	Two days National Workshop and Training on New Directions on Official Language Management in ICAR conducted at ICAR-CRIDA, Hyderabad, 24-25 April, 2018	Mr. V C Sunil
5	Trainers Training Programme conducted by Central Hindi Training Institute, New Delhi, 21- 25 May, 2018	Mr. O G Sivadas, Mr. V S Binoy
6	Hindi Prabodh training	Ms. R Sivaranjani

Publications

- *Varshik Prativedan* 2016-17
- *Anusandhan ke mukhya ansh* (2017-18)

- *Masala Samachar* (3 issues)
- *Masaloon ki Mehak* (Official language magazine)

Release of Masaloon ki Mehak 2018

Dr. Trilochan Mohapatra, Director General, ICAR released institute's official language magazine "*Masaloon Ki Mehak*" 2018 on 22 December 2018 during the Institute visit.

Fig. 33. Release of Masaloon ki Mehak

Award

Institute was awarded Ganesh Sankar Vidyarthi Hindi Krishi Patrika Puraskar 2018 (second prize). Dr. Rashid Pervez, former Principal Scientist and Hindi Officer received the award from ICAR, New Delhi on 16 July 2018.

LIBRARY

IISR library is a part of the Consortium of Electronic Resources in Agriculture (CeRA) and Full text of more than 3500 journals on agriculture and allied subjects are accessible.In addition to this library subscribed 29 Indian journals during the year. Library purchased twenty nine books and added to stock. Around 209 publications were received on *gratis* basis during the period. As part of exchange programme 220 publications were collected from various organizations. As part e-journal consortium of ICAR and catered nineteen document delivery requests from other partners. All institute publications for the last five year period were uploaded to Krishi portal. Added 210 full text publications to'DSpice' institutional repository. Cataloguing and Classification data updated in Library automation software 'KOHA' and all newly added publications were brought in to the database. Twelve issues of the 'Agrititbits', an agricultural news service, were brought out during the period.

HUMAN RESOURCE DEVELOPMENT

MoU for academic interaction

ICAR-IISR signed MoU with three institutions *viz.*, CSIR–National Institute of Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram, Kerala (March 30, 2019); Amrita School of Engineering, Coimbatore, Tamil Nadu (February 6, 2019) and Kerala University of Fisheries and Ocean Studies (December 5, 2018) Kochi, Kerala for research collaboration and exchange of students.

Training programmes

ICAR-IISR conducted Feed The Future-India Triangular Training (FTF-ITT), an International training program on 'Value Addition in Spices' during 15- 29 May 2018. The program was sponsored by Project Management Unit (PMU) of National Institute of Agricultural Extension Management (MANAGE) Rajendranagar, Hyderabad; USAID India and Ministry of External Affairs (MEA), Govt. of India. Twenty-two executive trainees from five partner countries; Uganda (5), Kenya (6), Malawi (5), Liberia (3) and Myanmar (3) attended the training programme.

Fig. 34. Inauguration of FTF –ITT and interaction among trainees

One month summer internship programme on "Advanced techniques in Microbiology, Biochemistry, Biotechnology and Bioinformatics" was organised by HRD cell from 7 May to 5 June 2018. HRD Cell also organized a three-day interactive co-learning workshop on Philosophy, Methods and Ethics in Science from 13-15 November 2018. Dr. K. Vijayakumaran, former Director General, Fisheries Survey of India and Principal Scientist, CMFRI was the core faculty of the workshop. Twenty young scientists and research scholars participated in the workshop.

Also, HRD cell conducted the two day training programme on Information Security Awareness during 15-16 March 2019 for all the staff members. Eleven students were awarded Ph D degree during the year.

Participation of staff members in training programmes

Scientific staff				
Sl. No.	**Name**	**Training particulars**	**Duration**	**Institute**
1	Dr. K. Anees	Emotional intelligence at workplace for scientists and technologists	6-10 August 2018	Centre for Organization Development, Madhapur, Hyderabad
2	Dr. M.S. Shivakumar	Training programme on developing winning research proposals	23-28 August 2018	ICAR-NAARM, Hyderabad
3	Dr. P. Umadevi	Advanced bioinformatic tools and its applications in agriculture	25-29 September 2018	ICAR-NAARM, Hyderabad
4	Dr. P. Rajeev, Dr. M.S. Shivakumar	Training on artificial intelligence for plantation crops	28-29 September 2018	ICAR – CPCRI, Kasaragod
6	Dr. C. Sarathambal Dr. S. Sellaperumal Dr. P. Umadevi Dr. Sharon Aravind Ms. R. Sivaranjani Mr. Muhammed Nissar Dr. M.S. Shivakumar Dr. H. J. Akshitha Dr. M. Balaji Rajkumar Dr. Muhammed Faisal Peeran Dr. Honappa Asangi Dr. M. Alagu-palamuthirsolai	Interactive co-learning workshop on Philosophy, methods and ethics in science	13-15 November 2018	IISR, Kozhikode
7	Dr. M. Balaji Rajkumar	CAFT sponsored 'Facets in biopesticide and botanical formulation production'	28 Nove-mber -18 December 2018	TNAU, Coimbatore
8	Mr. Mohammed Nissar	ISPRS TC V – Education & Outreach – Geospatial	20-23 November	IIRS, Dehradun

		technology	2018	
9	Dr. Muhammed Faisal Peeran	Training on microbial genomics	14-18 January 2019	National Centre for Microbial Resource, Pune
10	Dr. C. M. Senthil Kumar	Training on analysis of experimental data using R	21-26 February 2019	NAARM, Hyderabad
11	All Scientists	Information security awareness programme	15-16 March 2019	ICAR-IISR, Kozhikode
12	Dr. C. Sarathambal	Bioinformatics for metagenome data analysis	19-22 March 2019	ICAR-IISR, Kozhikode
Technical staff				
1	Mr. O.G. Sivadasan Mr V. S. Binoy	Intensive hindi workshops 2018 for Central Government Officers/ Employees	21-25 May 2018	Central Hindi Training Institute, New Delhi
3	Mr. E. S. Sujeesh	Pesticide application techniques and safety measures	16-20 July 2018	National Institute of Plant Health Management (NIPHM)
5	Mr. K. Krishnadas	ICAR nominated farm management'	14-20 September 2018	ICAR-IIFSR Modipuram
7	All Technical Officers	Information security awareness programme	15-16 March 2019	ICAR-IISR, Kozhikode
Administrative staff				
1	Mr. V. V. Sayed Mohammed	Hospitality management	20-25 April 2018	ICAR-NAARM, Hyderabad in collaboration with NITHM, Hyderabad at ICAR-NAARM, Hyderabad
2	Mr. K. G. Jegadeesan	Training on establishment and financial matters	5-10 July 2018	ICAR-NAARM, Hyderabad (Goa)
3	Ms. P. V. Sali	Workshop on mentoring programme	6-8 August 2018	ISTM, New Delhi
4	Mr. P. T. Jayaprakash, Mr. P. Rajeev, Mr. P. Muraleedharan	Training on pension & other retirement benefits including National Pension Scheme (NPS)	26-27 November 2018	ICAR National Rice Research Institute, Cuttack
7	Ms. P. V. Sali	Orientation programme for retiring Govt. Officials	11-12 March 2019	ISTM, New Delhi
8	All Administrative Staff	Information security awareness programme	15-16 March 2019	IISR, Kozhikode

MAJOR EVENTS

Workshop on Processing and value addition in spices

As a part of its tribal empowerment initiative, ICAR- IISR organized a workshop on spice processing and value addition at Chinthapalle, in Telangana state. The workshop was held on 7 June 2018 at AICRPS Centre located at Horticultural Research Station, Chinthapalle. Four turmeric polishers and four turmeric boilers were distributed among four leading tribal Farmer Producer Organizations involved in turmeric cultivation and value addition. Along with tribal farmers, representatives from Tata trust, Vijayavahini charitable foundation, Girijan Cooperative Corporation, Gramin Vikas Kendra, and Society for Elimination of Rural Poverty, Government of Andhra Pradesh took part in the deliberations.

Fig. 35. A turmeric boiling unit being handed over to representatives of FPO in Chintappalle, Telangana

IISR supports CSR initiatives in spice farming

Recognizing the potential for channelizing CSR funds of the private sector towards spice farming interventions, ICAR-IISR has been exploring the possibility of establishing efficient linkages with the private sector entities. In this quest, two collaborative ventures have been initiated in Telangana. The two private firms, Verity Pvt. Ltd. and Apollo Hospitals are being provided with technical support and guidance for creative use of CSR funds in spice farming initiatives in a manner befitting the core values of the firms.

Consultative meeting on turmeric

ICAR-IISR and the Department of Horticulture, Government of Telangana jointly organized a consultative meeting to formulate the strategies for enhancing the productivity of turmeric in the state with a strong focus on value chain development. The meeting was held at Centre of Excellence, Jeedimetla, Hyderabad on 5 June 2018. The deliberations were lead by Sri L Venkatram Reddy, Director Horticulture and Dr. K. Nirmal Babu, Director, ICAR IISR. Progressive turmeric farmers from across Telangana and representatives from spice industry attended the event. The consultative meeting designed a strategy road map for the turmeric economy of the state.

District level seminar on Good agricultural practices for clean and safe spices

As a part of its efforts to spread the awareness on Good agricultural practices, ICAR IISR organized a district seminar on Good Agricultural Practices for clean and safe spices on 22 December 2018. The seminar was inaugurated by Dr.TrilochanMohapatra, Secretary Department of Agricultural Research and Education and Director General, ICAR. More than 200 farmers attended the seminar. Dr. T. Janakiram, ADG (Hort II) and Sri Suresh Chandel, Member, Governing Body ICAR, were also present during the occasion. As part of the seminar, an exhibition was organized showcasing the technological advancements and varietal wealth in spices along with the current developments in post-harvest processing and value addition in spices. The seminar included technical sessions on soil management practices for production of clean and safe spices and crop management practices for spice based farming systems.

Fig. 36. Inauguration of the seminar on Good agricultural practices for clean and safe spices and inauguration of the exhibition by Dr. T. Mohapatra, DG, ICAR at ICAR-IISR, Kozhikode

Vigilance awareness week

Vigilance Awareness Week was observed from 29 October 2018 to 3 November 2018 in all the three campuses of ICAR-IISR namely, IISR head quarters at Chelavoor, Kozhikode; Regional station at Appangala and Experimental farm at Peruvannamuzhi, besides Krishi Vigyan Kendra, Peruvannamuzhi. The week started with a pledge taken by all the staff members of the institute in their respective centres at 11.00 am on 29 October, in all the stations. Various programmes were organized to promote integrity, transparency and accountability in public life and also to bring in awareness of the harmful effects and gravity of corruption and the need for having a vigilant society to prevent corruption based on the theme “Eradicate corruption, Build a New India” for this year. E-pledge was taken by the staffs, who have not taken it last year, at all the three campus and KVK, Peruvannamuzhi.

Nine programmes were conducted in the main campus during the week, keeping the theme of this year “Eradicate corruption. Slogan writing competition both in Malayalam and English, Drawing competition, Essay writing competition in English and Malayalam for staff were conducted based on this year’s theme. Staff also participated in the seminar during the valedictory function.

The institute also participated in the vigilance programmes organized by Regional Science Centre, Kozhikode. The institute staff participated in a Vigilance Awareness Rally organized by the Regional Science Centre in collaboration n with all the Central Government offices at Kozhikode, Kerala. The valedictory function of the VAW- 2018 was held on 3 November 2018 in all the campuses of the institute. Prizes were distributed to the winners of various competitions during the valedictory function.

Swacchta activities

The Swachhta Pakhwada campaign at ICAR-IISR, Kozhikode was inaugurated by Dr. K. Nirmal Babu, Director during which, the Swachhta pledge was administered. To spread the message of clean environment, health and to highlight the significance of Swacch Bharat Mission to the general public, banners highlighting significance of Swachhta were displayed in public premises and awareness rally with participation of farmers were organized. The staff of ICAR-IISR Regional Station, Appangala organized cleanliness and sanitation drives in the villages adopted under *Mera Gaon Mera Gaurav* programme (Bettageri and Ammathi). The personnel of ICAR-IISR KVK, Peruvannamuzhi organized cleanliness campaign at Naduvannur Panchayat, Kozhikode and provided on the spot solution besides demonstrating farm waste recycling and methods for coir pith composting. Creation of awareness among the staff as well as casual workers on Swachhta and generation of "Wealth from Waste" adopting green technologies and organic farming practices was the motto. On 22 December, the Swachhta cleaning programme at ICAR-IISR Headquarters was inaugurated by Secretary, DARE and Hon. Director General, ICAR, Dr. Trilochan Mohapatra. As a measure to share the experience on Swachhta initiatives with farming community and civil society officials, Kisan Diwas (Farmer's Day) was observed on 23 December 2018 which was followed by an exhibition on spices and value added products in which around 200 farmers participated. To disseminate message on the importance of waste management, pollution-free environment and conserving nature for future generation, an essay competition on "Sustainable waste management" was conducted at ICAR-IISR Headquarters.

Fig. 37. Swachhta activities conducted at various centres of ICAR-IISR

INSTITUTE MANAGEMENT COMMITTEE

1.	Dr. K. Nirmal Babu	Director, ICAR- Indian Institute of Spices Research, Marikunnu PO, Kozhikode	Chairman
2.	Sri. Asok Kumar Thekkan	Director, Directorate of Agriculture, Vikas Bhavan, Thiruvananthapuram	Member
3	Thiru L.Sitherasenan	Director (Hort.) Directorate of Horticulture & Plantation Crops, Chennai	Member
4	Dr. M.C. Narayanan Kutty	Associate Director, Regional Agricultural Research Station, Pattambi	Member
5.	Shri. T. P. Suresh	Srigovindam (H), MLA Road, Kunnamangalam PO, Kozhikode	Non-Official Member
6.	Shri. K.K. Rajeevan	Karuvangadiyil (H), Kadameri PO	Non –Official Member
7.	Dr. R. Viswanathan	Head, Plant Protection, ICAR – Sugarcane Breeding Institute, Coimbatore	Member
8.	Dr. V. Niral	Principal Scientist, ICAR-Central Plantation Crops Research Institute, Kasaragod	Member
9.	Dr. K. Kandiannan	Principal Scientist, ICAR-Indian Institute of Spices Research, Kozhikode	Member
10.	Dr. P. K. Ashokan	Principal Scientist & Scientist in-charge, Calicut Research Centre of ICAR-CMFRI, Kozhikode	Member
11.	Dr. T. Janakiram	Assistant Director General (H.S-II), Indian Council of Agricultural Research, New Delhi	Member
12.	Smt. R. Saribai	Finance & Accounts Officer, Central Tuber Crops Research Institute, Thiruvananthapuram	Member
13.	Administrative Officer	ICAR-Indian Institute of Spices Research, Kozhikode	Member

ACTION TAKEN ON THE RECOMMENDATIONS OF THE SECOND MEETING OF THE VIII RAC

Sl No	Recommendation	Director's comments	Councils Comments	ATR
1	A team may be constituted to analyze the reasons for higher productivity of black pepper in arecanut - black pepper cropping system in Chikkamagaluru region of Karnataka	A multi-disciplinary team is being constituted to study the high productive arecanut – black pepper cropping systems of Karnataka	Agreed	Scientists visited the plots, arecanut-black pepper cropping system at Chikkamagaluru and noted the cultural practices followed by the farmers. Soil and leaf samples have been taken for analysis
2	Sea weed extracts and protein hydrolysates readily available in the market may be utilized for enhancing productivity in spices	This programme will be taken up during current year under green house conditions	Agreed	Various concentrations of seaweed extract were tried in bush pepper. Sea weed (brown) extract (20%) recorded maximum yield (233 g/plant)
3	Gingerol/ Shogoal alone or in combination with phospholipids or other substrates may be examined for their anti-diabetic and other medicinal properties	This programme will be taken up during current year after harvest of ginger varieties	Agreed	Work initiated. Antidiabetic potential of solvent extracts of ginger, gingerol and shogaol was evaluated. Anti diabetic potential of combinations of spices will be studied further
4	Possibility of entrepreneurship development and value addition for skill development may be explored. KVK may give more emphasis on providing training on primary processing and value addition	Training programmes shall be designed and implemented with focus on entrepreneurship development and value addition. Primary processing and value addition shall be accorded more priority in training programmes of KVK	Agreed	Two training programmes with primary focus on skill development and entrepreneurship was conducted with the support from Agricultural Skill Council of India The training pedagogy and content of adhoc training programmes and sponsored training programmes at both IISR and KVK has been modified to give more emphasis on entrepreneurship and value addition in spice value chain. One Entrepreneurship Development Programme on value addition in spices was conducted for

				tribal beneficiaries from Andhra Pradesh.
5	A field trial may be planned to assess the efficacy of *Lecanicilliumpsalliot*, the entomopathogenic fungus against *Phytophthora capsici* (black pepper) and *P. meadii* (cardamom).	Pot and field trials will be laid out to study the efficacy of *Lecanicillium psalliote* in suppressing *Phytophthora capsici* and *P. meadii*.	Agreed	Pot trials to study the efficacy of *L. psallioate* against *P. capsici* & *P. meadii* infecting black pepper & cardamom respectively were undertaken. Field study against *P. capsici* is in progress.
6	Multilocational trials with promising biocontrol agents including endophytes may be undertaken to manage foot rot and slow decline diseases of black pepper.	Multi-location trials will be laid out in three locations in Kodagu, Kozhikode and Wayanad with promising biocontrol agents like endophytes and *Streptomyces* strains.	Agreed	Trials were laid out in farmers' plotsin Kodagu, and Kozhikode and Wayanad districts. The treatments were imposed and the plots are being monitored.
7	Complete genome sequencing of *Nucleorhabdovirus* associated with *Kokke Kandu* disease of cardamom and determination of its taxonomic identity may be taken up.	About 4 kb region of the *Nucleorhabdovirus* associated with *Kokke kandu* disease of cardamom has already been sequenced. The remaining region will be sequenced by designing new primers followed by RT-PCR, cloning and sequencing.	Agreed	A 9806 nucleotides (about 90% of the viral genome) of the causal virus associated with *Kokke kandu* disease of cardamom is sequenced. The sequence analyses of the virus showed identities ranging from 30-62% in the nucleocapsid (N), phosphoprotein (P), putative movement protein (P3), matrix protein (M), glycoprotein (G) and polymerase (L) genes of different nucleorhabdo viruses. Sequence and phylo-genetic analyses clearly showed that the causal virus belongs to a hitherto undescribed new species under the genus *Nucleorhabdovirus* for which name *Cardamom vein clearing virus.*

8	Personnel from KVK may visit NIANP, Bengaluru for developing programmes for enhancing animal productivity of cattle through area specific mineral mixture and other feed formulations.	Yes, SMS (Veterinary) from KVK shall visit NIANP, Bengaluru for developing suitable programme.	This does not contain any research component	Dr. Shanmugavel visited NIANP and had detailed discussion with different department heads and extension scientist and collected the technologies for infertility management in cattle, improving laying performance in hens, stress management in livestock, mineral mixture for enhancing milk yield and azolla for stress management in animals

RESEARCH PUBLICATIONS

Aarthi S, Sharon Aravind, Shivakumar M S, Rema J & Sasikumar B 2018 Influence of weather parameters on sex expression and flowering pattern of nutmeg (*Myristica fragrans* Houtt.). Journal of Agrometeorology 20(2):155-156.

Aarthi S, Suresh J & Prasath D 2018 Morphological characterization of Indian turmeric (*Curcuma longa* L.) genotypes using DUS descriptor. Journal of Plantation Crops, 46(3):173-179.

Akshitha H J, Prasath D & Umesha K 2018 Association studies for yield and quality traits in ginger (*Zingiber officinale* Rosc.) International Journal of Innovative Horticulture. 7(2):143-145.

Alagupalamuthirsolai M, Ankegowda S J & Krishnamurthy K S 2018 Effect of different shade levels on growth, physiology and biochemical characteristics of small cardamom (*Elettaria cardamomum* Maton). Current Journal of Applied Science and Technology 28(3):1-9.

Anandaraj M, Vinitha K B, Umadevi P & Monica Chandran 2018 Pathogenic variability in *Phytophthora capsici* from black pepper (*Piper nigrum* L.) as revealed by transcriptomeanalysis. Indian Phytopathology 71: 495. https://doi.org/10.1007/s42360-018-0077-0, 1-9.

Anusree Thampi, Suseela Bhai R & Shabeer Mohammad 2019 *Streptomyces* spp. from black pepper rhizosphere: a boundless reservoir of antimicrobial and growth promoting metabolites. Journal of Bioactive Products from Nature 9(1):1-23.

Bhat A I, Biju C N, Srinivasan V, Ankegowda S J & Krishnamurthy K S 2018 Current status of viral diseases affecting black pepper and cardamom. Journal of Spices and Aromatic Crops 27(1):01-16.

Bhat A I, Pamitha N S, Gopika A & Biju C N 2018 Complete genome sequencing of *Banana bract mosaic virus* infecting cardamom revealed its closeness to banana infecting isolate from India. Virus Disease 29:212-215.

Bijitha P K & Suseela Bhai R 2019 *Burkholderia cepacia* strain IISRCLRB5, a promising bioagent for the management of rhizome rot of turmeric (*Curcuma longa* L.). International Journal of Agricultural Sciences and Research 9(1):1-12.

Biju C N & Praveena R 2018 Evaluation of plant extracts for antifungal activity against *Colletotrichum gloeosporioides*, the incitant of leaf blight in small cardamom and anthracnose of black pepper. Journal of Plantation Crops 46(2):92-101.

Biju C N, Peeran M F & Gowri R 2018 Identification and characterization of *Neopestalotiopsis clavispora* associated with leaf blight of small cardamom (*Elettaria cardamomum* Maton). Journal of Phytopathology 166:532-546.

Biju C N, Peeran M F, Gowri R, Praveena R, Sharon A & Ankegowda S J 2018 Epidemiological parameters to delineate weather-disease interactions and host plant resistance against leaf blight in small cardamom (*Elettaria cardamomum* Maton). Journal of Spices and Aromatic Crops 27(1):22-31.

Dinesh R, Srinivasan V, Hamza S & Sarathambal C 2018 Isolation and characterization of potential Zn solubilizing bacteria from soil and its effects on soil Zn release rates, soil available Zn and plant Zn content. Geoderma 321:173-186.

Faisal M P, Biju C N, Praveena R, Gowri R & Ankegowda S J 2018 Isolation, characterization and antagonistic efficacy of fungal endosymbionts from allied genera of cardamom. Journal of Plantation Crops 46(1):1-7.

Jeena Mathew, Krishnakumar V, Srinivasan V, Ravi Bhat, Narayanan C G, Namboothiri A & Abdul Haris 2018 Standardization of critical boron level in soil and leaves of coconut palms grown in a tropical Entisol. Journal of Soil Science and Plant Nutrition 18(2):376-387.

Kandiannan K, Krishnamurthy K S, Thankamani C K & Ankegowda S J 2018 Annual and monthly rainfall trend in plantation and spice farming in Western Ghat districts. Journal of Spices and Aromatic Crops 27(1):45-53.

Karthika R, Prasath D & Anandaraj M 2018 Comparative gene expression studies of candidate genes associated with defence response in ginger and mango ginger post inoculation with *Ralstonia solanacearum*. Physiology and Molecular Plant Pathology, 103: 1-7. https://www.sciencedirect.com/science/article/pii/S0885576518300493.

Karthika R, Prasath D & Anandaraj M 2019 Transcriptome-wide identification and characterization of resistant gene analogs (RGAs) of ginger (*Zingiber officinale* Rosc.) and mango ginger (*Curcuma amada* Roxb.) under stress induced by pathogen. Scientia Horticulturae 248:81-88. https://doi.org/10.1016/j.scienta.2019.01.003.

Manjunatha T Gowda, Sellaperumal C, Rajasekhar Reddy B, Rai A B & Singh B 2018 Management of root-knot nematode *Meloidogyne incognita* in tomato with liquid bioformulations. Vegetable Science 45(2):262-268.

Nair K M, Abdul Haris, Jeena Mathew, Srinivasan V, Dinesh R & Hamza S 2018 Coconut-growing soils of Kerala: 2. Assessment of fertility and soil related constraints to coconut production. Journal of Plantation Crops 46:84-91.

Pandian R T P, Bhat A I, Biju C N & Sasi S 2018 Development of diagnostic assays for rapid and sensitive detection of *Phytophthora* infecting major spices and plantation crops. Journal of Spices and Aromatic Crops 27:119-130.

Prasath D, Kandiannan K, Srinivasan V, Leela N K & Anandaraj M 2018 Comparison of conventional and transplant production systems on yield and quality of ginger (*Zingiber officinale*). Indian Journal of Agriculture Science 88(4):615-620

Prasath D, Kandiannan K, Leela N K, Aarthi S, Sasikumar B & K Nirmal Babu 2019 Turmeric: Botany and production practices. Horticulture Reviews 46:99-184.

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Senthil Kumar C M, Jacob T K, Devasahayam S, Stephy T & Geethu C 2018 Multifarious plant growth promotion by an entomopathogenic fungus *Lecanicilliumpsalliotae*. Microbiological Research 207:153-160.

Senthil Kumar R, Sharon Aravind, Biju C N & Ankegowda S J 2018 Characterization of genotypes of small cardamom (*Elettaria cardamomum* Maton) for yield parameters and disease resistance. Journal of Plantation Crops 46(2):143-146.

Sheeja T E, Santhi R, Deepa K, P Prashina Mol, Aparna R S & Giridhari A 2018 Uncovering roles of micro RNAs in regulation of curcumin biosynthesis in turmeric (*Curcuma longa* L.). International Journal of Innovative Horticulture 7:146-149.

Shimna K, Krishnamurthy K S, Janardhanan J & Shamina Azeez 2018 Antimicrobial properties in bark and leaf extracts of four cinnamomum species. Journal of Evolution of Medical and Dental Sciences 7(5):683-689.

Suseela Bhai R, Prameela T P, Vincy K, Biju C N, Srinivasan V & NirmalBabu K 2019 Soil solarization and soil amelioration with CaCl2 -an effective integrated strategy for the management of bacterial wilt of edible ginger. European Journal of Plant Pathology 1-15. DOI: 10.1007/s10658-019-01709-y.

Suseela Bhai R, Subila K P, Eapen S J, Reshma A, Pervez R, Bhat A I & Srinivasan V 2018 Effect of biocontrol agents on production of rooted black pepper cuttings by serpentine method. Journal of Spices and Aromatic Crops 27(1):59-65.

Thomas V P, Sabu M & Muhammed Nissar V A 2019 A new species of *Amomum* Roxb. (Zingiberaceae) from Nagaland, India. Taiwania 64(1): 9-12.

Umadevi P & Anandaraj M 2019 Proteomics analysis of the tripartite interaction between black pepper, *Trichoderma harzianum* and *Phytophthora capsici* provides insights into induced systemic resistance mediated by *Trichoderma* spp. European Journal of Plant Pathology. 1-14.https://doi.org/10.1007/s10658-019-01685-3.

Umadevi P, Sowmya M, George J K & Anandaraj M 2018 Proteomics assisted profiling of antimicrobial peptide signatures from black pepper (*Piper nigrum* L). Physiology and Molecular Biology of Plants 24:379-387.

Umadevi P, Suraby E J, Anandaraj M & Nepolean T 2019 Identification of stable reference gene for transcript normalization in black pepper – *Phytophthora capsici* pathosystem. Physiology and Molecular Biology of Plants 25:1-8.

Vandana V V & Suseela Bhai R 2019 Role of cell wall and cell membrane integrity in imparting defense response against *Phytophthora capsici* in black pepper (*Piper nigrum* L.). European Journal of Plant Pathology DOI.org/10.1007/s10658-018-01661-3.

LIST OF PROJECTS

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

1. Gen. XXVIII (813): Conservation and characterization of *Piper* germplasm (2008-2020) [Dr. K.V. Saji, Dr. M.S. Shivakumar & Mr. 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 & Mr. Honnappa Asangi]
3. Gen. XXXIII (813): Identification of core collection, characterization and maintenance of cardamom germplasm (2012-2020) [Dr. H.J. Akshitha, Dr. S.J. Ankegowda, Dr. Mohammed Faisal Peeran, Dr. Sharon Aravind & Ms. R. Sivaranjani]

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

4. Gen. XXXI (813): Breeding black pepper for high yield, quality and resistance to stresses (2012-2022) [Dr. M.S. Shivakumar, Dr. K.V. Saji, Dr. K.S. Krishnamurthy, Dr. R. Suseela Bhai & Dr. P. Umadevi]
5. Gen. X (813): Breeding cardamom for high yield and disease resistance (2007-2018) [Dr. H.J. Akshitha, Dr. Mohammed Faisal Peeran & Dr. M. Balaji Rajkumar]
6. 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]
7. Gen. XXXIV (813): Induction of variability in ginger through induced mutation for yield and disease resistance (2012-2020) [Dr. D. Prasath, Dr. R. Ramakrishnan Nair & Dr. R. Suseela Bhai]
8. Gen. XXXV (813): Genetic improvement in turmeric through seedling selection and hybridization (2013-2020) [Dr. R. Ramakrishnan Nair & Dr. S. Aarthi]
9. ICAR-CIB 1. Computational and experimental biology approaches for delineation of selected secondary metabolite pathways and antimicrobial peptides (AMPs) in major spices" (2018-2020) [Dr. Johnson K. George, Dr. K.V. Saji, Dr. T.E. Sheeja, Dr. R. Praveena, Ms. P. Umadevi, Ms. R. Sivaranjani, Dr. Dinesh Kumar, Dr. Sarika, Dr. M.A. Iquebal & Dr. U.B. Angadi (IASRI)]
10. Biotech. XIV (813): DNA fingerprinting and barcoding in spices (2018 - 2023) [Dr. T.E. Sheeja, Dr. D. Prasath and Dr. M.S. Shivakumar]
11. 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 & Mr. Honnappa Asangi]
12. Biotech. XV (813): Identification and characterisation of gene editing targets in ginger for *Pythium* resistance (2018 - 2021) [Dr. P. Umadevi, Dr. D. Prasath & Dr. R. Praveena]
13. Gen. XXXVII (813): Conservation of vanilla spp. and their utilization in crop improvement (2018-2023) [Dr. Aarthi S, Mr. V.A. Muhammed Nissar, Dr. Mohammed Faisal Peeran & Ms. R. Sivaranjani]

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

14. 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]
15. SSc VI (813): Nutrient cycling and soil C sequestering potential of spice crops under different management systems (2011-2019) [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]
16. ICAR Mega Seed Project (Agr. XXXVII(813)): Production of nucleus planting materials of improved varieties of spice crops (2006-2022) [Dr. K. Kandiannan, Dr. S.J. Ankegowda, Dr. J. Rema, Dr. K.V. Saji, Dr. D. Prasath, Mr. Honnappa Asangi, Dr. P. Rajeev, Dr. R. Suseela Bhai, Dr. Sharon Aravind & Dr. Ljio Thomas]
17. 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]
18. 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]
19. Phy. XII (813): Physiological interventions for yield improvement in small cardamom (*Elettaria cardamomum* Maton) under weather extremities (2016-2021) [Dr. M. Alagupalamuthirsolai, Dr. S.J. Ankegowda & Dr. Sharon Aravind]
20. ICAR-CPPHT 5: Delineation of spices zone beyond boundaries using climate analogue tools in changing climate (2016-19) [Dr. K. Kandiannan, Dr. M. Alagupalamuthirsolai & Mr. K. Jayarajan]

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

21. 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

22. ICAR-CPPHT-1: Network project on Organic farming (2007-2020)[Dr. C.K. Thankamani, Dr. V. Srinivasan, Dr. R. Praveena, Dr. C. Sarathambal & Dr. S. Shanmughavel]
23. ICAR-CPPHT-2: Network on Organic farming in horticulture crops (2014-20) (Dr. J. Rema, Dr. V. Srinivasan, Dr. K. Kandiannan, Dr. R. Dinesh, Dr. S.J. Ankegowda, Dr. C.N. Biju, Dr. C.M. Senthil Kumar & Dr. 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

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

25. ICAR-CPPHT-3: Network project on high value compounds and phyto-chemicals (2014-2020) (Dr. N.K. Leela, Dr. Santhosh J. Eapen, Ms. R. Sivaranjani & Dr. K. Anees)
26. KERALA State CPPHT-5: 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]
27. Biochem. IX (813): Evaluation of chemo-diversity and microencapsulation of selected spices (2018-2023) [Ms. R. Sivaranjani, Dr, N.K. Leela & Dr. K. Anees]
28. Biochem. X (813): Study on spike abscission: Developing chemically induced method for harvesting black pepper (*Piper nigrum* L.)(2018-2022) [Dr. Anees K., Dr. K.S. Krishnamurthy & Dr. C.N. Biju]

Project VII: Bio-Intensive management of pests in spices

29. Ent. XIV (813): Survey and documentation of naturally occurring entomopathogens in spice cropping systems (2012-2019) [Dr. C.M. Senthil Kumar & Dr. M. Balaji Rajkumar]
30. ICAR-ORP 3: Outreach Programme on Management of sucking pests in Horticultural Crops: (2009-2019) [Dr. M. Balaji Rajkumar & Dr. C.M. Senthil Kumar]
31. ICAR-CP 1. ICAR-Consortium research project on borers in network mode (2014-2019) [Dr. C.M. Senthil Kumar & Dr. M. Balaji Rajkumar]

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

32. Crop. Prot. 1.5 (813): Integrated management of *Phytophthora* foot rot and slow decline diseases of black pepper (2008-2018) [Dr. R. Suseela Bhai, Dr. Santhosh J. Eapen, Dr. C. Sellaperumal, Dr. Biju C.N. & Dr. T.P. Ahammed Shabeer, NRCG, Pune]
33. 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, Dr. C. Sellaperumal, Dr. A. Jeevalatha & Mr. K. Jayarajan]
34. 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)
35. 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 & Ms. Aarthi, S.]

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

36. DST CP-I: Identification, characterisation and development of diagnostics for unknown viruses associated with cardamom and ginger (2016-2019) [Dr. A. Ishwara Bhat & Dr. C.N. Biju]

37. DBT CP-VII:Characterization of episomal and endogenous pararetro-viruses infecting black pepper (2018-2021) [Dr. A. Ishwara Bhat & Dr. K.S. Krishnamurthy]
38. 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]
39. Path. XXVIII (813):Novel strategies for managing bacterial wilt and soft rot diseases of ginger (2018-2022) [Dr. R. Suseela Bhai, Dr. Biju C.N. & Dr. Mohammed Faizal Peeran]
40. 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 X: Improving knowledge and skill of stakeholders for increasing production of spices

41. DBT-SS1: Distributed Information Sub-Centre (2000-2017) [Dr. Santhosh J. Eapen, Dr. D. Prasath & Mr. K. Jayarajan]
42. 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]
43. Eco. III (813): Economic analysis of technology, market dynamics and policy scenario in major spice crops (2014-19) [Dr. Lijo Thomas & Dr. P. Rajeev]
44. 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. Rajeev P., Dr. Lijo Thomas, Dr. S. Hamza, Ms. Mariya Dainy, Mr. K.M. Prakash, Dr. P.S. Manoj, Dr. P. Ratha Krishnan & KVK, Ernakulam]
45. Kerala State –CP-1. Area wide integrated pest management for wilt diseases in black pepper (2014-2018) [Dr. R. Suseela Bhai, Dr. Santhosh J. Eapen & Dr. K.K. Aiswariya]

PERSONNEL (1-4-2018 to 31-3-2019)

IISR HEADQUARTERS, KOZHIKODE

SCIENTIFIC STAFF

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. T John Zachariah	Principal Scientist (Biochemistry) (up to 30-11-2018)
5. Dr. T K Jacob	Principal Scientist (Entomology) (up to 31-10-2018)
6. Dr. J Rema	Principal Scientist (Horticulture)
7. Dr. K Johnson George	Principal Scientist (Genetics & Cytogenetics)
8. Dr. R Dinesh	Principal Scientist (Soil Science)
9. Dr. R Suseela Bhai	Principal Scientist (Plant Pathology)
10. Dr. A Ishwara Bhat	Principal Scientist (Plant Pathology)
11. Dr. R Ramakrishnan Nair	Principal Scientist (Genetics & Cytogenetics)
12. Dr. K S Krishnamurthy	Principal Scientist (Plant Physiology)
13. Dr. K Kandiannan	Principal Scientist (Agronomy)
14. Dr. N K Leela	Principal Scientist (Org. Chemistry)
15. Dr. K V Saji	Principal Scientist (Economic Botany)
16. Dr. P Rajeev	Principal Scientist (Agril. Extension)
17. Dr. V Srinivasan	Principal Scientist (Soil Science)
18. Dr. T E Sheeja	Principal Scientist (Biotechnology)
19. Dr. D Prasath	Principal Scientist (Horticulture)
20. Dr. E Jayashree	Principal Scientist (Agril. Engineering)
21. Dr. C M Senthil Kumar	Senior Scientist (Agricultural Entomology)
22. Dr. C N Biju	Senior Scientist (Plant Pathology)
23. Dr. R Praveena	Scientist (Plant Pathology)
24. Dr. P Umadevi	Scientist (Biotechnology)
25. Dr. Lijo Thomas	Scientist (Agri. Economics)
26. Ms. S Aarthi	Scientist (Spices Plantation Medicinal & Aromatic Plants)
27. Dr. Sharon Aravind	Scientist (Spices Plantation Medicinal & Aromatic Plants)
28. Ms. R Sivaranjani	Scientist (Plant Biochemistry)
29. Dr. C Sarathambal	Scientist (Agril. Microbiology)
30. Mr. V A Muhammed Nissar	Scientist (Spices Plantation Medicinal & Aromatic Plants)
31. Dr. M S Shivakumar	Scientist (Genetics & Plant Breeding)
32. Dr. A Jeevalatha	Scientist (Crop Protection)
33. Dr. C Sellaperumal	Scientist (Nematology)
34. Dr. K Anees	Scientist (Plant Biochemistry)

ADMINISTRATIVE STAFF

1. Sri. K Nataraj	Administrative Officer
2. Sri. T D S Prakash	Finance & Accounts Officer
3. Ms. P V Sali	Private Secretary

4.	Sri. R N Subramanian	Assistant Administrative Officer
5.	Sri. K G Jegadeesan	Asst. Finance & Accounts Officer (up to 21-03-2019)
6.	Sri. P Sundaran	Assistant Administrative Officer
7.	Sri. V C Sunil	Assistant
8.	Sri. V V Sayed Mohammed	Assistant
9.	Ms. C K Beena	Personal Assistant
10.	Ms. M Seema	Upper Division Clerk
11.	Mr. P Rajeev	Upper Division Clerk
12.	Ms. Rebeena N	Lower Division Clerk
13.	Mr. P T Jayaprakash	Lower Division Clerk
14.	Mr. P K Rahul	Lower Division Clerk
15.	Mr. A Z Anas	Lower Division Clerk (up to 25 -09 -2018)

TECHNICAL STAFF

1.	Dr. Hamza Srambikkal	Chief Technical Officer
2.	Mr. M P Ramesh Kumar	Chief Technical Officer
3.	Dr. E Radha	Asst. Chief Technical Officer
4.	Mr. K Jayarajan	Asst. Chief Technical Officer
5.	Ms. N Prasannakumari	Senior Technical Officer
6.	Mr. A Sudhakaran	Technical Officer
7.	Mr. K Krishnadas	Technical Officer
8.	Ms. P K Chandravally	Technical Officer
9.	Mr. M K Raveendran	Senior Technical Assistant
10.	Mr. K B Prasannakumar	Senior Technical Assistant (up to 11-10 -2018)
11.	Ms. N Karthika	Senior Technician (Lab. Tech.)
12.	Mr. I P Vijesh Kumar	Technical Assistant (T3)
13.	Ms. Asha K Chandran	Technical Assistant (T3) (up to 28-09-2018)
14.	Mr. O G Sivadas	Technician
15.	Mr. V S Binoy	Technician
16.	Ms. K S Hridya	Technical Assistant (T3) (w.e.f. 01-10-2018)

SUPPORTING STAFF

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

IISR EXPERIMENTAL FARM, PERUVANNAMUZHI

TECHNICAL STAFF

1.	Mr. E S Sujeesh	Senior Technical Officer
2.	Mr. N A Madhavan	Technical Officer
3.	Mr. K P Premachandran	Senior Technical Assistant
4.	Mr. T R Sadasivan	Technical Assistant
5.	Ms. Rejina P Govind	Technician
6.	Mr. Hareesh B T	Technician
7.	Mr. Rasmish A R	Technician

SUPPORTING STAFF

1.	Mrs. N K Girija	Skilled Support Staff (up to 31-05-2018)
2.	Mrs. P N Kausalya	Skilled Support Staff

IISR KVK, PERUVANNAMUZHI

SCIENTIFIC STAFF

1.	Dr. P Ratha Krishnan	Programme Coordinator

TECHNICAL STAFF

1.	Dr. P S Manoj	Subject Matter Specialist (T9) (Hort.)
2.	Dr. S Shanmugavel	Subject Matter Specialist (T 9) (Vet. Sci.)
3.	Mr. K M Prakash	Subject Matter Specialist (T 9) (Agr.) (on study leave)
4.	Dr. B Pradeep	Subject Matter Specialist (T-7-8) (Fisheries)
5.	Ms. A Deepthi	Subject Matter Specialist (T-7-8) (Hort. Sci.)
6.	Dr. K K Aiswariya	Subject Matter Specialist (T-7-8) (Pl. Prot.)
7.	Dr. Maria Dainy M	Programme Assistant (T4) (Lab Tech.) (up to 13-03-19)
8.	Mr. T C Prasad	Driver-cum-Mechanic (T4)
9.	Mr. C K Jayakumar	Programme Assistant (T4) (Computer)
10.	Mr. P Prakash	Technical Assistant (Driver)

ADMINISTRATIVE STAFF

1.	Mr. K Faisal	Stenographer Gr. III

SUPPORTING STAFF

1.	Mr. C V Ravindran	Skilled Support Staff
2.	Mr. C Ravindran	Skilled Support Staff

IISR REGIONAL STATION, APPANGALA

SCIENTIFIC STAFF

1.	Dr. S J Ankegowda	Head, CRC, Appangala
2.	Dr. Narendra Choudhary	Scientist (Spices Plantation Medicinal & Aromatic Plants) (up to 30-06-18)
3.	Dr. Muhammed Faisal Peeran	Scientist (Plant Pathology)
4.	Dr. P Alagupalamuthirsolai	Scientist (Plant Physiology)
5.	Ms. H J Akshitha	Scientist (Spices Plantation Medicinal & Aromatic Plants)
6.	Dr. Balaji Rajkumar	Scientist (Agri. Entomology)
7.	Dr Honnappa Asangi	Scientist (Spices Plantation Medicinal & Aromatic Plants) (w.e.f. 25-06-2018)

ADMINISTRATIVE STAFF

1.	Mr. P Muraleedharan	Assistant Administrative Officer
2.	Mr. D Chethan	Lower Division Clerk

TECHNICAL STAFF

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

SUPPORTING STAFF

1.	Smt. H B Lakshmi	Skilled Support Staff
2.	Sri. B N Seshappa	Skilled Support Staff
3.	Smt. B L. Chennamma	Skilled Support Staff (up to 01-02-2019)
4.	Smt. B M Lalitha	Skilled Support Staff
5.	Smt. K M Puttasiddamma	Skilled Support Staff
6.	Sri. B K Poovappa	Skilled Support Staff
7.	Sri. Marigowda	Skilled Support Staff

Important days observed at ICAR-IISR, kozhikode

Day	Date
World Water day	22 March 2019
International Women's day	8 March 2019
National Science day	28 February 2019
National Productivity week	12-18 February 2019
Swachhata Pakhwada	16-31 December 2018
Vigilance Awareness week	29 October to 3 November 2018
Swchhata Hi Seva	15 September to 2 October 2018
Institute Foundation day	1 July 2018
International Yoga day	21 June 2018
World Environmental day	5 June 2018

WEATHER DATA

ICAR-IISR Regional Station, Appangala, Madikeri						
Month	**Rainfall**		**Temperature (°C)**		**Relative humidity (%)**	
	Total Rainfall (mm)	**Rainy days**	**Max. (Mean)**	**Min. (Mean)**	**Max. (Mean)**	**Min. (Mean)**
January	0.0	0	27.75	10.93	90	75
February	0.0	0	29.90	11.98	90	75
March	92.6	5	30.30	12.21	87	69
April	103.5	9	30.81	14.08	89	72
May	329.5	13	30.24	15.20	94	82
June	782.8	22	29.37	14.10	93	88
July	1191.8	29	25.55	11.92	94	87
August	1299.8	31	23.21	15.15	95	88
September	186.7	12	25.33	14.50	93	87
October	213.4	10	25.57	15.40	89	83
November	9.0	1	24.84	14.35	91	86
December	10.0	1	24.56	12.78	92	87
Total/Mean	**4219.1**	**133**	**27.29**	**13.55**	**91.42**	**81.58**

ICAR-IISR Experimental Farm, Peruvannamuzhi						
Month	**Rainfall**		**Temperature (°C)**		**Relative humidity (%)**	
	Total Rainfall (mm)	**Rainy days**	**Max. (Mean)**	**Min. (Mean)**	**Max. (Mean)**	**Min. (Mean)**
January	0.00	0	34.74	19.56	88.80	46.16
February	0.00	0	36.34	20.57	88.28	47.50
March	78.00	4	35.85	23.67	91.03	52.67
April	131.00	10	35.40	24.86	91.13	59.10
May	468.20	20	33.14	24.59	94.70	72.45
June	1305.20	28	29.10	24.03	95.26	81.50
July	1666.40	29	28.58	23.77	95.22	84.58
August	1488.80	28	28.29	23.63	95.45	84.41
September	97.20	4	32.67	23.75	94.28	64.03
October	662.80	17	32.03	23.25	93.80	68.32
November	66.00	4	34.35	23.33	90.53	54.23
December	69.60	5	33.70	21.90	88.48	56.93
Total/Mean	**6033.20**	**149**	**32.85**	**23.08**	**92.25**	**64.32**

AWARDS

Institute was awarded Ganesh Sankar Vidyarthi Hindi Krishi Patrika Puraskar 2018 (second prize). Dr. Rashid Pervez, former Principal Scientist and Hindi Officer received the award from ICAR, New Delhi on 16 July 2018.

AICRP on spices has won the prestigious Chaudhary Devi Lal outstanding AICRP award for the best AICRP for the year 2017-18. Pepper Research Station, Panniyur under Kerala Agricultural University has been awarded as the Best Centre under AICRPS.

Dr R. Dinesh received NAAS Recognition Award in Soil, Water and Environmental Sciences for the year 2018.

Dr E. Jayashree received the Commendation Medal Award - 2018 of Indian Society of Agricultural Engineers.

Dr V. Srinivasan received HS Mehta Memorial Best Young Scientist Award-2018

Dr D. Prasath was awarded the Fellow of Horticultural Society of India during January 2019.

Dr. M. S. Shivakumar, Dr M. Alagupalamuthirsolai and Dr V. Srinivasan won best oral presentation awards in different national seminars.

Dr. Rashid Pervez, former Principal Scientist and Hindi Officer receiving the award

1. *Piper pedicellatum*, 2. *Etlingera fenzlii*
3. *Piper clypeatum*, 4. *Piper makruense*
5. *Garcinia nervosa*, 6. Mermithid nematode infesting turmeric shoot borer

ICAR-Indian Institute of Spices Research
Marikunnu P. O., Kozhikode - 673012, Kerala, India
Phone: 0495-2731410, Fax: 0495-2731187
E-mail: mail@spices.res.in, Web site: www.spices.res.in