वार्षिक प्रतिवेदन
ANNUAL REPORT
2024

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
श्रीकार्यम, तिरुवनंतपुरम 695 017, केरल, भारत

ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
Sreekariyam, Thiruvananthapuram 695 017, Kerala, India

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From the Director

Dr. G. Byju

Roots and tubers are essential to agri-food and industrial systems, providing vital nutrition, serving as raw materials for processing industries, and contributing to food security and economic growth. Ensuring consistent food and nutrition security is becoming increasingly challenging due to the impacts of climate change. At the same time, it is crucial to protect natural resources and prevent excessive strain on production systems. This highlights the need for continuous research on sustainable farming practices, climate-resilient crop varieties, and efficient resource management. I am pleased to present the 2024 annual report, which showcases the research advancements and developmental initiatives of ICAR-CTCRI.

The field gene bank preserves 5234 accessions of tuber crops, including cassava, sweet potato, yams, edible aroids, and minor tuber crops, across the headquarters and regional station, with 275 new collections added for valuable traits. Additionally, the *in vitro* active gene bank maintains 140 accessions. In a significant achievement, six new varieties were released: a semi-dwarf white yam variety, Sree Dhrona, two cassava varieties, Sree Annam & Sree Manna for Kerala, and three arrowroot varieties, Sree Nakshatra for Chhattisgarh and Jharkhand, Sree Karti for Kerala, Tamil Nadu, and Manipur, and one additional variety, Sree Aadya for Kerala, marking the first-ever release of arrowroot varieties in India. Several promising lines with specific valued traits were also identified, further strengthening the crop improvement programme.

The successful adoption of organic and integrated natural farming practices has resulted in remarkable productivity and profitability in cassava-based intercropping systems. With a strong emphasis on doubling farmers' income, these low-input, climate-resilient, and sustainable farming methods have shown great potential. The application of integrated nutrient management, combining FYM, biofertilizers, and inorganic nutrients, has significantly improved tuber yield, nutrient use efficiency, and soil health. Research on improving the multiplication rate of planting material has further strengthened crop production by ensuring the availability of quality planting material in larger quantities. Furthermore, protected cultivation has proven effective in producing high-yielding, healthy sweet potato with excellent sensory quality, promoting sustainable and profitable agricultural practices.

New and emerging pests, diseases, and nematodes linked to climate change have been effectively addressed through the identification of pests and pathogens and the development of innovative management strategies, including gene editing and early diagnosis. The introduction of new liquid formulations of bio-agents, namely *Sree Jala* and *Sree Syama*, along with the establishment of a mass production unit for the bio-control agent and identification of entomopathogenic nematodes, mark a significant step in enhancing crop protection. Additionally, the development of plant virus diagnostic kits and the extraction of leaf proteins from sweet potato weevil-resistant *Ipomoea mauritiana* further strengthen efforts towards sustainable and resilient agriculture.

Cassava and sweet potato-based products and technologies have been developed, promoting value addition and sustainability. Production methods for cassava stem particle boards were optimized and modified cassava starches have proven effective for both food and industrial uses. pH-sensitive films made from cassava starch and natural dyes enable real-time monitoring of food freshness, help detecting spoilage. Functional foods, such as probiotic-rich frozen desserts and antioxidant-loaded sweet potato gummies, provide added nutritional benefits. These innovations contribute to improved post-harvest processing. Machinery advancements, including a cassava sett cutter, a sweet potato grader, and a peeler for taro and Chinese potato, significantly reduce labour costs.

Through developmental outreach programmes such

as NEH, SCSP, and TSP, field demonstration trials and capacity building trainings were conducted, effectively bringing the Institute's technologies to local communities. National initiatives like *Mera Gaon Mera Gaurav* and the *Swachh Bharat Abhiyan Mission* were actively promoted, yielding noticeable outcomes. The Institute's visibility was further strengthened through six national training programmes and two brainstorming sessions. A dedicated field diagnostic team addresses farmers' challenges across the country. The Farmers Facilitation Center at the Institute was enhanced with a diverse range of products, supporting both popularization efforts and revenue generation by assisting farmers and stakeholders effectively.

ICAR-CTCRI farms both in HQ and Regional Station, Bhubaneswar are supplying quality planting materials to the farmers and stakeholders. More than 50 seed villages were established in different states to meet the quality planting material needs of the farmers.

ICAR-CTCRI, was recognized as a research center for both doctoral and post graduate programmes; conducted skill development programmes for farmers, officials, unemployed youth and other stakeholders; strengthening its academic and human resource development initiatives. The Institute engages government representatives, policymakers, officials, farmers, students, and stakeholders throughout the year for knowledge sharing, research advisory, and collaborations.

Demonstrations conducted on improved varieties, SSNM and other technologies in Kerala and Tamil Nadu showcased higher yields. Digital farms with e-Crop Based Smart Farming (eCBSF) technology were established, and statistical tools like Agrianalytics@R were upgraded. Two patents and three copyrights were granted, while eight technologies were certified by ICAR. Six incubatees joined the ICAR-CTCRI ABI, focusing on food processing and agricultural input marketing. Additionally, three new satellite incubation centers were established to promote tribal entrepreneurship, protect and commercialize traditional knowledge, and support indigenous and local community enterprises. The Institute mentored students, trained thousands of farmers and officials, and published 382 scientific contributions, strengthening agricultural sustainability and promoting rural livelihoods.

I express gratitude for the fruitful collaborations with CGIAR entities like CIP and CIAT; Indian government bodies such as CDB, RKVY, DST, DBT, NAIF, DAE, PPV&FRA, and NABARD; ICAR institutes, AICRP tuber crop centers, KVKs; and Kerala state organizations like KSCSTE, KSPB, and the Department of Agriculture & Farmers' Welfare, Universities from different states, private organizations and farmers.

Our sincere thanks to Dr. Himanshu Pathak, Secretary (DARE) & Director General (ICAR); Dr. Sanjay Kumar Singh, DDG (Hort. Sci); and Dr. Sudhakar Pandey, ADG (FVS&MP), ICAR, for their invaluable support, guidance and encouragement.

This report reflects the dedication of our staff, which I deeply appreciate. Members of the Editorial Committee deserve commendation for their unwavering support and for being relentless in their pursuit to bring this document as perfect as possible.

15 March 2025

G. Byju
Director

कार्यकारि सारांश

यहां प्रस्तुत संस्थान की अनुसंधान उपलब्धियां और आउटपुट, 46 इन-हाउस परियोजनाओं, 23 बाहरी सहायता प्राप्त और 3 विकासात्मक परियोजनाओं के तहत किए गए कार्यों को समाहित करते हैं, जिन्होंने तकनीकी प्रगति, क्षेत्र अपनाने और प्रौद्योगिकी हस्तांतरण में योगदान दिया। इन अनुसंधान प्रयासों के परिणामस्वरूप उत्पादकता, स्थिरता, रोग प्रतिरोधक क्षमता और आर्थिक व्यवहार्यता बढ़ाने के लिए उन्नत किस्मों, उन्नत फसल उत्पादन और सुरक्षा प्रौद्योगिकियों का विकास हुआ। इन अनुसंधान गतिविधियों, नवाचारों और आउटरीच पहलों के प्रमुख परिणामों का सारांश नीचे दिया गया है:

1. मुख्यालय में, कुल 5234 कंद फसल फील्ड जीन बैंक में बनाए रखे गए हैं जिसमें, 1216 कसावा, 905 शकरकंद, 801 रतालू, 655 खाद्य एरोइड और 387 लघु कंद फसलें शामिल है, और क्षेत्रीय स्टेशन से 1270 कंद फसल भी इस में शामिल है (113 कसावा, 380 शकरकंद, 51 रतालू, 554 खाद्य एरोइड और 172 लघु कंद फसलों)। इन विट्रो सक्रिय जीन बैंक (IVAG) के तहत मुख्यालय में 45 कसावा, 10 शकरकंद, 32 रतालू, 9 करकुमा और 3 अरारोट अभिग्रहण सहित 104 अभिग्रहण और क्षेत्रीय स्टेशन पर कसावा (10), शकरकंद की किस्में (11), तारो (5), रतालू (4), जिमीकंद (2), और चीनी आलू (4) सहित 36 अभिग्रहण रखे गए हैं।

2. कसावा में, दो पोषक तत्व उपयोग कुशल किस्में, श्री अन्नम और श्री मन्ना को केरल राज्य के लिए राज्य किस्म रिलीज समिति द्वारा जारी किया गया। इनके अलावा कई परिग्रहणों की पहचान महत्वपूर्ण लक्षणों से की गई, जैसे, नौ छोटे कद के परिग्रहण जिनकी पौधे की ऊंचाई < 180 सेमी (CE-8, CE-9, CE-15, CE-76, CE-122, CE-175, CE-182, CE-192, CE-231) है; पांच मीठे स्वाद और उच्च कंद भार वाले (CE-38, CE-71, CE-140, CE-198, CE-219), पांच उच्च स्टार्च >75% वाले (CE-28B, CE-23, CE-31, CE-18 और CE-16A), 25 सीएमडी प्रतिरोधी वंश-क्रम, चार प्रारंभिक बल्किंग जीनोटाइप (15S-41, 17S-48, 6-4 और 17S-247) जो रोपण के 3 महीने बाद ही बल्किंग हो जाते हैं (MAP), तीन β-कैरोटीन समृद्ध पीले मांस वाले कसावा वंश (CE-174, CE-348 और CE-430), 2 जीनोटाइप जो तले हुए चिप्स के लिए उपयुक्त हैं (CRNR-1 और II-3), 20 उच्च उपज देने वाले (4-6 किग्रा प्रति पौधा), उच्च स्टार्च सामग्री वाले सीएमडी प्रतिरोधी क्लोन, दो कसावा जीनोटाइप (KBH-18 और 15S-247) जो पीपीडी (5 दिन) के प्रति सहनशील हैं और CI-26 अत्यधिक सहनशील है जिसका शेल्फ जीवन 30-40 दिनों तक है।

3. शकरकंद में, कई प्रजातियों की पहचान महत्वपूर्ण लक्षणों के साथ की गई जैसे, चार मध्यम रूप से घुन प्रतिरोधी प्रजातियां (S-1668, S-27, S-1470 और S-1456), सूखी पदार्थ सामग्री >20% और अन्य भौतिक विशेषताओं के साथ तली हुई चिप्स बनाने के लिए उपयुक्त आठ प्रजातियां (S-27, S-1470, S-1653, S-1403, S-1401, S-1456, S-1668 और S-1712), पोषण संबंधी विशेषताओं के लिए जैव-प्रबलित प्रजातियां जैसे, उच्चतम P और K सामग्री 0.628% (CO3-50-33) और 1.21% (S-19), उच्चतम Fe और Mn सामग्री 221.8 पीपीएम (CO3-50-33) और 284.1 पीपीएम (KS-2), विटामिन सी की उच्चतम मात्रा, 29.94 मिलीग्राम 100 ग्राम-1 (KS-12) और प्रोटीन की मात्रा 2.74g 100g-1 (KS-2) है। IC50 मान जितना कम होगा, एंटीऑक्सीडेंट गतिविधि उतनी ही अधिक होगी और सबसे कम IC50 मान 14.14µg ml-1 (KS-12) के साथ था। इसके अतिरिक्त, पांच प्रारंभिक बल्किंग (80 दिन) बायोफोर्टिफाइड संकर (H-580/108, H-43/83, H-678/36, H-447/1 और H-575/10), दो सफेद मांस वाले उच्च उपज वाले संकर (H-526/7 और S-1401), सलाड के उद्देश्य के लिए स्टार्च में कम छह उच्च उपज वाले बायोफोर्टिफाइड संकर (H-447/1, H-39/9, H-43/126, H-514/1, H-50/14 और H-50/26), चार उच्च उपज वाले बायोफोर्टिफाइड संकर >25 टन प्रति हेक्टेयर (H-38/15, H-38/46, H-43/83 और H-110/28), आठ पोषण से भरपूर लाइनें (KS-22, CP-108-14, KS-12,KS-27, SP-9, SP-20, SP-1 और SP-11), शीघ्र पकने वाला (75-80 दिन), नारंगी गूदा (β-कैरोटीन तत्व 8.50 मिग्रा.100 ग्राम-1), एकसमान कंद आकार, औसत कंद उपज (19 टन प्रति हेक्टेयर) के साथ अच्छी पाक गुणवत्ता (SP-95/4), पांच सूखा सहिष्णु जीनोटाइप (DB/21/57, RS-III, B × 7, SP-123 और S-162) और पांच उच्च उपज देने वाले, शीघ्र पकने वाले (90-100 दिन) जीनोटाइप (SP-19, SP-5, SP-18, SP-27, SP-1 और SP-29) पहचाने गए।

4. केरल राज्य के लिए राज्य किस्म विमोचन समिति (SVRC) द्वारा एक सफ़ेद रतालू किस्म, श्री ध्रोना जारी की गई। यह एक अर्ध बौनी, गैर-अनुगामी किस्म है जिसकी उच्च उपज 35 - 45 टन प्रति हेक्टेयर (52.0 टन प्रति हेक्टेयर संभावित उपज) है, जिसकी अवधि 8-9 महीने है, जिसमें मध्यम बेलनाकार चिकने कंद हैं, जो पकाने में अच्छे हैं और कंद का आकार कॉम्पैक्ट है। बड़े रतालू में, एन्थ्रेक्नोज के लिए 28 अत्यधिक प्रतिरोधी और 23 सहनशील परिग्रहण की पहचान की गई; छोटे रतालू में, पाँच परिग्रहण रतालू हल्के मोज़ेक वायरस (De-24, De-28, De-34, De-42 और De-58) के लिए नकारात्मक थे।

5. तारो में, महत्वपूर्ण लक्षणों के साथ कई प्रजातियों की पहचान की गई, जैसे 10 उच्च उपज देने वाली प्रजातियाँ (>10 टन प्रति हेक्टेयर); 40 दिनों के बाद अच्छी शैल्फ लाइफ वाली एक प्रजाति (IC204205), तीन कम तीखे (ADG/2022-1, TTr22-6 और TTr22-5), एक उच्च उपज और उच्च जस्ता (CE-558) और एक उच्च उपज और उच्च लौह (CE-334357) वाली प्रजातियाँ। जिमीकंद के मामले में, दो रूट नॉट नेमाटोड प्रतिरोधी लाइनें (TEy22-1 और TEy22-6), पांच गैर-तीक्ष्ण संकर (H-102-2015, H-107-2015, H-843/2/2-2017, H-6-7-2017 और H-6-34-2017), दो उच्च उपज (1-1.5 किग्रा पौधा-1) (H-6-7-2017 और H-6-34-2017) और एक जल्दी पकने वाली संकर (AmH-22-99) की पहचान की गई। टैनिया में, दो उच्च उपज (कुल उपज >14 टन प्रति हेक्टेयर) (Xa-63 और Xa-AD/2014-18) की पहचान की गई। जैव रासायनिक लक्षणों (CL-56, NEH-44, NEH-14, Megh -19, सिरुली लोकल, पिप्पली, CE-12 और Megh-18) के लिए आठ बायोफोर्टिफाइड तारो एक्सेसियन की पहचान की गई।

6. अरारोट में, दो किस्में केंद्रीय किस्म विमोचन समिति (CVRC) द्वारा तथा एक किस्म राज्य किस्म विमोचन समिति (SVRC) द्वारा केरल के लिए पहली बार भारत में जारी की गई। श्री नक्षत्रा (छत्तीसगढ़ और झारखंड) की उपज 32.25 टन प्रति हेक्टेयर तथा स्टार्च की उपज 8.59 टन प्रति हेक्टेयर है, जबकि श्री कार्ति (केरल, तमिलनाडु और मणिपुर) की उपज 23.57 टन प्रति हेक्टेयर तथा स्टार्च की उपज 5.07 टन प्रति हेक्टेयर है। श्री आद्या (केरल) की उपज 30.04 टन प्रति हेक्टेयर तथा स्टार्च की उपज 5.95 टन प्रति हेक्टेयर है।

7. चीनी आलू में, कुलपरचल नामक एक स्थानीय किस्म उच्च उपज देने वाली (35.4 टन प्रति हेक्टेयर) थी। परिवर्तनशीलता को प्रेरित करने के लिए, 55 Gy पर गामा विकिरण के परिणामस्वरूप जल्दी फूल खिलते हैं, जिसमें कार्यात्मक मादा प्रजनन अंग होता है, जिसमें वास्तविक बीज सेट और कंद निर्माण की क्षमता होती है। 35 Gy और नियंत्रण से उपचारित एक्सप्लांट में 1 मिलीग्राम प्रति लीटर BAP से सुदृढ़ीकृत MS मीडिया में इन विट्रो प्ररोह गुणन देखा गया, जबकि 15 और 20 Gy पर विकिरणित पत्ती एक्सप्लांट में कैलस प्रेरण और पुनर्जनन देखा गया। ईस्ट इंडियन एरारूट में, CTCRI-CA-PM-1 को लंबे प्राथमिक प्रकंद (21.25 सेमी), उच्च स्टार्च सामग्री (16.8%), पर्याप्त प्रकंद उपज (39.4 टन प्रति हेक्टेयर) और उत्कृष्ट शुष्क वसूली (19.15%) के साथ सर्वश्रेष्ठ प्रदर्शन करने वाले के रूप में पहचाना गया। याम बीन में, महत्वपूर्ण लक्षणों के साथ पहचानी गई लाइनें चार बायोफोर्टिफाइड लाइनें (DPH-6, L.No.3, L.No.19 और DPH-10) और पाँच पोषण से भरपूर लाइनें (DPH-10, RM-1, YBBL-20, DPH-20 और IC002514) थीं। याम बीन के लिए प्रजनक बीज मानक स्थापित किए गए।

8. बायोप्रोस्पेक्टिंग अध्ययनों के तहत, बैंगनी तारो (IC652061) (ADSR) और ज़ैंथोसोमा वायलेसियम (Xa-AAV/2022-11) (VIOL) के अर्क इसके एंटीएंजियोजेनिक प्रभाव के साथ-साथ घाव के स्थानांतरण प्रभाव में भी प्रभावी थे, जिसमें ADSR द्वारा 120 µg/ml खुराक पर सबसे अच्छे परिणाम दिखाए गए। दोनों ने 1 मिलीग्राम पर VIOL के साथ जीवाणुरोधी प्रभाव भी दिखाया, जो क्लेबसिएला निमोनिया और विब्रियो कोलेरा के खिलाफ काम करता है, जबकि ADSR बैसिलस सबटिलिस और स्ट्रेप्टोकोकस पयोजेनस के खिलाफ काम करता है।

9. बिना आमिलोज़ के मोमी कसावा विकसित करने के लिए, एक जीन संपादन संरचना जो gbss जीन और एक अन्य लक्ष्यीकरण, SBEI और SBEIIb को लक्षित करती है, विकसित की गई, PHSE401 वेक्टर पर एकत्रित की गई और अनुक्रमण के माध्यम से पुष्टि की गई और कसावा किस्म H-226 के भुरभुरे भ्रूणजन्य कैली में रूपांतरित की गई।

10. कसावा CMD मैपिंग आबादी में, ट्रांसक्रिप्टोम अध्ययनों ने जैविक उत्तेजना और रक्षा प्रतिक्रिया से संबंधित प्रमुख जीन से जुड़े 12 कार्यात्मक मार्कर प्राप्त किए। माइक्रोसैटेलाइट रिपीट के लिए जीनोम-वाइड माइनिंग ने सभी 18 गुणसूत्रों में फैले 17,671 जीनिक और 28,231 गैर-जीनिक मार्करों की पहचान की। चार मार्कर अर्थात, MeESSR34, MeESSR39, SSRY28 और SSRY45 ने 32 कसावा जीनोटाइपों के बीच बहुरूपता प्रदर्शित की। शकरकंद में, तीन जीन पाइरोलाइन-5-कार्बोक्सिलेट रिडक्टेस (IbP5CR), DREB ट्रांसक्रिप्शन फैक्टर (IbCBF3), ARF ट्रांसक्रिप्शन फैक्टर (IbARF5) ने सूखा-सहिष्णु किस्म में बढ़ी हुई अभिव्यक्ति दिखाई। पाँच SSR मार्कर अर्थात, Ib182, Ib2082, Ib244, Ib1845 और Ib346 ने 20 शकरकंद जीनोटाइप में उच्च बहुरूपता प्रदर्शित की। इन सिलिको अध्ययनों से पता चला है कि कसावा प्रोटीन में कंद-विशिष्ट या वेक्यूलर लक्ष्यीकरण या N टर्मिनल सिग्नल अनुक्रमों की अनुपस्थिति कंदों में कम प्रोटीन सामग्री के लिए जिम्मेदार है। शकरकंद में, DNA बारकोडिंग के लिए, MatK को प्रवर्धन और अनुक्रमण में अत्यधिक कुशल और ITS4 जीन को द्वितीयक संरचना भविष्यवाणियों में एक शक्तिशाली DNA बारकोड उम्मीदवार के रूप में पहचाना गया।

11. जैविक खेती में, सब्जियों के साथ कसावा-आधारित अंतर-फसल प्रणाली, 100% जैविक ने कसावा (48.53 टन प्रति हेक्टेयर), मिर्च (2.88 टन प्रति हेक्टेयर), टमाटर (3.17 टन प्रति हेक्टेयर) की उच्चतम उपज और कंद समतुल्य उपज (TEY, 54.73 टन प्रति हेक्टेयर) प्राप्त की। 75% जैविक + नवीन प्रथाओं ने क्लस्टर बीन की उपज को अधिकतम किया (2.36 टन प्रति हेक्टेयर)। कसावा + मिर्च (58.61 टन प्रति हेक्टेयर) और कसावा + क्लस्टर बीन (58.30 टन प्रति हेक्टेयर) संयोजनों ने मजबूत उत्पादकता क्षमता दिखाई।

12. कंद फसल प्रणालियों में जैविक, अकार्बनिक और एकीकृत प्रबंधन प्रथाओं ने प्रथाओं के पैकेज (PoP) के तहत उच्चतम कसावा उपज (35.94 टन हेक्टेयर) दिखाई, जिसके बाद 50% जैविक + 50% अकार्बनिक (34.86 टन हेक्टेयर) का स्थान रहा। निवल प्रतिफल और बी:सी अनुपात PoP के तहत सबसे अधिक थे, उसके बाद 100% अकार्बनिक और 100% जैविक (प्रीमियम मूल्य के साथ) थे। तारो में, उच्चतम कॉर्मेल उपज (7.75 टन प्रति हेक्टेयर), शुद्ध आय और बी:सी

अनुपात (प्रीमियम मूल्य के साथ और बिना) 100% जैविक प्रबंधन के तहत दर्ज किया गया था। रतालू की किस्मों में, उड़ीसा एलीट (13.82 टन प्रति हेक्टेयर) और श्रीनिधि (11.84 टन प्रति हेक्टेयर) ने जैविक खेती में सबसे अच्छा प्रदर्शन किया। IOFS मॉडल ने कंद फसल आधारित खेती से 40.34 टन प्रति हेक्टेयर कंद समतुल्य उपज हासिल की।

13. कसावा + सब्जी लोबिया + मूंग में प्राकृतिक खेती से पता चला कि एकीकृत फसल प्रबंधन (ICM) प्रथाओं ने कसावा की पैदावार (101.29 t ha^{-1}) और रिटर्न में उल्लेखनीय वृद्धि की। ICM प्रथाओं के तहत उच्चतम कंद समतुल्य उपज (105.19 t ha^{-1}) और उत्पादन दक्षता भी दर्ज की गई। केरल में एक भू-संदर्भित सर्वेक्षण ने प्राकृतिक खेती को व्यापक रूप से अपनाने का खुलासा किया।

14. प्री-इमर्जेंस हर्बिसाइड पेंडीमेथालिन (1 DAP) और उसके बाद पोस्ट-इमर्जेंस क्लोडिनोफॉप (45 DAP) के साथ उपचार से खरपतवार की आबादी, शुष्क भार और तीव्रता में उल्लेखनीय कमी आई, जिससे 60 और 90 DAP पर 87% से अधिक खरपतवार नियंत्रण दक्षता प्राप्त हुई। इसके अतिरिक्त, शकरकंद की वृद्धि और उपज में भी सुधार हुआ, बेल की लंबाई 1.64 मीटर, माध्यमिक शाखाएं 6.60, और उपज 25.57 टन हेक्टेयर तक पहुंच गई। प्रमुख खरपतवारों में सेटेरिया ग्लौका, मिमोसा पुडिका, अल्टरनेथेरा पैरोनिचियोइड्स, सायनोटिस एक्सिलारिस, क्लियोम विस्कोसा और साइपरस रोटंडस शामिल हैं।

15. 50% CPE और छिद्रयुक्त भूमि आवरण मल्चिंग के साथ ड्रिप सिंचाई से उच्चतम कंद उपज (51.2 टन प्रति हेक्टेयर) प्राप्त हुई और सांख्यिकीय रूप से यह कसावा में पूसा हाइड्रोजेल + मल्चिंग और 100% CPE उपचार के बराबर थी। इस दृष्टिकोण ने 50% सिंचाई जल की बचत करते हुए उपज में 10.1% की वृद्धि की। जल-बचत उपचार (छिद्रित भूमि आवरण मल्चिंग, बायोमल्चिंग, कॉयर पिथ, पर्ण एंटीट्रांसपिरेंट, पूसा हाइड्रोजेल, ऑर्गेनिक जेल सुजलाम, पूसा हाइड्रोजेल + ग्राउंड कवर मल्चिंग) ने 50% CPE नियंत्रण की तुलना में उपज में 1-24.9% की वृद्धि की और तीन गुना कम पानी का उपयोग करने के बावजूद फरो सिंचाई के बराबर प्रदर्शन किया।

16. बड़े रतालू में, 3-दिन के अंतराल के साथ 60 विभाजनों के इष्टतम संयोजन ने उत्पादकता और लाभप्रदता को अधिकतम किया, जिससे 40.4 टन प्रति हेक्टेयर की उल्लेखनीय रूप से उच्च कंद उपज, ₹ 605,500 हेक्टेयर का सकल रिटर्न, ₹ 396,600 हेक्टेयर का शुद्ध रिटर्न और 2.90 का बी:सी अनुपात प्राप्त हुआ।

17. चीनी आलू में, 125% CPE पर ड्रिप सिंचाई ने काफी अधिक कंद उपज (27 टन प्रति हेक्टेयर) का उत्पादन किया, जबकि स्प्रिंकलर और फरो सिंचाई ने क्रमशः 46.6% और 25.6% कम उपज दी।

18. जिमीकंद में, उर्वरक की खुराक और समय-सारिणी ने कंद की पैदावार को महत्वपूर्ण रूप से प्रभावित नहीं किया। सबसे अधिक उपज (50.5 टन प्रति हेक्टेयर) थी, जबकि सबसे कम पोषक तत्व की खुराक (75-50-100 kg ha-1 N, P_2O_5 और K_2O) चरणों में लागू की गई: 90 DAP से पहले 50%, 90-120 DAP के दौरान 25% और 120-180 डीएपी के दौरान 25%।

19. अल्फिसोल में बड़े रतालू + मक्का प्रणाली में अकार्बनिक पोषक तत्वों, FYM, और जैव उर्वरकों (एज़ोस्पिरिलम और PSB) के प्रभाव से, FYM + 40-30-40 kg ha-1 N, P_2O_5 और K_2O के साथ कंद उपज में 88.2% की वृद्धि हासिल की गई। सर्वोत्तम पोषक तत्व उपयोग दक्षता (NUE: 293 kg tubers/kg N, PUE: 390 kg tubers/kg P) एज़ोस्पिरिलम + PSB + 40-30 kg ha-1 N, P_2O_5 के साथ देखी गई। FYM + 50% NPK ने मिट्टी की एंजाइम गतिविधियों और कार्बनिक कार्बन में सुधार किया, जिससे उपज के साथ एक मजबूत सकारात्मक सहसंबंध दिखा FYM, जैवउर्वरकों और 50% NPK एकीकृत उपयोग से मृदा के जैविक और रासायनिक गुणों में वृद्धि हुई, जिससे ग्रेटर रतालू प्रणाली की उपज और स्थिरता में सुधार हुआ।

20. ग्रेडेड N लेवल, FYM और बायोफर्टिलाइजर्स सहित नाइट्रोजन उपयोग दक्षता अध्ययन में, श्री भद्रा किस्म ने उल्लेखनीय रूप से उच्चतम कंद उपज (14.04 टन प्रति हेक्टेयर) प्राप्त की। उपचार के संबंध में, FYM + 50 kg N ha^{-1} ने नियंत्रण की तुलना में 67.5% की उपज वृद्धि के साथ उल्लेखनीय रूप से उच्चतम कंद उपज (15.32 टन प्रति हेक्टेयर) उत्पन्न की। इसके अतिरिक्त, श्री भद्रा में स्टार्च की मात्रा सबसे अधिक (17.74%) थी, जबकि किशन में अन्य किस्मों की तुलना में सबसे अधिक शुष्क पदार्थ (25.56%) और कुल शर्करा (2.95%) थी। एकीकृत पोषक तत्व प्रबंधन ने मृदा कार्बनिक कार्बन (0.602%), उपलब्ध NPK और एंज़ाइम गतिविधियों में सुधार किया, जिससे कंद की उपज, गुणवत्ता और मिट्टी के स्वास्थ्य में वृद्धि हुई और टिकाऊ उत्पादन हुआ।

21. अनुकूलित उर्वरकों (CF) और कम इनपुट प्रबंधन प्रथाओं (LIMP) के अनुप्रयोग से उच्चतम टिकाऊ उपज सूचकांक (SYI) प्राप्त हुआ। NPK के कुशल जीनोटाइप 7 III E3-5 और कैल्शियम के मिट्टी और पत्तियों पर प्रयोग (40 टन प्रति हेक्टेयर) के तहत कंद की उपज उल्लेखनीय रूप से उच्चतम थी। लोबिया (34.1 टन प्रति हेक्टेयर) के साथ हरी खाद और मिट्टी परीक्षण-आधारित NPK (32.5 टन प्रति हेक्टेयर) ने भी अच्छा प्रदर्शन किया। कम इनपुट प्रबंधन से मृदा घनत्व (1.34 Mg m^{-3}) कम हो गया और जल धारण क्षमता (39.92%) में सुधार हुआ, जो मृदा परीक्षण आधारित उर्वरक NPK (STBFNPK) + फसल अवशेष (41.07%) और अन्य पोषक तत्व प्रबंधन प्रथाओं के बराबर है।

22. साधारण यूरिया के माध्यम से 100% नाइट्रोजन (N) को पत्तियों पर छिड़काव के माध्यम से नैनो यूरिया के रूप में 50% N के साथ मिलाकर मिट्टी में प्रयोग करने से कसावा कंद की उपज में 52% की उल्लेखनीय वृद्धि हुई, जो 54 t ha^{-1} तक पहुँच गई। नैनो यूरिया ने क्लोरोफिल के स्तर, मिट्टी में N की उपलब्धता, पौधों द्वारा पोषक तत्वों के अवशोषण में भी थोड़ा सुधार किया और कंद के साइनोजेन्स और कंद के पोटेशियम (K) को कम किया। पैकेज ऑफ प्रैक्टिसेज (PoP) के अनुसार 50 kg P_2O_5 ha^{-1} का प्रयोग, सेट ट्रीटमेंट और

पत्तियों पर छिड़काव के माध्यम से लगाए गए नैनो DAP जितना ही प्रभावी था।

23. कसावा में सूखे के तनाव ने प्रकाश संश्लेषण, रंध्र चालकता और वाष्पोत्सर्जन ($P < 0.01$) को काफी हद तक कम कर दिया, जबकि पत्ती श्वसन भी प्रभावित हुआ ($P = 0.01$)। जीनोटाइपिक भिन्नता ने रंध्र चालकता ($P < 0.01$) को प्रभावित किया, लेकिन प्रकाश संश्लेषण, श्वसन या वाष्पोत्सर्जन को नहीं। क्लोरोफिल प्रतिदीप्ति पैरामीटर ज्यादातर स्थिर रहे, सिवाय NPQ ($P = 0.03$) में उल्लेखनीय वृद्धि के, जो बढ़ी हुई गर्मी अपव्यय को दर्शाता है। PhiPS2 ने मामूली महत्व दिखाया ($P = 0.05$), जो जीनोटाइप-विशिष्ट PSII प्रतिक्रियाओं को दर्शाता है।

24. सूखे के तनाव का पत्ती क्षेत्र सूचकांक (LAI) पर न्यूनतम प्रभाव पड़ा, लेकिन श्री कनक ने उच्च LAI (4.1 ± 0.19) बनाए रखा, जबकि कंजंगद में गिरावट आई (2.6 ± 0.16)। सूखा-सहिष्णु जीनोटाइप में ऑस्मोलाइट संचय में वृद्धि हुई (-1200 ± 100 mmol kg-1)। प्रकाश संश्लेषण (Pn), रंध्र चालकता और CO_2 सांद्रता में कमी आई ($P < 0.01$), जबकि श्वसन स्थिर रहा, लेकिन PSII दक्षता (Fv/Fm) कम हो गई। कम वाष्पोत्सर्जन के कारण जल उपयोग दक्षता में कमी आई ($P < 0.01$)। बायोमास और उपज में गिरावट आई, तने के ताजे वजन में कमी आई ($P < 0.01$) और जड़ और कंद उत्पादकता में महत्वपूर्ण नुकसान हुआ ($P < 0.01$), हालांकि बेल की वृद्धि अप्रभावित रही ($P = 0.88$)।

25. जलमग्नता तनाव ने क्लोरोफिल की मात्रा को कम कर दिया, CMR-2 4.5 mg g^{-1} FW से गिर गया, जबकि श्री पवित्रा ने उच्च स्तर (2.8 mg g^{-1} FW) बनाए रखा। श्री अपूर्वा ने उच्चतम झिल्ली स्थिरता (60%) और ऑस्मोलाइट संचय (600 mmol kg^{-1}) दिखाया, जबकि श्री अतुल्या ने उच्चतम RWC (94%) बनाए रखा। श्री स्वर्णा ने 89% DPPH गतिविधि के साथ सबसे मजबूत एंटीऑक्सीडेंट रक्षा का प्रदर्शन किया। प्रकाश संश्लेषण दर में गिरावट आई, लेकिन श्री अपूर्वा ने उच्चतम (20 µmol CO_2 m^{-2} s^{-1}) बनाए रखा। क्लोरोफिल प्रतिदीप्ति (Fv/Fm, PhiPS2) में कमी आई, जबकि NPQ में वृद्धि हुई, जो फोटोप्रोटेक्शन को दर्शाता है। Pn का संबंध Fv/Fm, फीनोलिक सामग्री और एंटीऑक्सीडेंट गतिविधि के साथ सकारात्मक है, लेकिन कैटेलेज गतिविधि के साथ नकारात्मक है, जो ऑक्सीडेटिव तनाव को दर्शाता है।

26. कसावा मिनिसेट के लिए ग्रोथ मीडिया को मानकीकृत करने के लिए किए गए अध्ययनों से पता चला है कि पॉटिंग मिक्सचर (मिट्टी: FYM 2:1) में सबसे पहले अंकुरण (5 दिन) और सबसे अधिक स्थापना (दो नोड मिनिसेट में 89%) हुई, जबकि एकल नोड में 51% थी। इस माध्यम से अंकुरों ने 15 और 30 दिनों के बाद क्रमशः 7 और 22 सेमी की बेहतर ऊंचाई दिखाई।

27. नियंत्रित परिस्थितियों में, शकरकंद की किस्म भू कृष्णा की बेल सबसे लंबी (274.08 सेमी) और जड़ का ताजा वजन (170.42 ग्राम) सबसे अधिक था, जबकि श्री अरुण ने सबसे अधिक कंद उपज (2290 ग्राम/पौधा) पैदा की। संरक्षित खेती के कंदों में उन्नत संवेदी गुण दिखाई दिए, 5 प्वाइंट हेडोनिक स्केल में भू कृष्णा ने सुगंध (3.81) और रंग (4.38) की तुलना में खुली स्थिति (3.19 और 3.81) में उत्कृष्ट प्रदर्शन किया।

28. केरल, तमिलनाडु, ओडिशा और मेघालय में कसावा, शकरकंद, जिमीकंद और चीनी आलू के लिए बीज गांव स्थापित किए गए, जिसमें 47 गांवों के 184 एकड़ क्षेत्र को शामिल किया गया। गुणवत्तापूर्ण रोपण सामग्री उत्पादन के लिए विकेन्द्रीकृत बीज गुणक (DSM) कार्यक्रम के तहत सौ सत्रह किसानों को पंजीकृत किया गया।

29. ग्रो बैग के साथ किए गए प्रयोग में रतालू की किस्मों श्री निधि और श्री नीलिमा के लिए छह माध्यमों के संयोजनों का मूल्यांकन किया गया, जिससे उपज में महत्वपूर्ण अंतर देखने को मिला। श्री निधि ने मिट्टी, वर्मीक्यूलाईट और वर्मीकम्पोस्ट (1:1:1) मध्यम (1143 ग्राम $पौधा^{-1}$) वाली मिट्टी में सबसे अच्छा उत्पादन दिया, जबकि श्री नीलिमा ने FYM (1:1) (880 ग्राम $पौधा^{-1}$) वाली मिट्टी में सबसे अच्छा प्रदर्शन किया। सेट आकार और प्रीट्रीटमेंट ने जिमीकंद (गजेंद्र) में कॉर्म उपज को काफी प्रभावित किया, बड़े सेट (200 ग्राम) से ग्रो बैग में 1.42 किलोग्राम तक उपज होती है।

30. कसावा आसवन के साथ धूमन से बोरर कीटों, राइजोपर्था डोमिनिका और कैलोसोब्रुचस फॉर्मिकेरियस को क्रमशः 4 और 5 मिनट में इन विट्रो में मार दिया जा सकता है। धूमन उपचार के बाद कीटों में साइटोक्रोम सी ऑक्सीडेज mRNA अभिव्यक्ति के अवरोध की पुष्टि की गई।

31. माइट, टेट्रानाइकस कंज़ावाई को रूपात्मक पहचान कुंजी और mt-co1 जीन अनुक्रमण के माध्यम से कसावा के एक नए कीट के रूप में पहचाना गया है। संक्रमण के परिणामस्वरूप कसावा में पीलापन, कांस्य रंग का मलिनकिरण और पतझड़ होता है, जिससे विकास अवरुद्ध हो जाता है और गंभीर स्थिति में कंद उत्पादन कम हो जाता है। 16S rRNA अनुक्रमण के माध्यम से माइट से जुड़े दो जीवाणु एंडोसिम्बियन्ट्स की पहचान बैसिलस सेरेस और बैसिलस मायकोइड्स के रूप में की गई।

32. केरल के तिरुवनंतपुरम से EPNs के तीन आइसोलेट्स, CTCRIS2, CTCRIS3 और CTCRIH2 प्राप्त किए गए। रूपात्मक लक्षण वर्णन के आधार पर, CTCRIS2 और CTCRIS3 की पहचान स्टीनरनेमा spp. के रूप में की गई और CTCRIH2 की पहचान हेटेरोरैबडाइटिस sp. के रूप में की गई। CTCRIS2 की पहचान आईटीएस अनुक्रमण का उपयोग करके स्टीनरनेमा सियामकाई के रूप में की गई। एस. सियामकाई से जुड़ा प्राथमिक एंडोसिम्बियन्ट, ज़ेनोरहैबडस स्टॉकिया था।

33. कंदीय आइपोमिया मॉरिषियाना के कच्चे पत्ते के प्रोटीन अर्क को शकरकंद के घुन के संक्रमण के लिए प्रतिरोधी के रूप में पहचाना गया, जिसने 4-5 mg ml-1 की प्रोटीन सांद्रता पर 48 घंटे के बाद वयस्क शकरकंद के घुन में मृत्यु दर दिखाई। इसने लिपिड पेरोक्सीडेशन, ग्लूटाथियोन पेरोक्सीडेज और ग्लूटाथयोन रिडक्टेस गतिविधियों को भी कम किया और सुपरऑक्साइड डिसम्यूटेज और ग्लूटाथियोन एस-

ट्रांसफरेज गतिविधियों को बढ़ाया। यह आइपोमिया मॉरिषियाना पत्तियों में कीटनाशक प्रोटीन की पहचान करने वाला पहला है। मीठे आलू के घुन के संक्रमण के तहत आई. मॉरिषियाना और आई. बटाटास की जड़ों की ट्रांसक्रिप्टोम अनुक्रमण ने क्रमशः 72 और 52 अलग-अलग अभिव्यक्त जीनों की पहचान की।

34. फ्लूओपीरम 34.48% SC (0.5 ml l-1) ने जिमीकंद में रूट नॉट नेमाटोड, मेलोइडोगाइन इन्कोग्निटा द्वारा सबसे कम कॉर्म क्षति (6.4%) दिखाई और सबसे अच्छी उपज दी (2.5 किग्रा प्रति पौधा), इसके बाद फ्लूएनसल्फोन 2% GR (1 ग्राम प्रति पौधा), नीम केक (500 ग्राम प्रति पौधा) और ट्राइकोडर्मा हरजियानम (20 ग्राम प्रति पौधा) (15.8, 13.7 और 15%) ने 2.03, 1.3 और 1.2 किग्रा प्रति पौधा उपज दी, जब इसकी तुलना नियंत्रण (18.27% क्षति और 0.78 किग्रा प्रति पौधा उपज) से की गई।)

35. पौधों परजीवी नेमटोड से जीनोमिक डीएनए के पृथक्करण के लिए प्रोटोकॉल को मानकीकृत किया गया। जिमीकंद को संक्रमित करने वाले मेलोइडोगाइन प्रजाति (EMK1) की पहचान इसके प्रवर्धन (जेनबैंक परिग्रहण संख्या PP756339) के माध्यम से मेलोइडोगाइन जावनिका (99.86% समानता) के रूप में की गई। चीनी आलू में, रूट-नॉट निमेटोड (मेलोइडोगाइन प्रजाति) मिट्टी के नमूनों में पाया जाने वाला सबसे प्रचलित निमेटोड था, जिसकी जनसंख्या घनत्व तमिलनाडु के तिरुनेलवेली और तेंकाशी जिले के दो-दो गांवों के सर्वेक्षण किए गए खेतों में प्रति ग्राम मिट्टी में 0.5 से 2 नेमटोड के बीच था।

36. पत्ती के नमूनों में नौ प्रकार के लक्षण देखे गए, जिनमें पत्ती सड़न/झुर्री और स्यूडोस्टेम सड़न के लक्षण दिखाई दिए। अधिकांश आइसोलेट्स कोलेटोट्राइकम और फ्यूजेरियम प्रजाति के हैं। जीवामृत (4.0) से उपचारित पौधों में सबसे कम प्रतिशत रोग सूचकांक (PDI) देखा गया, जो ट्राइकोडर्मा बायोकैप्सूल (5.6) और डिफेनोकोनाज़ोल (7.73) के बराबर था। जीवामृत उपचारित पौधों (52.9 टन प्रति हेक्टेयर) में सबसे अधिक उपज दर्ज की गई, उसके बाद टी. एस्परेलम (51.7 टन प्रति हेक्टेयर) के बायोकैप्सूल का स्थान रहा।

37. तारो पत्ती झुलसा रोग का सबसे कम PDI मेटालैक्सिल 4% + मैन्कोनजेब 64% (7.51) और साइमोक्सानिल 8% + मैन्कोजेब 64% (7.84) से उपचारित पौधों में देखा गया, जो पोटेशियम सिलिकेट (10.6) और फैमोक्साडोन 16.6% + साइमोक्सानिल 22.1% SC (11.96) के बराबर था।

38. तापमान सहनशीलता के लिए 97 ट्राइकोडर्मा आइसोलेट्स के मूल्यांकन में, वृद्धि दर 0.43 सेमी/दिन (15°C पर आइसोलेट T91) से लेकर 3.8 सेमी/दिन (35°C पर आइसोलेट T89) तक भिन्न थी। उच्चतम औसत माइसेलियल वृद्धि 30°C पर देखी गई, उसके बाद 35°C, तथा सबसे कम वृद्धि 15°C पर देखी गई। पंद्रह आइसोलेट्स - T3, T19, T20, T52, T59, T63, T66, T73, T79, T81, T87, T92, T94, T95, और T96 ने 20° C, 25° C, 30° C, और 35° C में 0.5 सेमी/दिन से कम की वृद्धि दर का अंतर बनाए रखा, जो महत्वपूर्ण मौसमी तापमान में उतार-चढ़ाव का अनुभव करने वाले क्षेत्रों के लिए उपयुक्त है।

39. कसावा स्टेम और रूट रॉट (CSRR) से जुड़े रोगजनकों की पहचान मॉर्फोकल्चरल कैरेक्टर के माध्यम से फ्यूजेरियम spp. के रूप में की गई और RNA पॉलीमरेज़ 2 (rpb2) और ट्रांसलेशन एलॉन्गेशन फैक्टर 1-अल्फा (tef1) जीन अनुक्रमण का उपयोग करके प्रजातियों के स्तर तक आगे बढ़ाया गया। चार आइसोलेट्स फ्यूजेरियम सोलानी प्रजाति कॉम्प्लेक्स (FSSC), फ्यूजेरियम फाल्सीफॉर्म (3) और नियोकोस्मोस्पोरा सुटोनियाना (1) से संबंधित हैं। केरल में विभिन्न किसानों के खेतों से छह नए आइसोलेट्स प्राप्त किए गए।

40. डोफाइटिक ट्राइकोडर्मा एस्परेलम (CTRI-Tr 15), बैसिलस सबटिलिस बायोकैप्सूल और ICAR-फ्यूसिकॉन्ट के साथ CSRR प्रबंधन परीक्षण ने नियंत्रण की तुलना में क्रमशः 89, 72 और 58% रोग की घटनाओं को कम किया। इन विट्रो में जांची गई सोलह किस्मों में से छह अर्थात श्री सुवर्णा, श्री अतुल्या, श्री पवित्रा, श्री रक्षा, एच-97 और श्री विशाखम CSRR से जुड़े फ्यूजेरियम फाल्सीफॉर्म के संक्रमण का सामना कर सकती हैं।

41. एज़ोक्सीस्ट्रोबिन और डिफेनोकोनाज़ोल (1 ml l^{-1}) का संयोजन सबसे प्रभावी उपचार साबित हुआ, जिससे बड़े रतालू (किस्म: उड़ीसा एलीट) में एन्थ्रेक्नोज़ की तीव्रता में उल्लेखनीय कमी (65%) प्राप्त हुई, जो अकेले डिफेनोकोनाज़ोल (1 मिली लीटर प्रति लीटर) और कार्बेन्डाजिम (0.5 g l^{-1}) के बराबर थी, जिसमें क्रमशः 60%-53% की कमी हुई। इसके अतिरिक्त, विभिन्न वितरण विधियों के माध्यम से लागू किए गए एंडोफाइट CTCRI EB12 के बायोकैप्सूल फॉर्मूलेशन ने, अनुपचारित नियंत्रण की तुलना में मिट्टी और कंद उपचार (क्रमशः 100 लीटर पानी और गोबर के घोल में एक कैप्सूल) के संयोजन के साथ महत्वपूर्ण कमी (21%) का प्रदर्शन किया।

42. संपूर्ण जीनोम अनुक्रम से पता चलता है कि CTCRI EB12 बैसिलस सबटिलिस है। इस पृथक में कई एंजाइमों को एनकोड करने वाले जीन होते हैं, जो फंगल कोशिका भित्तियों के हाइड्रोलिसिस में शामिल होते हैं, जो जीव के एंटीफंगल गुणों में योगदान करते हैं। इसके अलावा, उनमें पोषक तत्वों के चयापचय से संबंधित जीन भी होते हैं जो पौधों की वृद्धि को बढ़ाते हैं।

43. एंडोफाइट बैसिलस सबटिलिस को pEGFP प्लास्मिड के साथ रूपांतरित किया गया, जिसके परिणामस्वरूप एक GFP-टैग की उत्पत्ति हुई, जिसे CTCRI EB12T के रूप में नामित किया गया। ट्रांसफॉर्मेंट ने सी. ग्लोओस्पोरियोइड्स के खिलाफ अपनी विरोधी गतिविधि (82.6%) को बनाए रखा, जो दर्शाता है कि परिवर्तन ने इसके जैविक कार्यों से समझौता नहीं किया। जड़ उपनिवेशण के बाद, बैक्टीरिया मुख्य रूप से तने, डंठल और पत्ती में देखा गया।

44. मॉडल प्लांट निकोटियाना बेंथमियाना का रूपांतरण और CMD अतिसंवेदनशील कसावा किस्म H226 के भुरभुरे भ्रूणजन्य कैली (FEC) का कृषि संक्रमण, श्रीलंकाई कसावा मोजेक वायरस (SLCMV) के रेप क्षेत्र को लक्षित करने वाले CRISPR/Cas9

सिंगल और साथ ही मल्टीप्लेक्स एडिटिंग कैसेट को आश्रय देने वाले पुनः संयोजक एग्रोबैक्टीरियम क्लोन के साथ किया गया। SLCMV के CP और IR क्षेत्रों को लक्षित करने वाले sgRNA ओलिगोस को शटल वैक्टर में क्लोन किया गया और संबंधित sgRNA ट्रांसक्रिप्शन इकाइयों को गेटवे क्लोनिंग के माध्यम से बाइनरी वेक्टर pDGE2 में इकट्ठा किया गया।

45. एन. बेंथमियाना पत्ती डिस्क रूपांतरण एग्रोबैक्टीरियम स्ट्रेन EHA105 के साथ किया गया था, जिसमें pDGE62 में एकल gRNA Tu (IR), दो (IR और C1C4), चार (IR, C1, V1V2, C1C4) और pDGE1 में आठ gRNA Tus (c1c4, cr2, viv2, c2c3, c1c41, cr1, c1, v1) मौजूद थे। जड़ वाले पौधों की पुष्टि nptII प्राइमरों से की गई और उन्हें ग्रोथ चैंबर में रखा गया।

46. कुल 18 एंडोफाइटिक सूक्ष्मजीव प्राप्त किए गए, जिनमें ग्रेटर यम और शकरकंद के विभिन्न पौधों के भागों से छह बैक्टीरिया और बारह कवक शामिल थे। कवक एंडोफाइट्स ट्राइकोडर्मा, सेफलोस्पोरियम, फ्यूजेरियम और कर्वुलरिया प्रजाति के हैं और बैक्टीरिया बैसिलस और स्यूडोमोनास प्रजाति के हैं। पुष्प ऊतकों ने महत्वपूर्ण एंडोफाइटिक विविधता प्रदर्शित की, जो यह दर्शाता है कि विभिन्न पौधों के भागों में उनके विशिष्ट सूक्ष्म वातावरण के अनुकूल अद्वितीय सूक्ष्मजीव समुदाय होते हैं।

47. तीन एंडोफाइट्स, ट्राइकोडर्मा, सेफलोस्पोरियम और बैसिलस ने शकरकंद में बेल की लंबाई, जड़ की लंबाई और पोषक तत्वों के अवशोषण को बढ़ाया, विशेष रूप से नाइट्रोजन (294.05 से 335.96 किलोग्राम प्रति हेक्टेयर) और पोटेशियम (28.95 से 35.5 किलोग्राम प्रति हेक्टेयर) जैसे आवश्यक पोषक तत्वों का अवशोषण। कैल्शियम (Ca) और मैग्नीशियम (Mg) जैसे द्वितीयक पोषक तत्व भी कुशलतापूर्वक अवशोषित किए गए। संभावित जीवाणु एंडोफाइट की पहचान ऑटोमेटेड माइक्रोबियल आइडेंटिफिकेशन (AMI) सिस्टम (BIOMERIEUX कंपनी, मॉडल: VITEK2 कॉम्पैक्ट) का उपयोग करके बैसिलस सेरेस के रूप में की गई। AMI प्रणाली इन जीवाणु अंतःउद्भिद की जैविक विशेषताओं की पहचान करने और उन्हें स्पष्ट करने के लिए एक प्रभावी उपकरण साबित हुई।

48. उष्णकटिबंधीय कंद फसलों से प्राप्त सात कंदों के छिलकों में से, कसावा और शकरकंद के कंद के छिलके के अवशेषों को ट्राइकोडर्मा इनोकुलेंट उत्पादन के लिए सबसे प्रभावी माध्यम के रूप में पहचाना गया, जिसमें शकरकंद ने 90 दिनों में 4.7×10^8 CFU/g की उच्चतम बीजाणु व्यवहार्यता प्राप्त की। कसावा और बड़े रतालू ने मध्यम से उच्च प्रारंभिक CFU गणना का प्रदर्शन किया, लेकिन दो महीने बाद व्यवहार्यता कम हो गई।

49. उत्पादन प्रक्रिया की स्थितियों को कसावा स्टेम आधारित कण बोर्डों के लिए अनुकूलित किया गया था, अर्थात, रेजिन के रूप में यूरिया फॉर्मेल्डिहाइड का उपयोग करके कसावा स्टेम (130°C, 36.43 bar, 40% resin), गर्म पानी में ब्लांच किया हुआ कसावा स्टेम (116°C, 55 bar, 85.19°C and 90 min blanching) और कसावा स्टेम-कॉयर पिथ कम्पोजिट (110°C, 35 bar, 34.13% coir pith, 40% resin)।

50. ताजे कसावा के छिलकों (249-1714 ppm) में साइनाइड की मात्रा धूप में सुखाने के बाद 23.92-66.20% (142-1294 ppm तक) कम हो गई, कसावा की किस्मों में भिन्नता के साथ। एक अन्य प्रयोग में, श्री रक्षा के छिलकों के साथ, गर्म पानी में ब्लांच करने (50-100°C, 5-20 min) से 80°C तक साइनाइड में उल्लेखनीय कमी आई, जिसकी दर समय पर निर्भर करती है।

51. आशाजनक शकरकंद किस्मों अर्थात श्री अरुण, श्री वरुण, श्री भद्रा, भू कृष्णा और भू सोना की बेलों की जैव रासायनिक गुणवत्ता, एंटीऑक्सीडेंट गतिविधि और सूक्ष्म पोषक तत्व सामग्री में परिवर्तनशीलता से पता चला है कि नमी (86.77 से 79.13), स्टार्च (37.50 से 22.50), वसा (1.82 से 0.77), सेल्यूलोज (24.40 से 9.12), हेमीसेल्यूलोज, (37.20 से 26.55), लिग्निन (17.08 से 4.20), शर्करा (13.39 और 8.4), प्रोटीन (10.06 से 4.37) और एंटीऑक्सीडेंट गतिविधि (80.08 से 64.11) और मैग्नीशियम (145.91 से 121.83 पीपीएम) की प्रतिशत सामग्री किस्मों के बीच काफी भिन्न थी।

52. दो संशोधित कसावा स्टार्च, कसावा डिस्टार्च फॉस्फेट और अमोनियम कसावा स्टार्च फॉस्फेट कार्बामेट की आर्थिक व्यवहार्यता और कार्यात्मक गुणों ने क्रमशः ₹375/किग्रा और ₹350/किग्रा की बिक्री लागत का खुलासा किया, जिसमें लाभ-लागत अनुपात 1.397 और 1.433 था। कसावा डैस्टार्च फॉस्फेट खाद्य गाढ़ा करने के लिए उपयुक्त है, जबकि अमोनियम कसावा स्टार्च फॉस्फेट कार्बामेट ने जल उपचार में डाई हटाने की क्षमता दिखाई।

53. सक्सिनिलेटेड कसावा डैस्टार्च फॉस्फेट को संश्लेषित किया गया, जिसमें देशी कसावा स्टार्च (77.1%) की तुलना में बेहतर भौतिक रासायनिक गुण और पायसीकारी क्षमताएँ प्रदर्शित की गईं, साथ ही इसमें जल बंधन क्षमता (131-201%) भी काफी अधिक थी। संशोधित स्टार्च के लिए सूजन शक्ति और पेस्ट चिपचिपापन भी अधिक था। संशोधित स्टार्च के साथ तैयार मेयोनेज़ में वाणिज्यिक मेयोनेज़ (वसा-3 ग्राम 100 ग्राम-1, चीनी-5.22 ग्राम 100 ग्राम-1) की तुलना में कम वसा (5.2 ग्राम 100 ग्राम-1) और चीनी (3.7 ग्राम 100 ग्राम-1) की मात्रा होती है। इसने सफलतापूर्वक अंडा रहित मेयोनेज़ का मार्ग प्रशस्त किया, वसा और चीनी की मात्रा को कम किया, जिससे यह कम वसा, कम कैलोरी वाले खाद्य उत्पादों के लिए एक आशाजनक घटक बन गया।

54. एक नया छिद्रयुक्त कसावा स्टार्च संश्लेषित किया गया, जिसमें छिद्रता (50-82.1%) और तेल अवशोषण क्षमता (210.1% तक) में वृद्धि देखी गई, जबकि सूजन शक्ति और घुलनशीलता में कमी आई। इस संशोधित स्टार्च में खाद्य और सौंदर्य प्रसाधनों में संभावित अनुप्रयोग हैं।

55. प्राकृतिक रंगों (एंथोसायनिन और कुर्क्यूमिन) से युक्त पीएच-सेंसिंग कसावा स्टार्च फिल्मों का उपयोग करके एक नया खाद्य खराब होने का

पता लगाने वाला सिस्टम विकसित किया गया। pH में उतार-चढ़ाव के जवाब में फिल्मों ने रंग में स्पष्ट परिवर्तन प्रदर्शित किया, जो पैकेज्ड खाद्य पदार्थों में खराबी का संकेत देता है। कुर्क्यूमिन-आधारित फिल्मों के लिए, भंडारण समय बढ़ने के साथ पीला रंग क्रमिक रूप से एम्बर नारंगी, कीनू और अंत में लाल रंग में बदल गया। एंथोसायनिन-आधारित फिल्मों ने बैंगनी से नीले और अंततः गहरे जैतून के रंग में रंग परिवर्तन प्रदर्शित किया, जो पैक किए गए भोजन के खराब होने के अनुरूप था। परीक्षण की गई फिल्मों में, PVA की कम सांद्रता के साथ मिश्रित कसावा स्टार्च से बनी फिल्मों ने बेहतर प्रदर्शन किया, जिनमें नमी का अवशोषण कम हुआ और यांत्रिक अखंडता में वृद्धि हुई।

56. व्यावसायिक ग्रेडिंग के उद्देश्य से शकरकंद कंदों के व्यास और लंबाई पर ध्यान केंद्रित करते हुए मशीन विज़न आधारित शकरकंद ग्रेडर विकसित किया गया है, जिसकी क्षमता प्रति घंटे 500 किलोग्राम शकरकंद कंद की ग्रेडिंग करने की है। इससे ग्रेडिंग की सटीकता बढ़ती है और श्रम लागत (4 गुना) कम होती है।

57. गुणवत्ता वाले कसावा सेट बनाने के लिए एक पोर्टेबल स्व-चालित कसावा सेट कटर डिजाइन और विकसित किया गया था, जिसमें 98% काटने की दक्षता, प्रति घंटे 500 सेट की क्षमता और केवल 0.45% क्षतिग्रस्त सेट हैं। यह 85% श्रम और 90% उत्पादन लागत बचाता है। मैनुअल कटिंग के लिए 4000 रुपये की तुलना में उत्पादन लागत 400 रुपये प्रति हेक्टेयर है। ईंधन की खपत 0.6 लीटर प्रति घंटा है।

58. चीनी आलू और तारो के नरम छिलके वाले कंदों से छिलका हटाने में सहायता के लिए एक बहुउद्देशीय अपघर्षक प्रकार का छिलका हटाने वाला यंत्र डिजाइन और निर्मित किया गया है। विकसित मशीन 2 HP इलेक्ट्रिक मोटर द्वारा संचालित है, जिसे इष्टतम घूर्णन गति प्राप्त करने के लिए स्पर गियर तंत्र से जोड़ा गया है।

59. बैंगनी और नारंगी मांस वाले शकरकंदों से प्रोबायोटिक युक्त फ्रोजन मिठाई विकसित की गई, जिसमें एंथोसायनिन (30.45 mg 100 g-1) और बीटा-कैरोटीन (12.41 mg 100 g-1) का उच्च स्तर बरकरार रखा गया, साथ ही प्रोटीन (6.56% और 4.62%) और फाइबर (0.69% और 0.47%) की महत्वपूर्ण मात्रा भी थी। बैंगनी और नारंगी शकरकंद की मिठाइयों के लिए व्यवहार्य माइक्रोबियल गणना क्रमशः 5.45-7.22 log CFU ml-1और 4.52-5.87 log CFU ml-1 के बीच थी। यह अध्ययन बेहतर पोषण और स्वास्थ्य लाभ के साथ कार्यात्मक खाद्य पदार्थ विकसित करने के लिए एक प्रभावी कटाई के बाद की प्रसंस्करण रणनीति को प्रदर्शित करता है।

60. नारंगी और बैंगनी रंग के मीठे आलू के प्यूरी कॉन्संट्रेट (OSPC और PSPC) को मिलाकर गमी कन्फेक्शन विकसित किए गए, जो बीटा-कैरोटीन और एंथोसायनिन से भरपूर हैं। पेक्टिन-आधारित गमियों में जिलेटिन-आधारित गमियों की तुलना में एंथोसायनिन (4.05 mg g-1) और बीटा-कैरोटीन (3.28 mg g-1) की मात्रा अधिक पाई गई। गमियों में एंटीऑक्सीडेंट गतिविधि देखी गई, जिसमें PSPC युक्त नमूनों में उच्च क्षमता दिखाई दी। संवेदी मूल्यांकन में पेक्टिन गमियों को रंग के लिए प्राथमिकता दी गई, जबकि जिलेटिन गमियों को बनावट के लिए और PSPC-युक्त गमियों को स्वाद के लिए प्राथमिकता दी गई।

61. केरल और तमिलनाडु में किए गए 66 प्रदर्शनों से पता चला कि श्री अतुल्या की उपज 39.68 टन प्रति हेक्टेयर थी, जबकि स्थानीय किस्मों की उपज 36.05 टन प्रति हेक्टेयर थी। नामक्कल जिले में, श्री रक्षा की उपज 40.21 टन प्रति हेक्टेयर थी, जबकि स्थानीय किस्मों की उपज 37.46 टन प्रति हेक्टेयर थी। श्री कावेरी की उपज 30.12 टन प्रति हेक्टेयर थी, जबकि स्थानीय किस्म की उपज 28.14 टन प्रति हेक्टेयर थी। गजेंद्र के SSNM उपचारित भूखंड की उपज 29.37 टन प्रति हेक्टेयर थी, जबकि इरोड जिले में किसान अभ्यास से उपज 26.35 टन प्रति हेक्टेयर थी।

62. केरल के अट्टपाडी में 0.16 हेक्टेयर में किए गए तीन FLDs से पता चला कि भू कांति ने भू सोना (19.03 टन प्रति हेक्टेयर) और भू जा (6.67 टन प्रति हेक्टेयर) की तुलना में अधिक उपज (20.27 टन प्रति हेक्टेयर) दर्ज की। मेघालय के वेस्ट गारो हिल्स में 0.16 हेक्टेयर में किए गए तीन FLDs से पता चला कि भू सोना (15.42 टन प्रति हेक्टेयर) ने भू कृष्णा (11.10 टन प्रति हेक्टेयर) और श्री कनका (9.57 टन प्रति हेक्टेयर) की तुलना में अधिक उपज दी।

63. मेघालय में कसावा की खेती में शामिल पुरुषों का समग्र सशक्तिकरण सूचकांक 0.708 था जबकि महिलाओं के लिए यह 0.709 था।

64. ई-फसल आधारित स्मार्ट खेती (eCBSF) का प्रदर्शन करने के लिए ई-फसल की सिफारिशों के अनुसार ऑटो फर्टिगेशन के लिए तिरुवनंतपुरम, केरल में दो डिजिटल फार्म स्थापित किए गए।

65. एग्रीएनालिटिक्स@R के लिए सांख्यिकीय पैकेज को AMMI विश्लेषण और R में मेटान पैकेज का उपयोग करके प्लॉट शामिल करके अपडेट किया गया था। इंटरेक्शन और औसत तुलना के साथ फैक्टोरियल प्रयोगों के लिए दो कारक ANOVA शामिल किए गए।

66. आदिवासी उपयोजना (TSP) के तहत ओडिशा के गजपति (200), कोरापुट (120) और कंधमाल (37), पश्चिम बंगाल के पुरुलिया (24) और आंध्र प्रदेश के मान्यम (4) जिलों के 385 आदिवासी किसानों को सहायता दी गई। 10,000 किलोग्राम ग्रेटर याम और एलीफैंट फुट याम, 2,400 किलोग्राम कोलोकेशिया, 12 लाख शकरकंद की बेल की कटिंग, 20,000 कसावा के तने, 85 किलोग्राम याम बीन और 150 किलोग्राम फ्रेंच बीन सहित गुणवत्ता वाली रोपण सामग्री वितरित की गई, जिससे टिकाऊ फसल उत्पादन सुनिश्चित हुआ। किसानों को उन्नत खेती तकनीकों से लैस करने के लिए आठ प्रशिक्षण कार्यक्रम आयोजित किए गए।

67. SCSP कार्यक्रम के तहत केरल और तमिलनाडु में SC लाभार्थियों के लिए 12 प्रशिक्षण कार्यक्रम आयोजित किए गए, जिससे 821 किसान लाभान्वित हुए। केरल और तमिलनाडु के तीन ब्लॉकों से बीपीएल श्रेणी से एक सौ अनुसूचित जाति लाभार्थियों का चयन किया गया, नामतः पत्तनमत्तिट्टा जिले के परक्कोड, केरल के त्रिशूर जिले के ओल्लुक्करा ब्लॉक और तमिलनाडु के सेलम जिले के गंगावल्ली ब्लॉक और कंद फसल प्रौद्योगिकियों का क्षेत्र प्रदर्शन किया गया।

68. KVK के सहयोग से NEH कार्यक्रम के अंतर्गत, उन्नत कंद फसल किस्मों और मूल्य संवर्धन को बढ़ावा देने के लिए मेघालया में प्रशिक्षण कार्यक्रम आयोजित किए गए। इन कार्यक्रमों के दौरान, किसानों को उन्नत कसावा की रोपण सामग्री प्राप्त हुई, जिसमें श्री जया, श्री विजया, श्री पवित्रा, श्री रक्षा और शकरकंद की किस्में श्री अरुण, श्री कनका, भू सोना और भू कृष्णा शामिल हैं। प्रशिक्षण सामग्री, मूल्यवर्धित उत्पाद और कृषि उपकरण भी वितरित किए गए।

69. दो पेटेंट, (i) स्मार्ट खेती के लिए ई-क्रॉप IoT डिवाइस और (ii) बिजली से चलने वाला आकार आधारित चीनी आलू ग्रेडर और उसकी ग्रेडिंग की एक विधि प्रदान की गई। तीन पेटेंट दायर किए गए, (i) कृषि उत्पाद को छीलने के लिए एक उपकरण, (ii) फसलों के स्वचालित उर्वरीकरण के लिए एक प्रणाली और विधि और (iii) शकरकंद के लिए हाइड्रोपोनिक पोषक तत्व निर्माण।तीन कॉपीराइट – (i) SIMCAS- कसावा का एक विकास सिमुलेशन मॉडल, (ii) MADHURAM- शकरकंद के लिए एक विकास सिमुलेशन मॉडल, और (iii) SPOTCOMS- शकरकंद के लिए एक विकास सिमुलेशन मॉडल भी दायर किए गए।

70. दो प्रौद्योगिकियों को लाइसेंस दिया गया (i) ई-क्रॉप - स्मार्ट खेती के लिए एक IoT डिवाइस और (ii) जिमीकंद फ्लेक्स। आईसीएआर द्वारा आठ प्रौद्योगिकियों को प्रमाणित किया गया। 2024 में ICAR-CTCRI ABI में छह इनक्यूबेट नामांकित किए गए, जिसमें खाद्य प्रसंस्करण और कृषि इनपुट विपणन शामिल हैं। तीन नए उपग्रह ऊष्मायन केंद्र (i) KAU - क्षेत्रीय कृषि अनुसंधान केंद्र, केरल कृषि विश्वविद्यालय (KAU), पट्टाम्बि, पालक्काड़, केरल जनजातीय उद्यमिता के लिए (ii) बागवानी और वानिकी कॉलेज, केंद्रीय कृषि विश्वविद्यालय (इम्फाल), पासीघाट, अरुणाचल प्रदेश पारंपरिक ज्ञान और किसान नवाचारों के संरक्षण और व्यावसायीकरण के लिए और (iii) असम विश्वविद्यालय, सिलचर, असम स्वदेशी और स्थानीय सामुदायिक उद्यमिता के लिए स्थापित किए गए थे।

71. आईसीएआर-सीटीसीआरआई डॉक्टरेट कार्यक्रमों के लिए एक स्वीकृत अनुसंधान केंद्र है, जिसने बीएससी/बीटेक छात्रों के लिए इंटर्नशिप प्रशिक्षण प्रदान किया, एमएससी परियोजना कार्य में छात्रों का मार्गदर्शन किया (40), और पीएचडी विद्वानों (28) को सलाह दी। संस्थान ने किसानों (579), छात्रों (2756) और अधिकारियों (245) को प्रशिक्षित किया, 14 प्रदर्शनियों में भाग लिया, और FLDs/OFTs को भरने के लिए आयोजित किया गया।

72. देश के विभिन्न भागों से कुल 579 किसानों, 2756 छात्रों और 45 अधिकारियों ने संस्थान का दौरा किया।

73. संस्थान द्वारा कुल 324 प्रकाशनों में योगदान दिया गया, जिनमें शोध पत्र: 78; संगोष्ठियाँ: 42; पुस्तकें: 4; पुस्तक अध्याय: 16; तकनीकी बुलेटिन: 2; तकनीकी फ़ोल्डर/पत्रक/पर्चे: 23; लोकप्रिय लेख: 43; पाठ्यक्रम/प्रशिक्षण मैनुअल/सारांश की पुस्तक/कार्यवाही: 8; पाठ्यक्रम/प्रशिक्षण मैनुअलमें अध्याय और कार्यवाही:36; ई-प्रकाशन: 23; संस्थान प्रकाशन: 25; रेडियो वार्ता: 13; टीवी कार्यक्रम: 11.

Executive Summary

The research achievements and outputs of the Institute presented here encapsulate the work done under 46 in-house projects 3 developmental and 27 externally aided projects which contributed to technological advancements, field adoption, and technology transfer. These research efforts resulted in developing improved varieties, advanced crop production, and protection technologies to enhance productivity, sustainability, disease resistance, and economic viability. The key outcomes of these research activities, innovations, and outreach initiatives are summarized below:

1. A total of 5234 accessions, comprising 1216 cassava, 905 sweet potato, 801 yams, 655 edible aroids and 387 minor tuber crops from Head Quarters (HQ) and 1270 accessions from Regional Station comprising 113 cassava, 380 sweet potato, 51 yams, 554 edible aroids and 172 minor tuber crops are maintained in the field gene bank with 275 new collections during this period. Under *in vitro* active genebank (IVAG), 104 accessions comprising 45 cassava, 10 sweet potato, 32 yams, 5 taro, 9 *Curcuma* and 3 arrowroot accessions at HQ and at Regional Station, 36 accessions comprising cassava (10), sweet potato (11), taro (5), yam (4), elephant foot yam (2), and Chinese potato (4) are maintained.

2. In cassava, two nutrient use efficient varieties, Sree Annam and Sree Manna were released for the State of Kerala by the State Variety Release Committee, for Kerala. Apart from these, many accessions were identified with important traits viz., nine short statured accessions with plant height < 180 cm (CE-8, CE-9, CE-15, CE-76, CE-122, CE-175, CE-182, CE-192, CE-231); five with sweet taste and high tuber weight (CE-38, CE-71, CE-140, CE-198, CE-219), five with high starch >75% (CE-28B, CE-23, CE-31, CE-18 and CE-16A), 25 CMD resistant lines, four early bulking genotypes (15S-41, 17S-48, 6-4 and 17S-247) bulking as early as 3 months after planting (MAP), three β-carotene rich yellow fleshed cassava lines (CE-174, CE-348 and CE-430), 2 genotypes suitable for fried chips (CRNR-1 and II-3), 20 high yielding (4-6 kg plant^{-1}), CMD resistant clones, with high starch content, two cassava genotypes (KBH-18 and 15S-247) tolerant to PPD (5 days) and CI-26 as highly tolerant with a shelf life ranging from 30-40 days.

3. In sweet potato, many accessions were identified with traits of importance viz., four moderately weevil resistant accessions (S-1668, S-27, S-1470 and S-1456), eight accessions suitable for fried chips making with a dry matter content of >20% and other physical traits (S-27, S-1470, S-1653, S-1403, S-1401, S-1456, S-1668 and S-1712), biofortified lines for nutritional traits, viz., highest P and K content 0.628% (CO3-50-33) and 1.21% (S-19) respectively, the highest Fe and Mn content, 221.8 ppm (CO3-50-33) and 284.1ppm (KS-2), respectively, highest amount of vitamin C, 29.94 mg 100g^{-1} (KS-12) and protein content, 2.74g 100g^{-1} (KS-2). Lower the IC_{50} value higher is the antioxidant activity and the lowest IC_{50} value was with 14.14 µg ml^{-1} (KS-12). Additionally, five early bulking (80 days) biofortified hybrids (H-580/108, H-43/83, H-678/36, H-447/1 and H-575/10), two white fleshed high yielding hybrids (H-526/7 and S-1401), six high yielding biofortified hybrids low in starch for salad purpose (H-447/1, H-39/9, H-43/126, H-514/1, H-50/14 and H-50/26), four high yielding biofortified hybrids >25 t ha^{-1} (H-38/15, H-38/46,H-43/83 and H-110/28), eight nutritionally rich lines (KS-22, CP-108-14, KS-12, KS-27, SP-9, SP-20, SP-1 and SP-11), a promising genotype with early maturity (75-80 days), orange

flesh (β-carotene content of 8.50 mg $100g^{-1}$), uniform tuber shape, average tuber yield (19 t ha^{-1}) with good cooking quality (SP-95/4), five drought tolerant genotypes (DB/21/57, RS-III, B×7, SP-123 and S-162) and five high-yielding, early-maturing (90-100 days) genotypes (SP-19, SP-5, SP-18, SP-27, SP-1 and SP-29) were identified.

4. One white yam variety, Sree Dhrona was released by the State Variety Release Committee (SVRC) for the state of Kerala. It is a semi dwarf, non-trailing variety with high yield of 35 - 45 t ha^{-1} (52.0 t ha^{-1} potential yield) having 8-9 months duration, with medium cylindrical smooth tubers with good cooking quality and compact tuber shape. In greater yam, 28 highly resistant and 23 tolerant accessions to anthracnose were identified; in lesser yam, five accessions were negative to *Yam mild mosaic virus* (De-24, De-28, De-34, De-42 and De-58).

5. In taro, many accessions were identified with important traits viz., 10 high yielders (>10 t ha^{-1} cormel yield); one accession with good shelf life after 40 days (IC204205), three low acrid ones (ADG/2022-1, TTr22-6 and TTr22-5), one with high yield and high zinc (CE-558) and another one with high yield and high iron (CE-334357). In elephant foot yam, two root knot nematode resistant lines (TEy22-1 and TEy22-6), five non-acrid hybrids (H-102-2015, H-107-2015, H-843/2/2-2017, H-6-7-2017 and H-6-34-2017), two high yielders (1-1.5 kg $plant^{-1}$) (H-6-7-2017 and H-6-34-2017) and one early maturing hybrid (AmH-22-99) were identified. In tannia, two high yielders (total yield >14 t ha^{-1}) (Xa-63 and Xa-AD/2014-18) were identified. Eight biofortified taro accessions were identified for biochemical traits (CL-56, NEH-44, NEH-14, Megh-19, Ciruli local, Pipply, CE-12 and Megh-18).

6. In arrowroot, two varieties were released by the Central Varietal Release Committee (CVRC) and one variety by the State Variety Release Committee (SVRC) for Kerala for the first time in India. Sree Nakshatra (Chhattisgarh and Jharkhand) has a yield of 32.25 t ha^{-1} and starch yield of 8.59 t ha^{-1} while Sree Karti (Kerala, Tamil Nadu and Manipur) has a yield of 23.57 t ha^{-1} and starch yield of 5.07 t ha^{-1}. Sree Aadya (Kerala) has a yield of 30.04 t ha^{-1} and starch yield of 5.95 t ha^{-1}.

7. In Chinese potato, a local variety known as *Kulaparachal* was a high yielder (35.4 t ha^{-1}). For inducing variability, gamma irradiation at 55 Gy resulted in early flowering with functional female reproductive organ having potential for true seed set and tuber formation. *In vitro* shoot multiplication was observed in MS media fortified with 1 mg l^{-1} BAP in explant treated with 35 Gy and control, whereas, callus induction and regeneration were observed in leaf explant irradiated at 15 and 20 Gy. In East Indian arrowroot, CTCRI-CA-PM-1 was identified as the best performer with long primary rhizome (21.25 cm), high starch content (16.8%), substantial rhizome yield (39.4 t ha^{-1}), and excellent dry recovery (19.15%). In yam bean, lines identified with important traits were four biofortified lines (DPH-6, L.No.3, L.No.19 and DPH-10) and five nutritionally rich lines (DPH-10, RM-1, YBBL-20, DPH-20 and IC002514). The breeder seed standards for yam bean were established.

8. Under bioprospecting studies, extracts of purple taro (IC652061) (ADSR) and *Xanthosoma violaceum* (Xa-AAV/2022-11) (VIOL) were effective in its antiangiogenic effect as well as wound migration effect with best results shown by ADSR at 120 µg ml^{-1} dose. Both also showed antibacterial effects at 1 mg with VIOL acting against *Klebsiella pneumonia* and *Vibrio cholera* whereas, ADSR against *Bacillus subtilis* and *Streptococcus pyogenes*.

9. For developing waxy cassava with no amylose, a gene editing construct that targets *gbss* gene and another targeting, *SBEI* and *SBEIIb* were developed, assembled on to PHSE401 vector and confirmed through sequencing and transformed on to friable embryogenic calli of cassava variety H-226.

10. In cassava CMD mapping population, transcriptome studies yielded 12 functional markers linked to key genes correlated to biotic stimulus and defense response. Genome-wide mining for microsatellite repeats identified 17,671 genic and 28,231 non-genic markers spanning all 18 chromosomes. Four markers viz., MeESSR34, MeESSR39, SSRY28 and SSRY45 displayed polymorphism among 32 cassava genotypes. In sweet potato, three genes *Pyrroline-5-carboxylate reductase* (*IbP5CR*), *DREB transcription factor* (*IbCBF3*), *and ARF transcription factor* (*IbARF5*) showed enhanced expression in drought-tolerant variety. Five SSR markers viz., Ib182, Ib2082, Ib244, Ib1845 and

Ib346 displayed high polymorphism among 20 sweet potato genotypes. *In silico* studies showed that the absence of tuber-specific or vacuolar targeting or N terminal signal sequences in cassava proteins is responsible for the low protein content in tubers. In sweet potato, for DNA barcoding, *MatK* was identified as highly efficient in amplification and sequencing and the *ITS4* gene as a potent DNA barcode candidate in secondary structure predictions.

11. In organic farming, cassava-based intercropping system with vegetables, 100% organic achieved the highest cassava (48.53 t ha^{-1}), chilli (2.88 t ha^{-1}), tomato (3.17 t ha^{-1}) yields, and tuber equivalent yield (TEY, 54.73 t ha^{-1}). The 75% organic + innovative practices maximized cluster bean yield (2.36 t ha^{-1}). Cassava + chilli (58.61 t ha^{-1}) and cassava + cluster bean (58.30 t ha^{-1}) combinations showed strong productivity potential.

12. The organic, inorganic, and integrated management practices in tuber crop systems showed the highest cassava yield (35.94 t ha^{-1}) under the package of practices (POP) which was followed by 50% organic + 50% inorganic (34.86 t ha^{-1}). The net return and B:C ratios were highest under POP, followed by 100% inorganic and 100% organic (with premium price). In taro, the highest cormel yield (7.75 t ha^{-1}), net income, and B:C ratio (with and without premium price) were recorded under 100% organic management. Among yam varieties, Orissa Elite (13.82 t ha^{-1}) and Sree Nidhi (11.84 t ha^{-1}) performed best in organic farming. The IOFS model achieved a tuber equivalent yield of 40.34 t ha^{-1} from the tuber crop-based farming.

13. Natural farming (NF) in cassava + vegetable cowpea + green gram revealed that integrated crop management (ICM) practices produced significantly higher cassava yields (101.29 t ha^{-1}) and returns followed by complete NF. The highest tuber equivalent yield (105.19 t ha^{-1}) and production efficiency were also recorded under ICM practices. A geo-referenced survey in Kerala revealed widespread adoption of natural farming.

14. The treatment with pre-emergence herbicide pendimethalin (1 DAP) followed by post-emergence clodinofop (45 DAP) significantly reduced weed population, dry weight, and intensity, achieving over 87% weed control efficiency at 60 and 90 DAP. Additionally, growth and yield of sweet potato also improved, with vine length reaching 1.64 m, secondary branches 6.60, with a yield of 25.57 t ha^{-1}. Dominant weeds included *Setaria glauca*, *Mimosa pudica*, *Alternanthera paronychioides*, *Cyanotis axillaris*, *Cleome viscosa* and *Cyperus rotundus.*

15. Drip irrigation with 50% CPE and porous ground cover mulching achieved the highest tuber yield (51.2 t ha^{-1}) and statistically on par with Pusa hydrogel + mulching and 100% CPE treatments in cassava. This approach improved yield by 10.1% while saving 50% irrigation water. Water-saving treatments (porous ground cover mulching, biomulching, coir pith, foliar antitranspirant, Pusa hydrogel, organic gel Sujalam, Pusa hydrogel + ground cover mulching) increased yields by 1–24.9% compared to 50% CPE control and performed on par with furrow irrigation despite using three times less water.

16. In greater yam, optimal combination of 60 splits with a 3-day interval maximized productivity and profitability, achieving significantly higher tuber yield of 40.4 t ha^{-1}, gross returns of ₹ 605,500 ha^{-1}, net returns of ₹ 396,600 ha^{-1}, and a B:C ratio of 2.90.

17. In Chinese potato, drip irrigation at 125% CPE produced significantly higher tuber yield (27 t ha^{-1}), while sprinkler and furrow irrigation yielded 46.6% and 25.6% less, respectively.

18. In elephant foot yam, fertilizer doses and schedules did not significantly impact corm yields. The highest yield (50.5 t ha^{-1}) was with the lowest nutrient dose (75-50-100 kg ha^{-1} N, P_2O_5 and K_2O) applied in stages: 50% before 90 DAP, 25% during 90–120 DAP, and 25% during 120–180 DAP.

19. The effect of inorganic nutrients, FYM, and biofertilizers (*Azospirillum* and PSB) in the greater yam + maize system in an Alfisol, achieved 88.2% increase in tuber yield with FYM + 40-30-40 kg ha^{-1} N, P_2O_5 and K_2O. The best nutrient use efficiency (NUE: 293 kg tubers/kg N, PUE: 390 kg tubers/kg P) was observed with *Azospirillum* + PSB + 40-30 kg ha^{-1} N- P_2O_5. FYM + 50% NPK improved soil enzyme activities and organic carbon, showing a strong positive correlation with yield. Integrated use of FYM, biofertilizers, and 50% NPK enhanced

soil biological and chemical properties improving yield and sustainability of the greater yam system.

20. In nitrogen use efficiency study including graded N levels, FYM and biofertilizers, the variety Sree Bhadra achieved significantly highest tuber yield (14.04 t ha^{-1}). Regarding treatments, FYM + 50 kg N ha^{-1} produced significantly highest tuber yield (15.32 t ha^{-1}) with an increase of 67.5 % yield over control. Additionally, Sree Bhadra had significantly highest starch content (17.74%), whereas Kishan had highest dry matter (25.56%) and total sugars (2.95%) compared to other varieties. Integrated nutrient management improved soil organic carbon (0.602%), available NPK, and enzyme activities, enhancing tuber yield, quality, and soil health for sustainable production.

21. The application of customized fertilizers (CF) and low input management practices (LIMP) achieved the highest sustainable yield index (SYI). The tuber yield was significantly highest under NPK use efficient genotype 7 III E3-5 and soil and foliar application of calcium (40 t ha^{-1}). Green manuring with cowpea (34.1 t ha^{-1}) and soil test-based NPK (32.5 t ha^{-1}) also performed well. Low input management reduced soil bulk density (1.34 Mg m^{-3}) and improved water holding capacity (39.92%), comparable to soil test based fertilizer NPK (STBFNPK) + crop residue (41.07%) and other nutrient management practices.

22. Soil application of 100% nitrogen (N) through ordinary urea combined with 50% N as nano urea via foliar spray significantly increased cassava tuber yield by 52%, reaching 54 t ha^{-1}. Nano urea also slightly improved chlorophyll levels, soil N availability, plant nutrient uptake, and reduced tuber cyanogens and tuber potassium (K). Application of 50 kg P_2O_5 ha^{-1} as per the package of practices (PoP) was as effective as nano DAP applied through sett treatment and foliar spray.

23. Drought stress in cassava significantly reduced photosynthesis, stomatal conductance, and transpiration ($P < 0.01$), while leaf respiration was also affected ($P = 0.01$). Genotypic variation influenced stomatal conductance ($P < 0.01$) but not photosynthesis, respiration, or transpiration. Chlorophyll fluorescence parameters remained mostly stable, except for a significant increase in NPQ ($P = 0.03$), indicating enhanced heat dissipation. PhiPS2 showed marginal significance ($P = 0.05$), reflecting genotype-specific PSII responses.

24. Drought stress had minimal impact on leaf area index (LAI), but Sree Kanaka maintained a higher LAI (4.1 ± 0.19), while Kanjangad declined (2.6 ± 0.16). Osmolyte accumulation increased (-1200 ± 100 mmol kg^{-1}) in drought-tolerant genotypes. Photosynthesis (Pn), stomatal conductance, and CO_2 concentration declined ($P < 0.01$), while respiration remained stable, but PSII efficiency (Fv/Fm) decreased. Water use efficiency dropped due to lower transpiration ($P < 0.01$). Biomass and yield declined, with reduced stem fresh weight ($P < 0.01$) and significant losses in root and tuber productivity ($P < 0.01$), though vine growth remained unaffected ($P = 0.88$).

25. Submergence stress reduced chlorophyll content, with CMR-2 dropping from 4.5 mg g^{-1} FW, while Sree Pavithra maintained higher levels (2.8 mg g^{-1} FW). Sree Apoorva showed the highest membrane stability (60%) and osmolyte accumulation (600 mmol kg^{-1}), while Sree Athulya retained the highest RWC (94%). Sree Swarna exhibited the strongest antioxidant defense with 89% DPPH activity. Photosynthetic rate declined, but Sree Apoorva maintained the highest (20 µmol CO_2 m^{-2} s^{-1}). Chlorophyll fluorescence (Fv/Fm, PhiPS2) decreased, while NPQ increased, indicating photoprotection. Pn correlated positively with Fv/Fm, phenolic content, and antioxidant activity but negatively with catalase activity, reflecting oxidative stress.

26. Studies to standardize growth media for cassava minisetts showed that potting mixture (soil: FYM 2:1) had the earliest sprouting (5 days) and highest establishment (89% in two-node minisetts) compared to 51% in single node. Seedlings from this medium showed superior height, 7 and 22 cm after 15 and 30 days, respectively.

27. Under controlled conditions, sweet potato variety Bhu Krishna had the longest vine (274.08 cm) and highest root fresh weight (170.42 g), while Sree Arun produced the highest tuber yield (2290 g $plant^{-1}$). Tubers from protected cultivation showed enhanced sensory qualities, with Bhu Krishna excelling in aroma (3.81) and colour (4.38) compared to open condition (3.19 and 3.81) in 5

point Hedonic scale.

28. Seed villages for cassava, sweet potato, elephant foot yam, and Chinese potato were established in Kerala, Tamil Nadu, Odisha, and Meghalaya, covering 184 acres with 47 villages. Hundred and seventeen farmers were registered as Decentralized Seed Multiplier (DSM) for quality planting material production.

29. An experiment with grow bags assessed six media combinations for yam varieties Sree Nidhi and Sree Neelima, showed significant yield differences. Sree Nidhi yielded highest in soil, vermiculite and vermicompost (1:1:1) medium (1143 g plant^{-1}), while Sree Neelima performed best in soil with FYM (1:1) (880 g plant^{-1}). Sett size and pretreatments significantly affected corm yield in elephant foot yam (Gajendra), with larger setts (200 g) yielding up to 1.42 kg in grow bag.

30. Fumigation with cassava distillate could kill the borer pests, *Rhizopertha dominica* and *Cylas formicarius* in 4 and 5 min respectively *in vitro*. The inhibition of cytochrome C oxidase mRNA expression was confirmed in insects after fumigant treatment.

31. The mite, *Tetranychus kanzawai* has been identified as a new pest of cassava through morphological identification keys and *mt-co1* gene sequencing. The infestation results in yellowing, bronze discoloration, and defoliation in cassava, causing stunted growth and reduced tuber production under severe condition. Two bacterial endosymbionts associated with the mite was identified as *Bacillus cereus* and *Bacillus mycoides* through 16S rRNA sequencing.

32. Three isolates of EPNs, CTCRIS2, CTCRIS3 and CTCRIH2 were obtained from Thiruvananthapuram, Kerala. Based on morphological characterization, CTCRIS2 and CTCRIS3 were identified as *Steinernema* spp. and CTCRIH2 was identified as *Heterorhabditis* sp. CTCRIS2 was further identified as *Steinernema siamkayai* using ITS sequencing. The primary endosymbiont associated with *S. siamkayai* was *Xenorhabdus stockiae*.

33. The crude leaf protein extract of tuberous *Ipomoea mauritiana*, identified as resistant to sweet potato weevil infestation showed mortality in adult sweet potato weevils after 48 h at a protein concentration of 4-5 mg ml^{-1}. It also reduced lipid peroxidation, glutathione peroxidase, and glutathione reductase activities and increased superoxide dismutase and glutathione S-transferase activities. This is the first to identify insecticidal proteins in *I. mauritiana* leaves. Transcriptome sequencing of *Ipomoea mauritiana* and *Ipomoea batatas* roots under sweet potato weevil infestation identified 72 and 52 differentially expressed genes, respectively.

34. Fluopyram 34.48% SC (0.5 ml l^{-1}) showed the least corm damage (6.4%) by root knot nematode, *Meloidogyne incognita* in elephant foot yam and yielded best (2.5 kg plant^{-1}) followed by Fluensulfone 2% GR (1g plant^{-1}), neem cake (500 g plant-1) and *Trichoderma harzianum* (20 g plant^{-1}) (15.8, 13.7 and 15%) with 2.03, 1.3 and 1.2 kg yield per plant, when compared with control (18.27% damage and 0.78 kg per plant yield).

35. Protocol for isolation of genomic DNA from plant parasitic nematodes was standardised. The *Meloidogyne* sp. (EMK1) infecting elephant foot yam was identified as *Meloidogyne javanica* (99.86% similarity) through its amplification (GenBank Acc. No. PP756339). In Chinese potato, the root-knot nematode (*Meloidogyne* sp.) was the most prevalent nematode detected in soil samples, with population densities ranging from 0.5 to 2 nematodes per gram of soil in the surveyed fields across two villages each in Tirunelveli and Tenkasi district, Tamil Nadu.

36. Nine types of symptoms were observed in leaf samples exhibiting signs of leaf rot/blight and pseudo stem rot. Majority of the isolates belong to the genera *Colletotrichum* and *Fusarium.* The lowest percent disease index (PDI) was observed in the plants treated with Jeevamrit (4.0), which was on par with *Trichoderma* biocapsule (5.6) and Difenoconazole (7.73). The highest yield was also recorded in Jeevamrit treated plants (52.9 t ha^{-1}), followed by the bio-capsule of *T. asperellum* (51.7 t ha^{-1}).

37. The lowest PDI of taro leaf blight was observed in plants treated with Metalaxyl 4%+ Manconzeb 64% (7.51) and Cymoxanil 8% + Mancozeb 64% (7.84), which were on par with potassium silicate (10.6) and Famoxadone 16.6% + Cymoxanil 22.1% SC (11.96).

38. In the evaluation of 97 *Trichoderma* isolates for temperature tolerance, the growth rates varied from 0.43 cm/day (isolate T91 at 15ºC) to 3.8 cm/day (isolate T89 at 35ºC). The highest average mycelial growth was observed at 30ºC, followed by 35º C, with the lowest growth at 15º C. Fifteen isolates- T3, T19, T20, T52, T59, T63, T66, T73, T79, T81, T87, T92, T94, T95, and T96 maintained a growth rate difference of less than 0.5 cm/day across 20º C, 25º C, 30º C, and 35º C, which suit for regions experiencing significant seasonal temperature fluctuations.

39. The pathogens associated with cassava stem and root rot (CSRR) were identified as *Fusarium* spp. through morphocultural characters and further to species level using RNA polymerase 2 (*rpb2*), and translation elongation factor 1-alpha (*tef1*) gene sequencing. Four isolates belong to *Fusarium solani* species complex (FSSC), *Fusarium falciforme* (3) and *Neocosmospora suttoniana* (1). Six new isolates were obtained from different farmers' fields in Kerala.

40. CSRR management trial with *Trichoderma asperellum* (CTRI-Tr 15), an endophytic *Bacillus subtilis* biocapsule, and ICAR-Fusicont reduced 89, 72 and 58 % of disease incidence, respectively compared to control. Among sixteen varieties screened *in vitro*, six viz., Sree Suvarna, Sree Athulya, Sree Pavithra, Sree Reksha, H-97 and Sree Visakham could withstand the infection of *Fusarium falciforme* associated with CSRR.

41. The combination of Azoxystrobin and Difenoconazole (1 ml l^{-1}) proved to be the most effective treatment, achieving a significant reduction (65%) in anthracnose intensity in greater yam (var. Orissa Elite) which was on par with Difenoconazole alone (1 ml l^{-1}) and Carbendazim (0.5 g l^{-1}) with 60% and 53% reduction, respectively. Additionally, the biocapsule formulation of the endophyte CTCRI EB12, applied through various delivery methods, demonstrated significant reduction (21%) with the combination of soil and tuber treatment (one capsule in 100 liters of water and cowdung slurry, respectively) compared to the untreated control.

42. The whole-genome sequence suggests that the above endophyte, CTCRI EB12 is *Bacillus subtilis*. The isolate contains genes encoding several enzymes, which are involved in the hydrolysis of fungal cell walls, contributing to the organism's antifungal properties. In addition, they also possess genes related to nutrient metabolisms which enhance plant growth.

43. The endophyte *Bacillus subtilis* was transformed with the pEGFP plasmid, resulting in the generation of a GFP-tagged, designated as CTCRI EB12T. The transformant retained its antagonistic activity (82.6 %) against *C. gloeosporioides* indicating that the transformation did not compromise its biological functions. Following root colonization, the bacteria was predominantly observed in the stem, petiole and leaf.

44. Transformation of model plant *Nicotiana benthamiana* and agroinfection of friable embryogenic calli (FEC) of CMD susceptible cassava variety H226 with recombinant *Agrobacterium* clones harbouring CRISPR/ Cas9 single as well as multiplex editing cassettes targeting Rep region of *Sri Lankan cassava mosaic virus* (SLCMV) was done. sgRNA oligos targeting CP and IR regions of SLCMV were cloned into shuttle vectors and corresponding sgRNA transcription units were further assembled in binary vector pDGE2 through gateway cloning.

45. *N. benthamiana* leaf disc transformation was done with *Agrobacterium* strain EHA105 harbouring single gRNA Tu (IR) in pDGE62, two (IR & C1C4), four (IR, C1, V1V2, C1C4) and eight gRNA Tus (c1c4, cr2, viv2, c2c3, c1c41, cr1, c1, v1) in pDGE1. The rooted plants were confirmed with *nptII* primers and being maintained in growth chamber.

46. A total of 18 endophytic microorganisms were obtained comprising six bacteria and 12 fungi from different plant parts of greater yam and sweet potato. The fungal endophytes belong to the genera *Trichoderma*, *Cephalosporium*, *Fusarium* and *Curvularia* and bacterial isolates to *Bacillus* and *Pseudomonas* species. Floral tissues exhibited significant endophytic diversity, suggesting that different plant parts harbour unique microbial communities adapted to their specific microenvironments.

47. Three endophytes, *Trichoderma*, *Cephalosporium*, and *Bacillus* increased vine length, root length, and nutrient uptake in sweet potato notably, the

absorption of essential nutrients such as nitrogen (ranging from 294.05 to 335.96 kg ha^{-1}) and potassium (28.95 to 35.5 kg ha^{-1}). The secondary nutrients such as calcium (Ca) and magnesium (Mg) were also efficiently absorbed. The potential bacterial endophyte was identified as *Bacillus cereus* using the Automated Microbial Identification (AMI) system (BIOMERIEUX Company, Model: VITEK2 Compact). The AMI system proved to be an effective tool for identifying and elucidating the biological characteristics of these bacterial endophyte.

48. Among seven tubers peel derived from tropical tuber crops, cassava and sweet potato tuber peel waste were identified as the most effective media for *Trichoderma* inoculant production, with sweet potato achieving the highest spore viability of 4.7 × 10^8 CFU/g at 90 days. Cassava, and greater yam demonstrated moderate to high initial CFU counts but reduced viability after two months.

49. The production process conditions were optimized for cassava stem based particle boards, viz., cassava stem using urea formaldehyde as resins (130°C, 36.43 bar, 40% resin), hot water blanched cassava stem (116°C, 55 bar, 85.19°C and 90 min blanching) and cassava stem-coir pith composite (110°C, 35 bar, 34.13% coir pith, 40% resin).

50. The cyanide content in fresh cassava peels (249-1714 ppm) decreased by 23.92-66.20% (to 142-1294 ppm) after sun drying, with variations across cassava varieties. In another experiment, with peels of a cassava variety Sree Reksha, hot water blanching (50-100°C, 5-20 min) significantly reduced cyanide up to 80°C, with the rate influenced by time.

51. The variability in the biochemical quality, antioxidant activity and micronutrients content of the vines of the promising sweet potato varieties viz., Sree Arun, Sree Varun, Sree Bhadra, Bhu Krishna and Bhu Sona showed that the percentage content of moisture (86.77 to 79.13), starch (37.50 to 22.50), fat (1.82 to 0.77), cellulose (24.40 to 9.12), hemicelluloses, (37.20 to 26.55), the lignin (17.08 to 4.20), sugar (13.39 and 8.4), protein (10.06 to 4.37) and antioxidant activity (80.08 to 64.11) and magnesium (145.91 to 121.83 ppm) were significantly different between varieties.

52. The economic viability and functional properties of two modified cassava starches, cassava distarch phosphate and ammonium cassava starch phosphate carbamate, revealed selling costs of ₹375/kg and ₹350/kg, respectively, with benefit-cost ratios of 1.397 and 1.433. Cassava distarch phosphate is suitable as a food thickener, while ammonium cassava starch phosphate carbamate showed potential for dye removal in water treatment.

53. Succinylated cassava distarch phosphate was synthesized, exhibiting improved physicochemical properties and emulsifying capabilities with significantly higher water binding capacity (131-201%) than native cassava starch (77.1%). The swelling power and paste viscosity also were higher for the modified starches.The mayonnaise prepared with the modified starch has less fat (5.2 g $100g^{-1}$) and sugar (3.7 g $100g^{-1}$) contents when compared to those of the commercial mayonnaise (fat-3g $100g^{-1}$, sugar- 5.22 g $100g^{-1}$). It successfully paved the way for eggless mayonnaise, reducing fat and sugar content, making it a promising ingredient for low-fat, low-calorie food products.

54. A novel porous cassava starch was synthesized, exhibiting increased porosity (50-82.1%) and oil absorption capacity (up to 210.1%) while swelling power and solubility decreased. This modified starch has potential applications in food and cosmetics.

55. A novel food spoilage detection system was developed using pH-sensing cassava starch films infused with natural dyes (anthocyanin and curcumin). The films exhibited visible colour changes in response to pH fluctuations, indicating spoilage in packaged food items. For curcumin-based films, the yellow colour transitioned sequentially to amber orange, tangerine, and finally to scarlet red as storage time increased. Anthocyanin-based films exhibited a colour shift from purple to blue and eventually to dark olive, corresponding to the spoilage of the packed food. Among the films tested, those made from cassava starch composited with low concentrations of PVA demonstrated superior performance, characterized by reduced moisture absorption and enhanced mechanical integrity.

56. Machine vision based sweet potato grader was

developed, focusing on diameter and length of sweet potato tubers for commercial grading purposes with the capacity of grading 500 kg of sweet potato tuber per hour. It increases the accuracy of grading and reducing the labour cost (4 times).

57. A portable self-propelled cassava sett cutter was designed and developed for producing quality cassava setts, which has 98% cutting efficiency, a capacity of 500 setts per hour and only 0.45% damaged setts. It saves 85% labour and 90% of production cost. The production cost of Rs. 400 per hectare compared to Rs. 4000 for manual cutting. Fuel consumption is 0.6 litre per hour.

58. A multipurpose abrasive type peeler has been designed and fabricated to facilitate efficient removal of peel from soft skin tubers of Chinese potato and taro. The developed machine is powered by a 2 HP electric motor, which is coupled to a spur gear mechanism to achieve optimal rotation speed.

59. A probiotic-rich frozen dessert was developed from purple and orange fleshed sweet potatoes, retaining high levels of anthocyanin (30.45 mg 100 g^{-1}) and beta-carotene (12.41 mg 100 g^{-1}) with significant amounts of protein (6.56% and 4.62%) and fiber (0.69% and 0.47%). Viable microbial counts ranged from 5.45-7.22 log CFU ml^{-1} and 4.52-5.87 log CFU ml^{-1} for purple and orange sweet potato desserts, respectively.

60. Gummy confections were developed incorporating orange and purple sweet potato puree concentrates (OSPC and PSPC) rich in beta-carotene and anthocyanin. Pectin-based gummies showed higher anthocyanin (4.05 mg g^{-1}) and beta-carotene (3.28 mg g^{-1}) content compared to gelatin-based gummies. The gummies exhibited antioxidant activity (1.08 mg GAE/100g FW), with PSPC-containing samples showing higher potential. Pectin gummies were preferred for colour, while gelatin gummies for texture and PSPC-incorporated gummies for taste in sensory evaluation.

61. Sixty six demonstrations conducted in Kerala and Tamil Nadu revealed that the yield of Sree Athulya was 39.68 t ha^{-1} whereas, the local varieties yielded 36.05 t ha^{-1}. In Namakkal district, Sree Reksha yielded 40.21 t ha^{-1} whereas, for local varieties the yield was 37.46 t ha^{-1}. Sree Kaveri yielded 30.12 t ha^{-1}, whereas the yield of local variety was 28.14 t ha^{-1}. Yield of SSNM treated plot of Gajendra was 29.37 t ha^{-1} whereas, the yield from farmer's practice was 26.35 t ha^{-1} in Erode district.

62. Three FLDs conducted in 0.16 ha in Attapadi, Kerala showed Bhu Kanti with higher yield (20.27 t ha^{-1}) than Bhu Sona (19.03 t ha^{-1}), and Bhu Ja (6.67 t ha^{-1}). Three FLDs conducted in West Garo hills, Meghalaya in 0.16 ha, showed Bhu Sona (15.42 t ha^{-1}) produced higher yield than Bhu Krishna (11.10 t ha^{-1}) and Sree Kanaka (9.57 t ha^{-1}).

63. In Meghalaya, the overall empowerment index of men involved in cassava cultivation was 0.708 whereas for women, it was 0.709.

64. Two digital farms to demonstrate e-Crop Based Smart Farming (eCBSF) were set up in Thiruvananthapuram, Kerala for auto fertigation as per the recommendations of e-Crop.

65. Statistical package for Agrianalytics@R was updated by including AMMI analysis and plots using metan package in R. Two factor ANOVA was included for factorial experiments with interaction and mean comparison.

66. Under Tribal Sub Plan (TSP) 385 tribal farmers across Gajapati (200), Koraput (120), and Kandhamal (37) districts of Odisha, Purulia (24) in West Bengal and Manyam (4) in Andhra Pradesh were supported. Quality planting materials including 10,000 kg each of greater yam and elephant foot yam, 2,400 kg of *Colocasia*, 12 lakh sweet potato vine cuttings, 20,000 cassava stems, 85 kg of yam bean, and 150 kg of French bean were distributed, ensuring sustainable crop production. Eight training programs were organized to equip farmers with advanced cultivation techniques.

67. Under SCSP programme 12 training programs were conducted in Kerala and Tamil Nadu for SC beneficiaries, benefiting 821 farmers. One hundred SC beneficiaries were selected from BPL category from three blocks from Kerala and Tamil Nadu namely Parkkode, Pathanamthitta District, Ollukkara block in Thrissur district in Kerala and Gangavalli block, Salem district in Tamil Nadu and field demonstration of tuber crop technologies were carried out.

68. Under NEH programme in collaboration with KVKs, training programs were conducted in

Meghalaya, to promote improved tuber crop varieties and value addition. During these programmes, farmers received planting materials of improved cassava, including Sree Jaya, Sree Vijaya, Sree Pavithra, Sree Reksha and sweet potato varieties Sree Arun, Sree Kanaka, Bhu Sona, and Bhu Krishna. Training materials, value-added products, and farm implements were also distributed.

69. Two patents, (i) e-Crop IoT Device for smart farming and (ii) power operated size based Chinese Potato grader and a method of grading there of were granted. Three patents were filed, (i) an apparatus for peeling an agricultural product, (ii) a system and a method for automated fertigation of crops and (iii) hydroponic nutrient formulation for sweet potato. Three copyrights (i) SIMCAS- A growth simulation model of cassava (ii) MADHURAM- A growth simulation model for sweet potato, and (iii) SPOTCOMS- A growth simulation model for sweet potato were also filed.

70. Two technologies were licensed (i) e-crop- an IoT Device for smart farming and (ii) elephant foot yam flakes. Eight technologies were certified by ICAR. Six incubatees were enrolled in the ICAR-CTCRI ABI in 2024, covering food processing and agricultural input marketing. Three new satellite incubation centers (i) KAU- Regional Agricultural Research Station, Kerala Agricultural University (KAU), Pattambi, Palakkad, Kerala for Tribal Entrepreneurship (ii) College of Horticulture & Forestry, Central Agricultural University (Imphal), Pasighat, Arunachal Pradesh for Protection and Commercialisation for Traditional Knowledge and Farmer Innovations and (iii) Assam University, Silchar, Assam for Indigenous and Local Community Entrepreneurship were established

71. ICAR-CTCRI is an approved research center for doctoral programmes, provided internship training for B.Sc/B.Tech students, guided students in M.Sc. project work (40), and mentored Ph.D. scholars (28). The Institute trained farmers (579), students (2756) and officials (245), participated in 14 exhibitions, and conducted 281 FLDs/OFTs.

72. A total of 579 farmers, 2756 students and 45 officials from different parts of the country had exposure visit to the Institute.

73. A total of 324 publications were contributed by the Institute including Research papers: 78; Symposia: 42; Books: 4; Book chapters: 16; Technical bulletins: 2; Technical folders/leaflets/pamphlets: 23; Popular articles: 43; Course/training manuals/ book of abstracts/proceedings: 8; Chapters in course/training manuals and proceedings: 36; E-publications: 23; Institute publications: 25; Radio talks: 13; TV programmes: 11.

Introduction

ICAR-CTCRI, Headquarters, Thiruvananthapuram (48.19 ha)

ICAR-CTCRI Regional Station, Bhubaneswar (20 ha)

ICAR-CTCRI (1963-2024)

The ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) was established during the Third Five Year Plan for intensification of research on tuber crops (other than potato). The Institute started functioning on 01 July 1963 with its headquarters (HQ) at Sreekariyam, Thiruvananthapuram, Kerala. It has one Regional Station (RS) at Bhubaneswar, Odisha which was established in 1976. The All India Co ordinated Research Project on Tuber Crops (AICRP TC) was started at ICAR-CTCRI in 1968 for testing and popularizing the location specific tuber crop technologies in various parts of India. It has presently 21 centres including ICAR-CTCRI HQ and Regional Station. The Institute is also one of the centres of the All India Co-ordinated Research Project on Pre and Post-harvest Technology. The ICAR-CTCRI is conducting basic, strategic and applied research on various edible tropical tuber crops.

Vision

Root and tubers for ensuring better health, wealth generation and inclusive growth

Mission

To integrate root and tuber crops as sustainable farming system components to ensure food and nutritional security of the nation and livelihood improvement of rural population

Mandate

The Institute has a broad mandate of generating information on research of tropical tuber crops that will help to enhance productivity and improve the utilization potential

- Basic, strategic and applied research on genetic resource management, crop improvement, sustainable production and utilization of tropical tuber crops
- Co-ordinate research and validation of technologies through AICRP on Tuber Crops

General Achievements

The ICAR-CTCRI is a leading global research organization exclusively dedicated to tropical tuber crops. Over its 61 years of dedicated research, the Institute has released 77 improved varieties and has developed numerous sustainable production, protection, and processing technologies for tuber crops. With a focus on marginal and resource-poor farmers, the Institute places special emphasis on the welfare of the farming community and sustains their food and nutritional security through the innovative technologies. In recent years, ICAR-CTCRI has also introduced several technologies aimed at generating resources through consultancies, contract research and commercialization.

The Institute holds an extensive collection of 5234 tuber crop germplasm. Its pioneering efforts in the breeding of tropical tuber crops have attracted international collaborations for breeding and genetic enhancement. The Institute continues to do advance research on molecular-based crop improvement. To date, ICAR-CTCRI has released 77 varieties with diverse quality traits and farmer-preferred characteristics. The cassava starch and sago industries in India largely rely on four major industrial varieties developed by the Institute: H-165, H-226, Sree Athulya, and Sree Apoorva. In addition Sree Kaveri is notable for its CMD resistance, drought tolerance, and high nutrient-use efficiency. These varieties are widely accepted by the farmers and industries for their productivity and quality. In addition, three cassava varieties, Sree Reksha, Sree Sakthi, and Sree Suvarna are resistant to cassava mosaic disease (CMD) with high yields. Among sweet potato varieties, β-carotene-rich Bhu Sona, Bhu Kanti, and Bhu Ja, along with anthocyanin-rich Bhu Krishna and the mid-season drought-tolerant Bhu Swami, have gained significant popularity among rural and tribal communities. Two arrowroot varieties, Sree Nakshatra (Chhattisgarh and Jharkhand) and Sree Karti (Kerala, Tamil Nadu and Manipur) with high rhizome and starch yield were released by Central Variety Release Committee (CVRC) and Sree Aadya (Kerala) by State Variety Release Committee (SVRC) in Kerala for the first time in India. Additionally, two nutrient use efficient cassava varieties Sree Annam and Sree Manna, a semi dwarf type white yam named Sree Dhrona were also released for Kerala by SVRC. Improved tuber crop varieties introduced through RKVY and other schemes are gaining widespread popularity in Kerala, Tamil Nadu, Andhra Pradesh, Odisha, Bihar, Uttar Pradesh, Gujarat, the Northeastern states, and the Lakshadweep Islands.

The Institute runs robust biotechnology research programs, focusing on the development of diagnostic tools for viral and fungal diseases and the creation of transgenic plants resistant to cassava mosaic disease, with enhanced starch content and sweet potato weevil resistance. A new flagship project on genome editing has been initiated to develop waxy cassava, for use in food and industrial applications. Eco-region-specific agro-techniques have been developed for cultivating tuber crops across various production systems in the country. The Institute has also developed technologies for producing good quality planting material, sustainable nutrient management (including INM, SSNM, and organic practices), water management (through micro-irrigation and drip fertigation), and weed control. These advancements contribute to increased yields, improved soil fertility, and higher farm incomes.

Integrated crop protection technologies developed to combat key diseases and pests affecting tuber crops include management strategies for cassava mosaic disease, tuber rot and stem and root rot; taro leaf blight; collar rot and post-harvest rot in elephant foot yam; anthracnose in greater yam; and sweet potato weevil. These technologies provide valuable remedies to overcome crop health challenges. The Institute successfully demonstrated the management of banana pseudostem weevil in farmers' fields using cassava-based bioformulations, Nanma and Menma. Notably, sweet potato weevil (SPW) mortality caused by leaf protein extracts from the SPW-resistant *Ipomoea mauritiana* is the first of its kind globally. In collaboration with ICAR-IISR, Kozhikode, the Institute developed three biocapsules using ICAR-IISR's encapsulation technology. In addition, two liquid bioformulations were released: Sree Syama (*Trichoderma asperellum*) and Sree Jala (an endophytic *Bacillus subtilis*) with high colony-forming units. These bioagents promote plant growth and suppress diseases in tuber crops and vegetables. New entomopathogenic nematode isolates are obtained and are being utilized against major pests of different crops including tuber crops.

Efforts in crop utilization have paid rich dividends in terms of value addition and diversified technologies. Technologies for the industrial sector include products like modified starches, superabsorbent polymer, adhesives, thermoplastic starch and particle board apart from pre and postharvest machinery. A novel food spoilage detection system was developed using pH-sensing cassava starch films infused with natural dyes (anthocyanin and curcumin). A power operated size based Chinese potato grader was patented. Vision based sweet potato grader machine, a portable self-propelled cassava sett cutter and multipurpose abrasive type peeler were recently developed and commercialized for boosting farmers' income. The other value added products developed includes pasta, noodles, fried snack foods etc. Functional foods from cassava, sweet potato, yams and elephant foot yam were also developed. Sweet potato vacuum-fried chips and sweet potato nutribar were selected for branding by Kerala Startup Mission, Government of Kerala. Innovative extension

programmes and methodologies have been developed for enhancing technology adoption and thereby increasing the income of the farmers and stakeholders. Probiotic-rich frozen desserts and gummy confections were developed from purple and orange fleshed sweet potatoes, which are rich in anthocyanin and beta-carotene.

The IT tools such as e-Crop, smart fertigation system, Tuber Crops Online Marketing System (TOMS) and growth simulation and self learning growth models for different crops were developed and validated for applications in smart farming. Intelligent bioinformatics tools were developed to predict plant-pathogen interaction, biological network construction, omics data integration and visualization. Molecular markers, miRNAs, lncRNAs and differentially expressed genes associated with biotic/abiotic stress and quality parameters of tuber crops were identified. The North Eastern Hill (NEH) programme, Tribal Sub Plan (TSP) and Scheduled Caste Sub Plan (SCSP) are the three important developmental programmes implemented successfully and have greatly helped to increase the livelihood security of the farmers and other stakeholders across the country through trainings and demonstrations. Techno incubation centre at the Institute also trained farmers and other stake holders in value added products for entrepreneurship development in tuber crops. The ICAR-CTCRI bagged the Sardar Patel Outstanding Institution Award for the year 2005 instituted by the ICAR for outstanding contributions made in the improvement of tropical tuber crops and development of low-cost production technologies. The Institute also bagged many national and international recognitions in the past that include: J. Chinoy Gold Medal (1970), ICAR Team Research Awards (1985, 1996, 1998, 2014), D.L. Plucknett Award for Tropical Root Crops (1991), Hari Om Ashram Trust Award (1993), Jawaharlal Nehru Award (1975, 1995, 1998, 2000 and 2003), Young Scientist Award instituted by Deseeya Sasthra Vedi (1996), NRDC cash reward for biodegradable plastics (2000), Pat Coursey Award (2000, 2006), Vasantharao Naik Memorial Gold Medal (2002), Chaudhary Devi Lal outstanding All India Coordinated Research Project (AICRP) Award (2007), Samantha Chandrasekhar Award (2013), International Potash Institute (IPI) - Fertilizer Association of India (FAI) Award (2014), Shri. L.C. Sikka Endowment Award (2014), IZA (International Zinc Association)-FAI Award (2017) and Panjabrao Deshmukh Woman Scientist Award (2017). In recognition of its contribution to cassava growers and consumers worldwide, ICAR-CTCRI has been rewarded at the First International Meeting on Cassava Plant Breeding, Biotechnology and Ecology organized at Brasilia, Brazil, during 11-15 November 2006. The Institute bagged several prizes in national and international agricultural exhibitions. The Best Annual Report Awards (1997-98) and (2017-18) among the category of small Institutes were conferred to ICAR-Central Tuber Crops Research Institute for succinctly presenting the research results. ICAR-CTCRI bagged 14th rank among all ICAR Institutes in the list of Ranking of Institutes of Indian Council of Agricultural Research for the year 2019-20 and 2020-21 for the significant research and extension achievements. A total of eight technologies from ICAR-CTCRI were certified by ICAR, New Delhi during 2023 and the technology on e-Crop based smart fertigation system was selected as one of the five best technologies in horticulture sector. The Institute has conducted more than 30 national and international symposia/seminars/workshops. The Institute is well equipped to conduct basic, strategic and applied research with its state-of-art laboratories. The infrastructural facilities of the Institute have increased during the X and XII Plan periods. Extramural support by way of research schemes from both international (CIAT, CIP, CIRAD, European Union, IFAD and Indo-Swiss) and national agencies (DBT, DIT, DST, DRDO, DSIR, ICAR, KSCSTE, LSRB, MOEF, DoA, Kerala, KSPB, NABARD, PPIC, RKVY, PPV&FRA, SHM, CDB, UGC and Network and Consortia projects of ICAR) are enriching the research activities.

The Institute Technology Management Unit (ITMU) is carrying out IP activities. Various technologies related to machinery and value addition have been commercialized through ITMU under technology transfer, consultancy, licensing and contract research modes. The Institute has MoUs with different ICAR-Institutes, universities, state departments and private firms to strengthen the collaboration for research and education on tuber crops. MoUs were also signed recently for commercializing Electronic Crop loT device for smart farming, elephant foot yam flakes, cassava based protein enriched noodles which helps in building agribusiness and entrepreneurship development. Three growth simulation models, one for cassava (SIMCAS) two for sweet potato (MADHURAM and SPOTCOMS) were filed for copyright. The Bioinformatics & Statistics laboratory is equipped with Linux and Windows workstations, 6 stand alone terminals and 8 TB network assisted

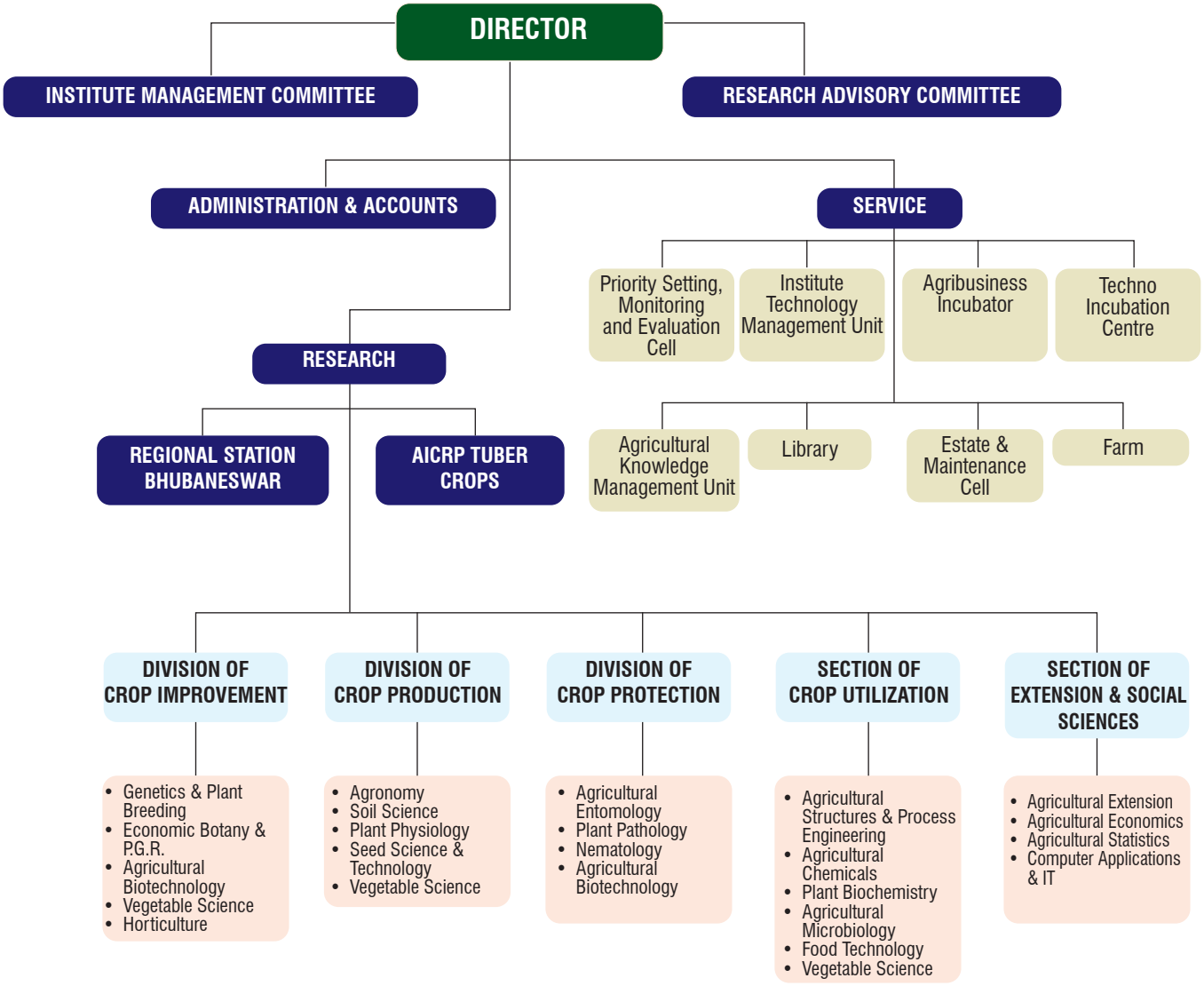
storage to assist high performance computing. The lab is installed with commercial software packages such as SAS, DNASTAR, BioBam (Blast2GO) and other open source softwares for statistics and bioinformatics applications. The Institute has established a full-fledged Local Area Network connecting various divisions, sections, administration, accounts and farm sections of ICAR-CTCRI through a strong fiber optic backbone. Six incubatees enrolled in the ICAR-CTCRI ABI in 2024, for food processing and agricultural input marketing. Three new satellite incubation centers at Kerala Agricultural University (KAU), Regional Agricultural Research Station, Pattambi, Palakkad, Kerala for Tribal Entrepreneurship; College of Horticulture & Forestry, Central Agricultural University (Imphal), Arunachal Pradesh for Protection and Commercialisation for Traditional Knowledge and Farmer Innovations and Assam University, Silchar, Assam for Indigenous and Local Community Entrepreneurship were established.

The main building of the Institute has CCTV facility and the entire campus is now Wi-Fi enabled through access controlled Wi-Fi devices and controllers. The VPN connectivity is established for global access to the servers. The Institute home page https://www.ctcri.org was redesigned, which provides comprehensive information about the various activities of the Institute and online facilities like an array of institute publications, academic and HRD details etc. The library at the Institute offers mobile e-resource access, static IP for secure e-journal access, and supports research with scientific books, circulation, and reference services. Two brainstorming sessions were organized on harnessing crop wild relatives and quality material production to address the challenges faced by the farmers. Infrastructure facilities were created with new equipments under Genome editing project and foundation stone was laid at Regional station, Bhubaneswar for mass production unit for bio-control agents. The Institute regularly organizes MGMG and Swachhata Hi Seva, the Government of India programmes both on and off campus with active participation from all staff members.

Mandate Crops

1. Cassava: *Manihot esculenta* Crantz, Euphorbiaceae
2. Sweet potato: *Ipomoea batatas* (L.) Lam., Convolvulaceae
3. Greater yam: *Dioscorea alata* L., Dioscoreaceae
4. White yam: *Dioscorea rotundata* Poir., Dioscoreaceae
5. Lesser yam: *Dioscorea esculenta* (Lour.) Burk., Dioscoreaceae
6. Elephant foot yam: *Amorphophallus paeoniifolius* (Dennst.) Nicolson, Araceae
7. Taro: *Colocasia esculenta* (L.) Schott., Araceae
8. Tannia: *Xanthosoma sagittifolium* (L.) Schott., Araceae
9. Giant taro: *Alocasia macrorrhiza* (L.) Schott., Araceae
10. Swamp taro: *Cyrtosperma chamissonis* (Schott.) Merr., Araceae
11. Chinese potato: *Plectranthus rotundifolius* (Poir.) Spreng., Lamiaceae
12. Yam bean: *Pachyrhizus erosus* (L.) Urban, Fabaceae
13. West Indian arrowroot: *Maranta arundinacea* L., Marantaceae
14. Queensland arrowroot: *Canna edulis* (Ker-Gawler), Cannaceae
15. East Indian arrowroot: *Curcuma angustifolia* Roxb., Zingiberaceae

Organisational Set Up



Staff position

Name	Sanctioned	In Position	Vacant
RMP	1	1	0
Scientific staff	44	42	2
Technical staff	47	33	14
Administration staff	30	17	13
Skilled supporting staff	38	15	23
Total	**160**	**108**	**52**

Progressive expenditure 2023-24

Head of Account		RE 2023-24	Progressive Expenditure	
Code	Name	(In Lakhs)	(In Lakhs)	
	CAPITAL			
1	Works			
	A. Land			
	B. Building			
	i. Office building	22.45	22.45	
	ii. Minor Works	0.00	0.00	
2	Equipments - Institute	31.42	31.42	
	- SCSP	0.00	0.00	
	- TSP	4.00	3.99	
3	Information Technology	38.31	38.31	
4	Library Books and Journals	.85	.85	
5	Vehicles & Vessels	2.27	2.27	
6	Furniture & Fixtures	4.70	4.70	
	Total – Capital	104.00	103.99	
	REVENUE EXPENDITURE			
1	A. Establishment Charges	2171.42	2171.42	
	B. Pension & Other Retirement Benefits	258.48	258.48	
2	Travelling Allowances	520.00	26.76	520.00
3	Research & Operational Expenses		226.42	
4	Administrative Expenses		252.30	
5	Miscellaneous		14.52	
	NEH	30.00	25.89	
	TSP	40.00	40.00	
	SCSP	25.00	25.00	
	Total – Revenue Expenditure	3044.90	3040.79	
	GRAND TOTAL (Capital + Revenue)	3148.9	3144.78	
	P. Loans & Advances	1.00	1.00	

Research Projects

Institute Projects

Sl. No.	Project Title	PI	Co-PIs
I	**HORTCTCRISIL 202000901465** **Mega Project 1: Conservation and utilization of germplasm of tuber crops for sustaining production**	**K.I. Asha**	M.N. Sheela (till 31.05.2024), C. Visalakshi Chandra, S.N. Rahana, A. Asha Devi, P. Murugesan, Kalidas Pati, N. Krishna Radhika **Project Associates** L.K. Bharathi, K.M. Senthilkumar, M.L. Jeeva, S.S. Veena, V.B.S. Chauhan, T. Krishnakumar, E.R. Harish, T. Makeshkumar, A.N. Jyothi, H. Kesava Kumar, J. Sreekumar, R. Arutselvan, K. Hanume Gowda, T.P. Sujatha, Saravanan Raju, Pradeepika Chintha and P.S. Sivakumar
II	**HORTCTCRISIL 202001001466** **Mega Project 2: Genetic improvement of tuber crops through conventional breeding and molecular approaches**	**C. Mohan**	
1	**Project 1:** Breeding to evolve trait specific varieties in cassava, yams and arrowroot for productivity, earliness, quality and resistance to biotic stresses	M.N. Sheela (Till 31.05.2024) S.N. Rahana	K.I. Asha, C. Mohan, T. Makeshkumar, A. Asha Devi, G. Suja, K. Susan John, A.N. Jyothi, N. Krishna Radhika, C. Visalakshi Chandra, J. Sreekumar, K.M. Senthilkumar, E.R. Harish, T. Krishnakumar, P. Prakash, S. Sunitha, T.P. Sujatha
2	**Project 2:** Map based cloning of CMD resistant gene(s) & identification of markers associated with drought tolerance and high starch content in cassava	C. Mohan	K.M. Senthilkumar, J. Sreekumar, A.N. Jyothi, T. Makeshkumar, Saravanan Raju
3	**Project 3:** Genetic analysis and QTL mapping for determining genetic basis of post-harvest physiological deterioration (PPD) tolerance and enhanced shelf life in cassava	C. Visalakshi Chandra	M.N. Sheela (Till 31.05.2024), Saravanan Raju, K.I. Asha, A.N. Jyothi, J. Sreekumar, S.N. Rahana
4	**Project 4:** Genome analysis, identification and functional characterization of early bulking genes in cassava, abiotic stress and tuberization responsive genes in sweet potato	K.M. Senthilkumar	M.N. Sheela (Till 31.05.2024), C. Mohan, Saravanan Raju, N. Krishna Radhika, J. Sreekumar CC-PI : Monika Dalal (ICAR-NIPB)
5	**Project 5**: Molecular characterization of nutrient homeostasis in tubers for biofortification of cassava	T.P. Sujatha	M.N. Sheela (Till 31.05.2024), A.N. Jyothi, J. Sreekumar

6	**Project 6:** Phenomics approaches for physiological trait based breeding for drought and PPD tolerance in cassava	C. Mohan	C. Visalakshi Chandra, K.M. Senthilkumar, N. Krishna Radhika, J. Sreekumar, V.S. Santhosh Mithra, Saravanan Raju
7	**Project 7:** Breeding and evaluation for development of high yielding nutritionally enriched, photo-insensitive, processable and multipurpose sweet potato varieties	Shirly Raichal Anil	C. Visalakshi Chandra, S. Sunitha, E.R. Harish, Saravanan Raju, A.N. Jyothi, J. Sreekumar
8	**Project 8:** Harnessing the genetic potential of wild *Ipomoea* spp. through wide hybridization for improvement of sweet potato	L.K. Bharathi	Kalidas Pati, E.R. Harish, T. Makeshkumar, C. Visalakshi Chandra
9	**Project 9:** Breeding for development of high starch, anthocyanin and β-carotene rich varieties in sweet potato and high yielding nutritional rich varieties in yam bean	Kalidas Pati	V.B.S. Chauhan, R. Arutselvan, M. Nedunchezhiyan, K. Laxminarayana, K. Hanume Gowda
10	**Project 10:** Genetic improvement for drought tolerance in sweet potato and high yielding, disease tolerant nutritionally rich lines in taro	V.B.S. Chauhan	Kalidas Pati, R. Arutselvan, M. Nedunchezhiyan, K. Laxminarayana, K. Hanume Gowda, Manas Ranjan Sahoo
11	**Project 11:** Breeding for earliness, quality traits and salinity tolerance in sweet potato	K. Hanume Gowda	K.M. Senthilkumar, K. Laxminarayana, V.B.S. Chauhan, Kalidas Pati, Saravanan Raju, Manas Ranjan Sahoo
12	**Project 12:** Genetic improvement of edible aroids for resistance to biotic stress and quality parameters	A. Asha Devi	Shirly Raichal Anil, S. Sunitha, S.S. Veena, N. Krishna Radhika, K.M. Senthilkumar, Manas Ranjan Sahoo
13	**Project 13:** Developing breeder seed standards and precocity of genetic vigour for tropical tuber crops	P. Murugesan	Shirly Raichal Anil, Kalidas Pati, R. Arutselvan CC-PIs Pakmakshi Thakur (IGKV), Asish Narayan (RPCAU), K. Sujatha (TNAU)
14	**Project 14:** Inducing genetic variability, characterization, grouping and developing breeding lines with large tuber size and short duration in Chinese potato	P. Murugesan	L.K. Bharathi, T.P. Sujatha, H. Kesava Kumar, C. Visalakshi Chandra
15	**Project 15:** Development of DNA barcode standards and RNA secondary structure predictions in sweet potato	Manas Ranjan Sahoo	C. Visalakshi Chandra, Kalidas Pati, K. Hanume Gowda
III	**HORTCTCRISIL 202001101465** **Mega Project 3: Resource management and climate smart agriculture for sustainable production of tropical tuber crops**	**G. Suja**	
17	**Project 1:** Crop diversification involving tropical tuber crops	G. Suja	G. Byju, J. Suresh Kumar, S. Sunitha, K. Sunilkumar, S.S. Veena, E.R. Harish, D. Jaganathan
18	**Project 2:** Weed management in tropical tuber crops	J. Suresh Kumar	S. Sunitha, P. Prakash, S.S. Veena
19	**Project 3:** Precision management of water and nutrients in tropical tuber crops	S. Sunitha	G. Suja, V. Ramesh , J. Suresh Kumar
20	**Project 4:** Drip irrigation and fertigation management in greater yam	M. Nedunchezhiyan	Kalidas Pati
21	**Project 5:** Sustainable nutrient management in tropical tuber crops	K. Laxminarayana	M. Nedunchezhiyan, J. Suresh Kumar, A.N. Jyothi, K. Susan John, Kalidas Pati
22	**Project 6:** Long term integrated nutrient management in tropical tuber crops	K. Susan John	R. Muthuraj, V. Ramesh, S.S. Veena, T. Makeshkumar, J. Suresh Kumar, S. Sunitha

23	**Project 7:** Soil carbon quality and conservation studies in tropical tuber crops	V. Ramesh	S. Sunitha, P. Prakash, H. Kesava Kumar
24	**Project 8:** Climate change adaptation and mitigation in tropical tuber crops	V. Ramesh	K. Susan John, Saravanan Raju, J. Suresh Kumar, P. Prakash, T. Krishnakumar
25	**Project 9:** Physiological studies related to climate change in tropical tuber crops	Saravanan Raju	J. Sreekumar, K.M. Senthilkumar
IV	**HORTCTCRISIL 202001201468 Mega Project 4: Quality planting material production of tropical tuber crops**	**R. Muthuraj**	
26	**Project 1:** Developing innovative techniques for seed production in tropical tuber crops and quality planting material production in cassava, sweet potato and Chinese potato	R. Muthuraj	G. Suja, K. Sunilkumar, T. Makeshkumar, Saravanan Raju, K. Susan John, M. Nedunchezhiyan, D. Jaganathan, P. Sethuraman Sivakumar, V.B.S Chauhan, K. Laxminarayana, T. Krishnakumar, J. Suresh Kumar
27	**Project 2:** Investigations on rapid multiplication of yams and aroids	K. Sunilkumar	R. Muthuraj, M. Nedunchezhiyan, K. Laxminarayana, J. Suresh Kumar
V	**HORTCTCRISIL 202001301469 Mega Project 5: Development of innovative technologies for the intensification of pest management in tuber crops through biorational approach**	**E.R. Harish**	
28	**Project 1:** Management of important pests and documentation of emerging pests in tuber crops	E.R. Harish	H. Kesava Kumar, B.G. Sangeetha, R. Arutselvan, K. Susan John, V.S. Santhosh Mithra CC-PI Berin Pathrose (KAU)
29	**Project 2:** Characterization of sweet potato weevil (*Cylas formicarius* (Fabricius)) resistance genes in sweet potato and related *Ipomoea* spp.	B.G. Sangeetha	E.R. Harish, Shirly Raichal Anil, J. Sreekumar CC-PIs T. Santhoshkumar (KAU), P.S. Benher lal (UAS, GKVK), N. Nagesha (UAS, GKVK)
30	**Project 3:** Screening of newer molecules and bio-control agents for the management of nematodes in tuber crops	H. Kesava Kumar	B.G. Sangeetha, M.L. Jeeva, E.R. Harish CC-PI K.M. Anes (ICAR-CPCRI)
VI	**HORTCTCRISIL 202001401470 Mega Project 6: Development and refinement of integrated disease management and forecasting system for improved tuber crop production**	**M.L. Jeeva**	
31	**Project 1:** Emerging fungal diseases and management strategies for major diseases of aroids	S.S. Veena	M.L. Jeeva, V.S. Santhosh Mithra, J. Sreekumar, R. Arutselvan, G. Suja CC-PI K.N. Anith (KAU)
32	**Project 2:** Fungal pathogens and disease management in cassava and yams	M.L. Jeeva	S.S. Veena, T. Makeshkumar, V.S. Santhosh Mithra , R. Arutselvan, H. Kesava Kumar, K. Susan John, Saravanan Raju, C. Visalakshi Chandra
33	**Project 3:** Virus and phytoplasma diseases of tropical tuber crops and their management	T. Makeshkumar	M.L. Jeeva, S.S. Veena, R. Arutselvan

34	**Project 4:** Mass production and effective utilization of bioagents to manage fungal diseases of tuber crops	R. Arutselvan	M.L. Jeeva, S.S. Veena, E.R. Harish, T. Makeshkumar , K. Laxminarayana, Kalidas Pati, M. Nedunchezhiyan, H. Kesava Kumar
VII	**HORTCTCRISIL 202001501471 Mega Project 7: Development and refinement of post-harvest handling, storage and processing techniques for minimization of losses in tropical tuber crops and production of value added products**	**M.S. Sajeev**	
35	**Project1:** Non-conventional applications of cassava starch in construction and building materials	M.S. Sajeev	T. Krishnakumar, A.N. Jyothi , C. Pradeepika, E.R.Harish
36	**Project 2**: Development of cassava and sweet potato-based animal feed	M.S. Sajeev	M. Nedunchezhiyan , T. Krishnakumar , A.N. Jyothi CCPIs E. Sanal, ICAR-CMFRI, Kochi , S. Chandrasekar, ICAR-CMFRI, Kochi , Pratap Chandra Das, ICAR-CIFA, Bhubaneswar K. Ambasankar, ICAR-CIBA, Chennai, Sarjan Rao, Andhra Pradesh Veterinary University, Tirupathi
37	**Project 3:** Development of modified starches of cassava and functional characterization of lesser known tropical tuber starches	A.N. Jyothi	M.S. Sajeev, P. Prakash
38	**Project 4:** Design and development of pre and post-harvest machineries/storage systems in tuber crops	T. Krishnakumar	M.S. Sajeev, C. Pradeepika
39	**Project 5:** Quality changes associated with post-harvest storage/processing and development of value-added functional foods from cassava and sweet potato	C. Pradeepika	M.S. Sajeev, A.N. Jyothi, C. Visalakshi Chandra, M. Nedunchezhiyan, T. Krishnakumar, Kalidas Pati
VIII	**HORTCTCRISIL 202001601472 Mega Project 8: Developing methodologies and tools for assessment and transfer of tuber crops technologies**	**Sheela Immanuel**	
40	**Project 1:** Technological interventions and documentation of farmers' innovations including ITKs in tropical tuber crops	D. Jaganathan	Sheela Immanuel, P. Prakash, V.S. Santhosh Mithra, P. Sethuraman Sivakumar, G. Suja, R. Muthuraj, H. Kesava Kumar, P. Murugesan, T. Krishnakumar, M. Nedunchezhiyan

41	**Project 2:** Upscaling tuber crops technologies for promoting food and nutritional security	P. Sethuraman Sivakumar	P. Prakash, M. Nedunchezhiyan, T. Krishnakumar, K. Laxminarayana Sheela Immanuel, J. Sreekumar CC-PIs Mahesh B Tengli , CAU(I), Umiam, B. Shanmughasundaram, (RARS Pattambi), M. Elavarasan, (KVK, Tenkasi), P. Mooventhan, (ICAR-NIBSM, Raipur), Bineeta Satpathy, (RPCAU, Pusa), Sandeep K. Panda, Kalinga (KIIT, Odisha), R.Sasikumar (RS), NEHU, Tura, Meghalaya, Ipsa Mohapatra (KIMS, Odisha)
42	**Project 3:** Mapping of women's empowerment in tuber crops cultivation for engendering research and development	Sheela Immanuel	D. Jaganathan, P. Prakash, P. Sethuraman Sivakumar, R. Muthuraj
43	**Project 4:** Impact assessment of technologies of tropical tuber crops	P. Prakash	D. Jaganathan, Sheela Immanuel, J. Sreekumar CC-PI Prabhat Kishore, ICAR-NIAP, New Delhi
44	**Project 5:** Development of intelligent smart technologies for tuber crops	V.S. Santhosh Mithra	S. Sunitha, D. Jaganathan
45	**Project 6:** Generation and application of statistical and bioinformatics tools for tuber crops research and development	J. Sreekumar	K.M. Senthilkumar , C. Visalakshi Chandra, A.N. Jyothi

Institute Flagship project

Sl. No.	Project Title	PI	Co-PIs
1	Genetic improvement of cassava through gene editing for modified starch	**N.Krishna Radhika**	K.M. Senthilkumar, T.P. Sujatha, T., Makeshkumar, A.N. Jyothi

Developmental Projects (ICAR-New Delhi)

Sl. No.	Title	PI	Co-PIs	Total Budgets (₹ in lakhs)
1	ICAR-CTCRI-TSP: Livelihood improvement of tribal farmers through tuber crops technologies	M. Nedunchezhiyan	Kalidas Pati, K. Hanume Gowda, J. Suresh Kumar, C. Pradeepika, B.G. Sangeetha	61.00
2	ICAR-CTCRI-SCSP: Empowerment of tuber crops farmers through sustainable use of resources and tuber crops technologies	V. Ramesh (Till March 2024) K. Sunilkumar	S. S. Veena, D. Jaganathan, H. Kesavakumar, J. Sureshkumar, T. Krishnakumar (Till March 2024) M.S. Sajeev, V. Ramesh, C. Mohan, E.R. Harish, P. Prakash, S.N. Rahana	46.50

3	ICAR-CTCRI-NEH: Scaling up biofortified tuber crops through 'Rainbow Diet Approach' in the North Eastern Hills Region	R. Muthuraj	Manas Ranjan Sahoo, P. S. Sivakumar, D. Jaganathan, T. Krishnakumar, V.B.S. Chauhan, R. Arutselvan	10.00

Externally Aided Projects

Sl. No.	Title	PI	Co-PIs	Funding Agency	Total and (2024-2025) Budget (₹ in lakhs)
1	Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*)	M.N. Sheela (Lead Centre) till 31.05.2024 C.Visalakshi Chandra	K.I. Asha, A. Asha Devi Shirly Raichal Anil N. Krishna Radhika	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	21.00 (6.70)
2	Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in sweet potato (*Ipomoea batatas*) and cassava (*Manihot esculenta*)	Kalidas Pati (Collaborating Centre)	K. Hanume Gowda	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	13.40 (6.39)
3	Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in yam bean (*Pachyrhizus erosus)* and greater yam (*Dioscorea alata*)	M.N. Sheela (Lead Centre) till 31.05.2024 S.N. Rahana	J. Sreekumar P. Murugesan	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	21.00 (6.89)
4	Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in yam bean (*Pachyrhizus erosus)* and greater yam (*Dioscorea alata*)	Kalidas Pati (Collaborating Centre)	R. Arutselvan	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	9.26 (5.75)
5	Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in taro and elephant foot yam	Kalidas Pati	V.B.S. Chauhan	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	13.60 (6.36)
6	ICAR-Bioversity International & CIAT Alliance collaborative project No.5.1: Germplasm exchange, improvement and testing advanced clean seed technology in cassava (*Manihot esculenta* Crantz)	M.N. Sheela (till 31.05.2024) T. Makeshkumar S. Sunitha	G. Byju, K.I. Asha K.M. Senthilkumar P. Murugesan R. Muthuraj C. Visalakshi Chandra	ICAR-Bioversity International & CIAT Alliance	14.79
7	ICAR-CIP collaborative work plan activity on Crop improvement and varietal selection of sweet potato	Shirly Raichal Anil	C. Visalakshi Chandra A.N. Jyothi V.S. Santhosh Mithra P.Sethuraman Sivakumar Saravanan Raju	International Potato Centre (CIP), New Delhi	42.26 (10.00)

8	Micro tuber production and gene prospecting for photoresponsive tuberization in *Ipomoea batatas* (L.) Lam.	Shirly Raichal Anil	N. Krishna Radhika K.M. Senthilkumar	DST-The Science and Engineering Research Board (Core Research Grant), New Delhi	30.36 (6.00)
9	Collection and database creation of important named landraces of tuber crops from southern districts of Kerala	K.I. Asha	M.N. Sheela (till 31.05.24) A. Asha Devi Shirly Raichal Anil N. Krishna Radhika	Kerala State Biodiversity Board (KSBB), Government of Kerala	8.00 (4.00)
10	Establishment of aeroponics system for production of mini tubers insweet potato and greater yam to fulfill the quality planting materials requirement of Odisha	K. Hanume Gowda	M. Nedunchezhian V.B.S. Chauhan R. Arutselvan Kalidas Pati	(RKVY, Dept. of Agriculture & Farmers' Welfare, Govt. of Odisha)	Started in December 2024
11	All India Network Programme on Organic Farming (AINP-OF)	G. Suja	G. Byju, S. Sunitha S.S. Veena, A.N. Jyothi M.N. Sheela (till 31.05.24) D. Jaganathan	ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh	145.42 (5.14)
12	Adoption of biofortified varieties of tuber crops and promoting entrepreneurship development for livelihood and nutritional security of tribal farmers	K. Laxminarayana	M. Nedunchezhiyan R. Arutselvan M.S. Sajeev B.B. Das	Directorate of Horticulture, Govt. of Odisha	138.00 (0.00)
13	Rural bioresource complex for tubers and millets in Kandhamal, Odisha	Vishakha Raina M. Nedunchezhiyan	Sandeep Kumar Panda Mrutunjay Suar, KIIT DU	DBT-KIIT, Govt. of India	(5.00)
14	Development of biofortified sweet potato value chain for industrial production in Telangana, Karnataka and Odisha	M. Nedunchezhiyan	G. Byju, P. Sethuraman Sivakumar, V. Ramesh	Xobu Foods and Beverages Private Limited, Hyderabad	-
15	ICAR-CRP on Vaccines & Diagnostics: Development and application of diagnostics to viruses infecting tropical tuber crops (cassava, elephant foot yam, sweet potato and yams)	T. Makeshkumar	M.L. Jeeva R. Arutselvan R. Muthuraj	ICAR-CRP on vaccines and diagnostics, New Delhi	25.60 (16.11)
16	Establishment of mass production unit of bioagents for ecofriendly disease management in vegetable crops of Odisha	R. Arutselvan	Kalidas Pati V.B.S. Chauhan K. Hanume Gowda M. Nedunchezhiyan K. Laxminarayana	Rashtriya Krishi Vikas Yojana (RKVY), Govt. of Odisha	320.91 (105.75)
17	Abiotic stress-hormesis to enhance the phenolic-linked antioxidant protective system in biofortified sweet potatoes for designing functional food ingredients	C. Pradeepika	-	DST-The Science and Engineering Research Board (SERB), Govt. of India	47.87 (7.50)
18	Development of cassava custard	C. Pradeepika	A.N. Jyothi M.S. Sajeev	Contract Research Project, M/S KCM Agri Clinic, Tirunelveli	(0.35)
19	Development of smart foods, bio-composites, green packaging and bio-energy from agro-residues	M.S. Sajeev	T. Krishnakumar A.N.Jyothi S.S.Veena	NASF, ICAR, New Delhi	395.35 (5.22)

20	AICRP on Post-harvest Engineering and Technology	M.S. Sajeev	T. Krishnakumar	ICAR, AICRP - PHET	
21	Development of value –added products from *Mudali* (*Colocasia esculenta*) and *Kone* (*Dioscorea*)	M.S. Sajeev	T. Krishnakumar C. Pradeepika	Contract Research Project, M/s Spudnik Farms, Bengaluru, Karnataka	-
22	Developing the Standard Operating Procedures (SOP) for good manufacturing practices and Hazard Analysis and Critical Control Points (HACCP) for tapioca starch and sago production	A.N. Jyothi	M.S. Sajeev T. Krishnakumar J. Sreekumar P. Prakash	SAGOSERVE, Salem, Tamil Nadu	31.11 (0.70)
23	Soil health management in coconut based cropping systems involving tuber crops for enhanced yield and income	D. Jaganathan	G. Byju, G. Suja	Coconut Development Board, Kochi, Kerala	(8.70)
24	IP & TM Scheme: National Agricultural Innovation Fund (NAIF) Component I: Innovation Fund	P. Sethuraman Sivakumar	T. Krishnakumar P. Prakash	IP & TM, ICAR, New Delhi	(5.50)
25	IP & TM Scheme: National Agricultural Innovation Fund (NAIF) Component II: Incubation Fund	P. Sethuraman Sivakumar	M. Nedunchezhiyan T. Krishnakumar Satellite Incubation Centre Team: C. Sharmila Bharathi, Head KVK, Kallakurichi; Ashok Chhetri, Assistant Professor, MTTC&VTC, College of Fisheries, Lembucherra, Tripura; B. Shanmugasundaram, Professor, RARS, KAU, Pattambi; Mahesh B. Tengli, Assistant Professor, CPGSAS, CAU, Umiam,Meghalaya	IP & TM, ICAR, New Delhi	(11.99)
26	Demonstration of applications of drones in agriculture	V.S. Santhosh Mithra	Dr. G. Byju D. Jaganathan M.S. Sajeev T. Makeshkumar C. Mohan E.R. Harish		35.00
27	Rainbow diet campaign for Odisha-Development and scaling of customized rainbow diet food matrices for combating malnutrition among children in Keonjhar District, Odisha	Dr.G. Byju (Project leader) P. Sethuraman Sivakumar (PI: Project management) M. Nedunchezhiyan (PI: Product management)	T. Krishnakumar K. Hanume Gowda S.K. Jata & Sandeep Kumar Panda, KIIT, Bhubaneswar Ipsa Mohapatra, KIIT, Bhubaneswar Luna Goswami, KIIT, Bhubaneswar Chandan Goswami, NISER, Khurda Saurabh Chawla, NISER, Khurda	Govt. of Odisha	683.30 (70.00)

Research Highlights

Institute Projects

Crop Improvement

Conservation and utilization of germplasm of tuber crops for sustaining production

Germplasm conservation and evaluation at Head quarters

Cassava

A total of 101 new collections (Kerala) were added to the existing germplasm. The 1216 accessions of cassava comprising indigenous (545), exotic (315), landraces (115) and breeding lines (241) were replanted in the field during 2023-2024 for maintenance, characterization and preliminary evaluation.

A total of 100 accessions were subjected to morphological characterization for 50 traits (33 above ground plant and 17 tuber and yield traits) viz., weight of tubers, fresh weight of foliage, number of storage roots/plant, number of commercial roots, single tuber weight, tuber length, tuber diameter, extent of root peduncle, tuber constrictions, tuber shape, external colour of tuber, color of tuber cortex, color of tuber pulp, ease of peeling of cortex, cortex thickness, texture of tuber epidermis, tuber taste and tuber growth attribute and screening for CMD and mite tolerance.

Among the 100 accessions characterized, variation was noticed in all the traits (Fig. 1). Amongst the plant traits, plant height ranged from 146-310 cm. Nine accessions were short statured with height below 180 cm while, four accessions possessed plant height above 300 cm. Plant type varied from compact (47), cylindrical (4), open (5) and umbrella (44) type. Growth habit of young stem was straight (96) and zigzag (4). Leaf scar was prominent (98) and semi prominent (2). Colour of stem cortex ranged from dark green (72), light green (27) and orange (1). The distance between leaf scars ranged from long (4), medium (41) and short (55). Stem perimeter was as thin as 5.5 cm (CE-192 and CE-231) and thick as 19 cm (CE-38). Mature leaf colour was dark green (92), light green (2) purplish green (5) and purple (1). Leaf lobe margin was smooth (81) and winding (19). Leaf vein colour ranged from green (61), reddish green in less than half of the lobe (22), reddish green in more than half of the lobe (10) and red (7). Petiole orientation was found horizontal (22), inclined upwards (62), inclined downward (6) and irregular (10).

Among the tuber traits, tuber growth direction varied from horizontal (100) to vertical (52) and irregular (49). The tuber peduncle among the accessions varied from sessile (39) to pedunculate (43) and mixed (18). The tuber periderm/external colour varied from the basic dark brown (62) followed by light brown (32) and cream (6). Texture of tuber epidermis showed variations viz., rough (42), smooth (21) and intermediate (37). Root constrictions varied from many (2), some (20) and few to none (78). Ease of peeling varied from easy (83) to difficult (17). The colour of tuber cortex ranged from cream (48), pink (33), purple (18) and yellow (3). Tuber length varied from long (85), medium (10) to short (5) and diameter from wide (63), medium (26) to narrow (11). Three β-carotene rich yellow flesh accessions with sweet taste were identified in cassava (Table 1). The accession CE-430 with highest yellow colour flesh recorded a total carotenoid content of 0.945 mg $100g^{-1}$ FW. CE-71 (27.28 kg) recorded the highest mean tuber weight followed by CE-89 (25.34 kg), CE-48 (21.77 kg), CE-34 (17.87 kg), CE-14 (16.77 kg). CE-25 (15.25 kg) and CE-39 (14.73 kg). The accession CE-108 recorded the highest number of storage roots (26) along with highest number of marketable roots (22). CE-71 had the highest single tuber weight (10.13 kg) followed by CE-48 (7.25 kg), CE-34 (5.83 kg) and CE-219 (5.47 kg).

Among the quantitative traits studied, the mean weight of tuber ranged from 0.23 to 27.28 kg (Table 1). CE-71 (27.28 kg) recorded the highest tuber weight followed by CE-89 (25.34 kg), CE-48 (21.77

Fig. 1. Distribution of important morphological traits in 100 cassava accessions screened

kg), CE-34 (17.87 kg), CE-14 (16.77 kg), CE-25 (15.25 kg) and CE-39 (14.73 kg). The mean fresh weight of foliage ranged from 0.96 to 11.94 kg. CE-198 recorded the highest foliage fresh weight (11.94 kg) followed by CE-152 (11.39 kg) and CE-219 (11.39 kg). The mean number of storage tubers plant^{-1} ranged from 2 to 26. The accessions CE-108 recorded the highest number of storage roots (26) followed by CE-198 (22) and CE-152 (21). The mean number of commercial roots ranged from 1 to

22. CE-108 had the highest number of commercial roots (22) followed by CE-38 (20) and CE-152 (19). The mean single tuber weight ranged from 0.08 to 10.13 kg. CE-71 had the highest single tuber weight (10.13 kg) followed by CE-48 (7.25 kg), CE-34 (5.83 kg) and CE-219 (5.47 kg). Taste of the tuber varied from sweet (36) to intermediate (30) and bitter (34). Five promising accessions with sweet taste and high tuber weight were identified (Table 1).

Biochemical characterization of 60 accessions of cassava was done for starch, sugar, crude fat, crude fibre and total ash on dry weight basis. Among these, starch content on dry weight basis ranged from 52.9 (CE-15) to 81.65% (CE-16A). The promising accessions with starch content >75% were CE-28B (75%), CE-23 (78.4%), CE-31 (79.01%), CE-18 (81.25%) and CE-16A (81.65%). Sugar content ranged from 0.55 (CE-50) to 2.25 (CE-38). Crude fat ranged from 0.25 (CE-40A) to 1.08 (CE-108). Crude fibre ranged from 0.31 (CE-71A) to 1.95 (CE-71 and CE-83). Total ash ranged from 0.61 (CE-14) to 2.05 (CE-38A).

Under the preliminary yield evaluation trial, yield per plant of 420 accessions showed that 7 accessions recorded values above 7 kg [IC0649758 (7.34), IC0649968 (7.79), IC0649622 (7.93), IC0649948 (8.20), IC0649874 (9.09), IC0649610 (10.41) and IC0650003 (11.23)].

The 25 CMD resistant accessions selected from field screening (Table 1) along with Sree Reksha and Sree Sahya as controls, were subjected to molecular screening using Virus-Specific Coat Protein Primer and the

Fig. 2. Distribution map of cassava germplasm based on the passport data information

The distribution map of cassava germplasm based on the passport data information was prepared (Fig. 2).

Cluster dendrogram based on 50 morphological traits grouped the 100 accessions of cassava into 4 main groups. Cluster 1 showed a significantly greater degree of separation than clusters II, III and IV. Cluster IV is the largest one with 48 accessions, Cluster II with 25, Cluster I with 18 and Cluster III was the smallest with 9 accessions. Cluster I and IV showed diverse traits and hence can be used in the breeding programs.

Table 1. Promising accessions identified in cassava

Character	Number of accessions evaluated	Number of promising accessions	Promising accessions
Short statured lines (<180 cm)	100	9	CE-8, CE-9, CE-15, CE-76, CE-122, CE-175, CE-182, CE-192, CE-231
Sweet taste and high tuber weight (>5 kg plant^{-1})	100	5	CE-38, CE-71, CE-140, CE-198, CE-219
β-carotene rich yellow flesh accessions with sweet taste	100	3	CE-174, CE-348 and CE-430
CMD resistant lines	100	25	CE-28A, CE-38, CE-48, CE-50, CE-89, CE-90, CE97, CE-99, CE-108, CE-114, CE-127, CE-142, CE-144, CE-152, CE-166, CE-272, CE-273, CE-279, CE-326, CE-331, CE-338, CE-403, CE-428, CE-456 and CE-594A
High yielding lines (>7 kg plant^{-1})	420	7	IC0649758, IC0649968, IC0649622, IC0649948, IC0649874, IC0649610 and IC0650003
High starch content (>75%)	60	5	CE-28B, CE-23, CE-31, CE-18 and CE-16A

Sweet potato

Fifteen diverse accessions of sweet potato collected from Meghalaya (4), Kerala (1), Arunachal Pradesh (5), Karnataka (3) and Tripura (2) were added to the field gene bank (FGB). A total of 905 accessions of

sweet potato are being maintained in the FGB for conservation and characterization.

One hundred and ten accessions were characterized for 30 morphological traits including 17 above ground traits (plant type; ground cover; 4 vine traits viz., vine internode length, vine internode diameter, vine colour and vine tip pubescence; 2 Petiole traits viz., petiole length and pigmentation; 8 leaf traits viz., outline of leaf, leaf lobe type, lobe number, shape of central leaf lobe, mature leaf size, abaxial leaf pigmentation, mature leaf colour and immature leaf colour) and 13 tuber traits (storage root shape, surface defects, cortex thickness, predominant skin colour and intensity, secondary skin colour and intensity, predominant flesh colour and intensity, secondary flesh colour and intensity, latex production and oxidation) as per IPGRI descriptor. Apart from this, 146 sweet potato accessions were characterized for 17 above ground characters and 199 accessions for tuber flesh and skin colour. The identified lines are given in Table 2.

Molecular characterization of 103 sweet potato accessions was done with six SSR markers. The 103 accessions grouped into three major clusters and five sub clusters. The percentage polymorphism observed was 83.3%. Two hundred sweet potato accessions and 20 released varieties were established in pots inside the polyhouse for bench conservation.

Table 2. Promising accessions identified in sweet potato

Character	Number of accessions evaluated	Number of trait specific accessions	Trait specific accessions identified
Weevil resistance (Moderately resistant)	54	4	S-1248, S-27, S-1470, S-1456
Suitable for fried chips with dry matter content (>20%)	54	8	S-27, S-1470 S-1653, S-1403, S-1401, S-1456, S-1668, S-1712

Yams

A total of five accessions of yams were collected from Kerala (4) and Arunachal Pradesh (1) and planted for characterisation as per the DUS guidelines. Eight hundred and one accessions of yams, comprising greater yam (450). white yam (98), lesser yam (185), potato yam (3) and wild yam (65) were maintained in the field gene bank.

For evaluating greater yam germplasm accessions for anthracnose, 54 lines were screened under field condition in the first season, of which, 33 showed resistance to anthracnose. Twenty two accessions were highly resistant and 11 moderately resistant (Table 3). In the second season (2024-2025), 47 greater yam accessions were screened of which, 18 showed resistance to anthracnose across both seasons. Six were highly resistant and 12 were moderately resistant (Table 3). The resistant lines are valuable materials for the development of anthracnose resistant yam varieties in future.

Morphological characterization of 50 lesser yam accessions for 45 vegetative traits (32 leaf characters and 13 stem characters) based on IPGRI descriptors were recorded. Much variability was observed in stem waxiness, twinning direction, presence of hair and spine on stem, whereas, little or no variability were observed in nearly seven traits. Flowering was not observed this year in any of the accessions. Twenty seven accessions of lesser yam were tested for the presence of Yam mild mosaic virus using DAC-ELISA, followed by RT-PCR with virus-specific primers. Out of these, 22 samples (De 4, De 6, De 11, De 13, De 14, De 16, De 19, De 20, De NL, De 36, De 43, De 44, De 45, De 49A, De 56, De 57, De 59, De 62, De 63, De 65, De 67, De 69) tested positive for the virus, while 5 samples (De 24, De 28, De 34, De 42, De 58) tested negative. Among white yam, 30 accessions were evaluated for 66 vegetative characters based on IPGRI descriptors were recorded. Notable variability was observed in stem number, spine characters and petiole colour.

Under molecular characterization, a genomic DNA isolation method without liquid nitrogen was developed for white yam and compared with other methods. DNA from white yam tuber samples of seven genotypes was prepared by alcohol-drying, freezing and oven drying as well as fresh tubers. The quantity, quality and PCR-fidelity of isolated DNA from these methods were compared to liquid nitrogen-based extraction. Alcohol-dried tuber samples gave better quality DNA. Apart from this, molecular

characterization of 32 white yam genotypes was carried out with 11 ISSR markers and dendrogram constructed using DARWIN.

Table 3. Promising accessions identified in yam

Character	Crop	Number of accessions evaluated	Number of trait specific accessions	Trait specific accessions identified
Anthracnose resistance (highly resistant)	Greater yam	101	28	CI-4, Da-12-A, Da-27, Da-31, Da-72, Da-73, Da-127, Da-161-A, Da-205, Da-388, Da-489, Da-496, Da-502, Da-515, Da-523, Da-601, Da-610, Da-621, Da-1004, DaH-10-3-28, DaH-7-590, DaH-9-35-16, DAS-67, GY-24, GY-58, TCR-66, TCR-160 and TCR-281
Anthracnose resistance (moderately resistant)	Greater yam	101	23	Da-11, Da-2, Da-40, Da-46, Da-58, Da-63, Da-93, Da-94, Da-110, Da-239, Da-243, Da-298, Da-343, Da-367, Da-384, Da-493, Da-506, Da-524, Da-527, DaH-9-75, DAS-19, TCR-43 and TCR-222

Edible aroids

Forty five edible aroids were added to the field genebank comprising elephant foot yam (1); taro (43) and tannia (1). The collections were made from Kerala (30), NEH region (11), Karnataka (3) and Chhattisgarh (1). IC Nos. were obtained for the unique purple taro accession (ADSR/2020-1 – IC652061) and tannia (Xa-MTS local - IC652281) from ICAR-NBPGR. Six hundred and fifty five edible aroid germplasm comprising 409 taro, 200 elephant foot yam, 42 tannia and 4 *Alocasia* are maintained in the field genebank at ICAR-CTCRI, Thiruvananthapuram.

Morphological characterization of 11 taro accessions for 29 above ground morphological traits as per a combination of NBPGR and IPGRI descriptors was done. Most of the characters showed variation except leaf base shape which was peltate in all the accessions.

Under evaluation trials, flesh colour of 12 elephant foot yam entries was done and photo documented. All of them recorded yellow flesh colour. Ten elephant foot yam accessions comprising two varieties (Sree Padma and Gajendra) and eight AICRP entries (TEy22-1 to TEy22-8) were tested for *Melodoigyne incognita* (root knot nematode) resistance under field condition. Two entries were rated as resistant with a score of 1 (Table 3); five moderately resistant with a score 2 (TEy22-2, 4, 5, 7 and 8) and both the checks moderately susceptible with a score of 3. Calcium oxalate content of a five taro accessions were done which ranged from 0.22 to 1.70% DW of which, three recorded values <0.5% (Table 3). Storability was recorded in 25 taro accessions after 40 days of harvest, the yield loss ranged from 4.8% (IC204205) to 36.5% (IC394399).

Preliminary yield evaluation of 35 taro accessions showed that three accessions recorded high cormel yield of >10 t ha^{-1} (Table 4) and total yield of >15 t ha^{-1}. Corm yield of >5 t ha^{-1} was recorded in the bunda type taro, Colocasia NCV. In a second set comprising 25 taro accessions, cormel yield of >10 t ha^{-1} was recorded in nine accessions (Table 4) and total yield of >15 t ha^{-1} was recorded in nine accessions. Corm yield >5 t ha^{-1} was recorded in three accessions. Amongst these, two accessions recorded corm yield >5 t ha^{-1}, cormel yield >10 t ha^{-1} and total yield >15 t ha^{-1} (C-110 and C-553). Preliminary yield evaluation of 30 tannia accessions showed that two accessions recorded cormel yield >10 t ha^{-1} and total yield >14 t ha^{-1} (Table 4). Preliminary yield evaluation of 37 elephant foot yam accessions showed that three accessions recorded corm yield of >18 t ha^{-1} (KSBB-14/2024/AKI-1, Am-64 and AC-78).

Molecular characterization was done for 16 taro accessions using 12 ISSR markers. No duplicates could be identified from this set. They were grouped into two major clusters and three divergent lines were identified (NEH-109, RNCA-1 and NEH-77). The 12 ISSR primers showed an average percentage polymorphism of 80.92%.

Minor tuber crops

A total of 25 minor tuber crops accessions comprising Chinese potato landraces (15) and Queensland arrowroot (10) were added to the field gene bank. Chinese potato, collections were made from Kerala (9),

Table 4. Promising accessions identified in edible aroids

Character	Crop	Number of accessions evaluated	Number of trait specific accessions	Trait specific accessions identified
High cormel yield (>10 t ha^{-1})	Taro	60	12	U-89, Kelva, BCC-38, C-110, C-553, AAV/2022-14, CA-82, CA-76, IC211388, C-286, U-89 and TCR-531
Good shelf-life with less than 5% loss after 40 days of harvest	Taro	25	1	IC204205
High yielding (>15 t ha^{-1}), with good tuber shape and low acridity (0.18% DW)	Taro	5	1	ADG/2022-1
Low acrid lines (<0.5% DW basis)	Taro	5	3	ADG/2022-1, TTr22-6 and TTr22-5
High cormel yield >10 t ha^{-1} and total yield >14 t ha^{-1}	Tannia	30	2	Xa-63 and Xa-AD/2014-18
Root knot nematode resistant lines	Elephant foot yam	10	2	TEy22-1 and TEy22-6

Karnataka (1) and Tamil Nadu (5), whereas, in Queensland arrowroot, collections were made from Tamil Nadu (1) and Kerala (9). A total of 387 minor tuber crops accessions comprising Chinese potato (150), yam bean (154), West Indian arrowroot (12), Queensland arrowroot (20), East Indian arrowroot (50) and *Curcuma zedoaria* (1) are maintained in the FGB.

Queensland arrowroot: Germplasm characterization of the 10 edible *Canna edulis* accessions from the Palani hills of Kodaikanal Western Ghats showed significant phenotypic and genetic diversity. Rhizome fresh weight, starch content, plant height, and moisture content showed notable variation ranging from 1.88 to 4.78 kg plant^{-1}, 8.4 to 16.9%, 139 to 235 cm, and 64.0 to 71.2%, respectively. Proximate composition analysis revealed an average nutrient profile of 69.1% moisture, 11.82% starch, 0.62% sugar, 0.58% fiber, 0.53% fat and 0.96% ash. Principal component analysis identified two major clusters: One with green parthenocarpic capsules and another with red capsules containing black fertile seeds.

Molecular analysis using 12 ISSR markers confirmed genetic divergence, revealing two distinct clusters, with Kodalangadu and Agasthi S-IV forming a separate group and Agasthi S-V as an outlier. Kodalangadu stood out both in morphological and molecular characterization due to its unique reddish-orange flowers, green parthenocarpic capsules, highest rhizome weight (4.78 kg plant^{-1}), and starch content (16.9%), making it as a promising candidate for breeding and development. The results emphasize the potential of these underutilized germplasm for agronomic and industrial applications.

Chinese potato: The study on the morphological and molecular characterization of Chinese potato was conducted to analyze the diversity among 10 landraces and varieties (Sree Dhara and Nidhi) collected from Kerala and Tamil Nadu. Morphological characterization included 27 traits. Results revealed significant variability in traits such as tuber weight, shape, color, size, and aroma with environmental factors contributing to morphological differences. Among these, Kulaparachal exhibited the highest tuber yield with a maximum weight of 637 g per replication, followed by Ettayapuram and Tenkasi. Low-yielding accessions were Varavoor and Kovilpatti. The accessions also displayed differences in tuber shape, ranging from globose to oblong, and flesh color, with most having white flesh except a few with light yellow.

Molecular characterization using ISSR, SSR, and RAPD markers revealed significant genetic diversity among the accessions, with ISSR markers showing the highest polymorphism followed by RAPD and SSR. Landraces Kulaparachal and Vandanmedu displayed the most variability, confirming their potential as sources of genetic diversity for breeding. The study highlights Kulaparachal as a high-performing variety in terms of tuber yield and size, making it a strong candidate for cultivation and further breeding programs.

East Indian arrowroot: Ten genotypes of East Indian arrowroot (*Curcuma angustifolia*), comprising eight landraces, a released variety, and a wild species were evaluated for phenotypic and biochemical traits to identify superior genetic stocks. CTCRI-

CA-PM-1, a landrace from Kerala, demonstrated the best performance, featuring a long primary rhizome (21.25 cm), high starch content (16.8%), substantial rhizome yield (709.8 g per plant), and excellent dry recovery (19.15%). Other promising selections included IGSJT-10-2 (Chhattisgarh Tikhur-1) and IGDMT-10-1 (from Dhamtari, Chhattisgarh).

Yam bean: The yam bean (*Pachyrhizus erosus*) Havelock landrace (IC635945), collected from the Andaman & Nicobar Islands, was evaluated along with the RM-1 variety during 2022–2024. The study revealed significant differences in phenotypic and biochemical traits between the two accessions. The Havelock landrace exhibited unique characteristics, including longer vine growth (108.5–111.5 cm), higher flower density, elongated pedicels (4.1–4.4 cm), cylindrical tubers, and distinct globose seeds. In contrast, RM-1 displayed shorter vine growth (78–82.5 cm), lower flower density, shorter pedicels (2.1–2.3 cm), fusiform tubers, and square seeds with curved edges. Biochemical analysis showed that the Havelock landrace tuber had higher moisture and starch content, while RM-1 exhibited higher fat content.

Germplasm conservation and evaluation at Regional Station

At the Regional Station, ICAR-CTCRI, Bhubaneswar, a total of 1270 germplasm accessions comprising taro (510), sweet potato (380), cassava (113), yams (51), elephant foot yam (40), yam bean (165), Chinese potato (5), arrowroot (2), tannia (1) and *Alocasia* (3) are conserved in the field gene bank. Five new taro germplasm were collected from Ranchi (4) and Assam (1).

Sweet potato

For the development of phenological growth stages in sweet potato as per the improved BBCH (Biologische Bundesanstalt, Bundessortenamnt and ChemischeIndustrie) scale, a study was initiated and the phenological growth stages of sweet potato are described here for the first time. There are nine primary growths that have been specifically defined, including bud (stage 0), main shoot (stage 1), leaf (stage 2), side shoot (stage 3), tuber development (stage 4), inflorescence emergence (stage 5), flowering (stage 6), fruit (stage 7), fruit maturation (stage 8), and senescence (stage 9) (Fig. 3).

Fig. 3. Sequential progression of principal growth stages of sweet potato in eastern region of India

Biochemical characterization of 25 sweet potato accessions was done for minerals (P, K, Fe, Mn), vitamin C, protein and their anti-oxidant activity. Results showed that the highest P and K content were 0.628% (CO3-50-33) and 1.21% (S-19), respectively whereas, the highest Fe and Mn content were 221.8 ppm (CO3-50-33) and 284.1ppm (KS-2), respectively. Among these accessions, highest amount of vitamin C was 29.94 mg $100g^{-1}$ (KS-12) and protein content is 2.74 g 100 g^{-1} (KS-2). Lower the IC_{50} value higher is the antioxidant activity and the lowest IC_{50} value was observed to be 14.14 µg ml^{-1} (KS-12).

For molecular characterization, 30 sweet potato accessions were tested using 10 SSR markers. The mean PIC value for the SSR markers was 0.584. The mean of major allele frequency was 0.48. The observed heterozygosity in the mean value was 0.89 which was more than the mean expected heterozygosity value 0.57. Based on Jaccard's similarity coefficient the highest similarity coefficient shown between cultivars was 0.85, while the lowest percentage similarity coefficient was 0.16. The average similarity value was 0.64. The 30 sweet potato accessions were grouped into two main clusters. Similarly, on analyzing the Cophenetic similarity coefficient matrix, highest similarity percentage obtained was 0.82 and the lowest similarity percentage was 0.25. The mean similarity percentage was 0.63 which is near to the mean value of Jaccard's similarity coefficient.

Taro

Biochemical characterization of 25 taro accessions was done for mineral content (P, K, Fe, Mn, Cu),

protein content, and antioxidant activity. The highest P and K contents were 350.85 mg 100 g^{-1} (CL-56) and 1027.20 mg 100 g^{-1} (NEH-44), respectively, while the highest Fe and Mn contents were 10.91 mg 100 g^{-1} (NEH-14) and 5.14 mg 100 g^{-1} (Megh-19). The highest copper and zinc contents were 0.74 mg 100 g^{-1} (Ciruli local) and 5.63 mg 100 g^{-1} (Pipply). The maximum concentration of phenolics among these genotypes was 4.57 mg gallic acid g^{-1} (Ciruli local) and highest protein content was 11.27 g 100 g^{-1} (CL-56). The highest antioxidant activity using the CUPRIC assay was 15.93 µ moltrolox g^{-1} (CE-12) and the DPPH assay was 35.89% (Megh-18).

Yam bean

Biochemical characterization of 25 yam bean genotypes was done for protein, vitamin C, minerals (P, K, Fe, and Mn), and antioxidant activity. The results indicated that the highest P and K contents was achieved in RM1 (0.292%) and DPH6 (0.357%), respectively, while the highest Fe and Mn content was obtained in L.No.3 (280.55 ppm) and L.No.19 (86.59 ppm), respectively. The genotypes with the highest protein content of 2.72g 100g^{-1} (DPH10) and vitamin C content of 23.71 mg 100g^{-1} (LNo3) were identified. High antioxidant activity was exhibited by lower IC_{50} values and the lowest IC_{50} value was found as 462.47µg ml^{-1} (L.No.3).

In vitro conservation of tuber crops

At the headquarters, a total of 104 accessions comprising cassava (45), sweet potato (10), yams (32), taro (5), East Indian arrowroot (9) and arrowroot (3) accessions are being maintained under IVAG spanning 1221 tubes, with 571 cassava, 274 sweet potato, 330 yams, 6 taro, 31 East Indian arrowroot and 9 arrowroot tubes, respectively.

At the Regional Station, around 300 cultures comprising pre-released lines and released varieties are maintained *in vitro*. These cultures includes cassava released varieties (10), sweet potato varieties (11), taro varieties (5), yam varieties (4), elephant foot yam varieties (2), and Chinese potato (4).

Bio-prospecting for novel traits in tuber crops

For studying the antiangiogenic effect as well as wound migration effect of leaves of coloured taro and tannia, ethanol extract was prepared from purple coloured taro leaf (IC652061) (ADSR) and *Xanthosoma violaceum* (Xa-AAV/2022-11) (VIOL). The antiangiogenic effect as well as wound migration effect of both extracts was studied using Zebra fish model system. This study investigated the wound healing and regeneration-inducing potential of plant extracts ADSR and VIOL using zebra fish. Based on the toxicity data, three doses (30, 60, and 120 µg/ml) of both extracts were selected. Zebra fish larvae, 72 h post-fertilization, were amputated at the tail end and treated with ADSR and VIOL extracts. The larvae were maintained for three days along with normal control (NC) and solvent control (DMSO), and tail regeneration was photographed using an inverted microscope. The total area of tail growth was quantified using ImageJ software. The results showed that ADSR induced significantly higher tail regeneration compared to VIOL. The 120 µg/ml dose of ADSR exhibited the most prominent regeneration activity, compared to untreated control and DMSO groups (Fig. 4). The zebra fish tail regeneration model provides valuable insights into regenerative biology, offering a robust system to study tissue repair and regeneration at the molecular, cellular, and genetic levels. Understanding the regeneration process in zebra fish could potentially inform therapeutic strategies for human conditions such as trauma recovery, tissue degeneration, and cancer, ultimately advancing regenerative medicine and tissue healing techniques. Further, antibacterial effects of these two ethanol extracts were studied by agar well diffusion method. 1 mg dose of ethanol extract of VIOL imparted anti bacterial effects towards *Klebsiella pneumonia* and *Vibrio cholera* with a zone of inhibition of 9 mm diameter. Ethanol extract of ADSR showed antibacterial effect towards *Bacillus*

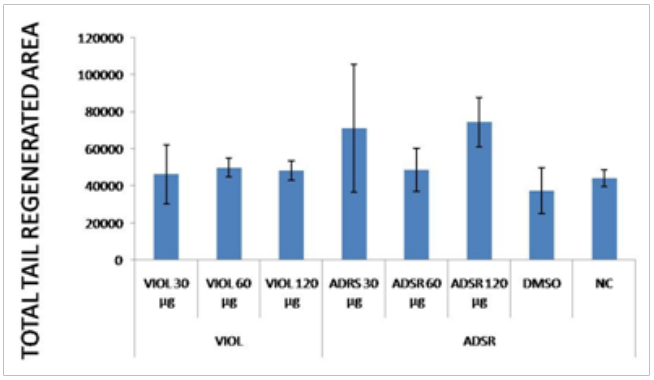


Fig 4. Effect of ethanol extract of purple coloured taro leaf ADSR/2020-1 (IC652061) and *Xanthosoma violaceum* Xa-AAV/2022-11 (VIOL) on regeneration of Zebra fish tail

subtilis and *Streptococcus pyogenes* indicated by a 9 mm zone of inhibition indicating that both extracts showed antibacterial effects at higher concentrations of 1 mg.

Genetic improvement of tuber crops through conventional breeding and molecular approaches

Breeding to evolve trait specific varieties in cassava, yams and arrowroot for productivity, earliness, quality and resistance to biotic stresses

Cassava

Ten and 20 cassava breeding lines were evaluated for earliness and fried chips quality, respectively. Of these, four genotypes namely 15S-41, 17S-48, 6-4 and 17S-247 showed tuber bulking as early as 3 MAP and 2 genotypes (CRNR-1 and II-3) is suitable for fried chips based on sensory evaluation using a 9 point hedonic scale.

Yams

Sree Dhrona (SD-15), a semi dwarf white yam variety was released through the State Variety Release Committee (SVRC) for the state of Kerala. Sree Dhrona is a non-trailing white yam variety with high yield of 35 – 45 t ha^{-1} having a potential yield of 52 t ha^{-1} (Fig.5). It has sparsely spiny green vines twining to right with dark glossy unifoliate narrow leaves having wavy margin. It has medium cylindrical smooth tubers with good cooking quality and compact tuber shape. The starch percentage ranges from 23.2 – 28.5%. It has 8-9 months duration and can be grown both under non trailing and trailing conditions in Kerala.

Fig. 5. Sree Dhrona, a semi dwarf white yam variety grown under non-trailing condition and tuber

Arrowroot

In arrowroot, two high yielding varieties were released centrally during the 31st meeting of the Central Sub-Committee on crop standards, notification and release of varieties for horticultural crops held on 19 July 2024 viz., Sree Nakshathra (IC650786) for the states of Chhattisgarh and Jharkhand and Sree Karti (IC650789) for the states of Kerala, Tamil Nadu and Manipur.

Sree Nakshathra is the first variety in arrowroot released centrally for the states of Chhattisgarh and Jharkhand with an average rhizome yield of 32.25 t ha^{-1}, potential yield of 39.55 t ha^{-1}, starch content of 26.63% and starch yield of 8.59 t ha^{-1} (Fig. 6).

Fig. 6. Arrowroot variety Sree Nakshathra

Sree Karti on the other hand, is the first variety for Kerala, Tamil Nadu and Manipur with an average yield of 23.57 t ha^{-1}, potential yield of 41.46 t ha^{-1}, starch content of 21.52% and starch yield of 5.07 t ha^{-1} (Fig. 7).

Fig. 7. Arrowroot variety Sree Karti

Another arrowroot variety Sree Aadya (IC650781) was released by the 29th State Seed Sub-Committee for Varietal Release for the State of Kerala. This is the first high yielding variety of arrowroot recommended for the State (Fig. 8). Sree Aadya recorded an average rhizome yield of 30.04 t ha^{-1} and potential yield of 49.0 t ha^{-1}. This variety was identified as the best one for processing having a high starch yield of 5.95 t ha^{-1}. In this variety, the plant height ranges from 100.36-136.70 cm, number of tillers per plant ranges from 8-11 and the average number of rhizomes per plant was 18.

Fig. 8. Arrowroot variety Sree Aadya

Map based cloning of CMD resistant gene(s) and identification of markers associated with drought tolerance and high starch content in cassava

CMD mapping population

Twenty high yielding CMD resistant clones, producing 4-6 kg per plant with high starch content, were identified from the CMD-resistant clonal selection done in the Sree Jaya and 9S-127 populations. To study the nature of gene action for CMD resistance in 9S-127 parent (Heterozygous-Rr), 80 seedling progenies developed by self-pollination and segregating in the 3:1 ratio were selected and from these, 57 C_1S_1 clones were established in the field to identify homozygous resistant lines using CMD associated SNP markers. Among 250 CMD resistant clonal (C_1F_1) populations, 156 clones were selected that had yield of 4-5 kg per plant and planted as C_2F_1 - clones and established in the field for yield and biometric observations. For CMD resistance study, 430 C_1F_1 clones were planted in row trial to identify resistance with good plant type.

For identification of markers, transcriptome study was done. In treatment cages, both the parents Sree Jaya and 9S-127 were challenge inoculated with viruliferous whiteflies. Next generation sequencing techniques were used for transcriptome profiling of both control and whitefly challenged samples. The data revealed that 233 genes were up-regulated and 52 genes were down-regulated in the susceptible parent Sree Jaya, whereas 159 genes were up-regulated and 426 genes were down-regulated in 9S-127, the resistant parent under *Sri Lankan cassava mosaic virus* (SLCMV) infection. In addition, DEG comparison between SLCMV challenged Sree Jaya and 9S-127 showed, 1,242 and 327 upregulated and downregulated genes, respectively. Among the DEGs, Long Chain Acyl-CoA Synthetase1, WNK11, PERK1, Gibberellin 2-Beta-Dioxygenase1 genes were downregulated in the susceptible parent.

The expression levels of selected candidate genes were validated by qRT-PCR to corroborate their differential expression upon SLCMV infection in resistant and susceptible cassava parents. Furthermore, 26,622, 18,044 SNPs and 5,550, 4,349 InDels were identified in 9S-127 and Sree Jaya, respectively upon SLCMV infection. Among these, 12,685, 7,147 SNPs were present only in the exonic regions in 9S-127 and Sree Jaya, respectively. The SSR motifs TC, AG, CT and GA were the most common types, accounting for 32.63, 26.50, 17.25 and 26.02%, respectively in SLCMV challenged 9S-127 resistant line. From the transcriptome study, 12 functional markers linked to key genes correlated with the response to biotic stimulus and regulation of defence response were obtained.

Starch mapping population progenies

The physical and biochemical properties of sixteen cassava genotypes comprising released varieties (12) and advance breeding genotypes (4) from the breeding trial were included in this study. The plant morphological and tubers characters of the 16 cassava genotypes were recorded. The dry matter content (DMC), starch, sugar, amylose, amylopectin, crude fibre, ash and water activity, colour properties and viscosity of starch of the cassava genotypes were studied and lot of variation found for all these characters.

Drought tolerant population

In the drought tolerant population, 200 C_1F_1 cassava clones were evaluated. The yield of the harvested clones ranged from 3 to 4 kg per plant. The selected 114 C_2F_1 clonal generation were planted and established in the field for drought screening and biometric observations.

Genetic analysis and QTL mapping for determining genetic basis of PPD tolerance and enhanced shelf life in cassava

Post harvest physiological deterioration (PPD) evaluation of cassava genotypes

The second season PPD evaluation of nine pre-release breeding lines and varieties of cassava grown under irrigated and rainfed conditions was done 5 days after harvest and two cassava genotypes KBH-18 and 15S-247 were tolerant to PPD under both irrigated and rainfed conditions.

Clonal progenies evaluation

The evaluation of 315 clonal progenies, along with their parents, recorded per plant yield ranging from 1.54 to 5.6 kg. The average PPD score was 2.78 and CMD score was 2.11. Fourteen selected progenies were planted in a replicate trial for preliminary yield trial-1 (PYT-1) along with checks and parents.

Phenotyping and genotyping of the mapping population

The mapping population (200) was phenotyped for PPD tolerance using visual assessment scale at 3, 5, 7, 10, 15 and 20 days after harvest and distinct segregation for PPD tolerance was observed. Twenty-four markers out of 47 markers screened were selected for progeny screening based on parental polymorphism study and the mapping population was screened with 15 markers. In addition, 140 SSR markers were designed based on transcriptome data analysis and 28 markers were validated.

Yield trials

Five cassava progenies namely, CI-13, CI-19, CI-20, CI-23 and CI-26 were selected as the best performers for On-Farm Trials (OFT) and AICRP trials during 2024-25 based on four year on-station yield trials. PPD evaluation over four years identified CI-26 as the highly tolerant genotype with a shelf life ranging from 30-40 days. Three on-farm trials of five selected progenies were initiated and are in progress in three different agro-ecological units of Kerala namely, AEU-10, AEU-9 and AEU-3. Under the Advanced Yield Trial-1 (AYT-1), the CMD scoring of 13 clonal progenies with PPD tolerance up to seven days after harvest was done at 3, 6 and 9 MAP. The average yield per plant was 4.12 kg and the CMD score at 3 MAP was 1.14. The average dry matter content recorded was 34.25%. The selected 10 PPD tolerant progenies were replanted for AYT-2.

Genome analysis, identification and functional characterization of early bulking genes in cassava, abiotic stress and tuberization responsive genes in sweet potato

In cassava, genome-wide mining for microsatellite repeats resulted in the identification of 17,671 genic (gene-based) markers and 28,231 non-genic (markers other than genic region). Both genic and non-genic markers were seen to be spanning in all the 18 chromosomes of cassava. Out of the 26 SSR markers studied, four markers viz., MeESSR34, MeESSR39, SSRY28 and SSRY45 displayed polymorphism among 32 cassava genotypes. In sweet potato, out of ten genes studied, three genes *Pyrroline-5-carboxylate reductase* (*IbP5CR*), *DREB transcription factor* (*IbCBF3*), *ARF transcription factor* (*IbARF5*) displayed enhanced expression in the leaf tissues of the drought-tolerant variety Sree Kanaka in comparison with the drought-sensitive variety Kanjangad Local under drought stress conditions. Out of the 18 SSR markers studied, five SSR markers viz., Ib182, Ib2082, Ib244, Ib1845 and Ib346 displayed high polymorphism among 20 sweet potato genotypes.

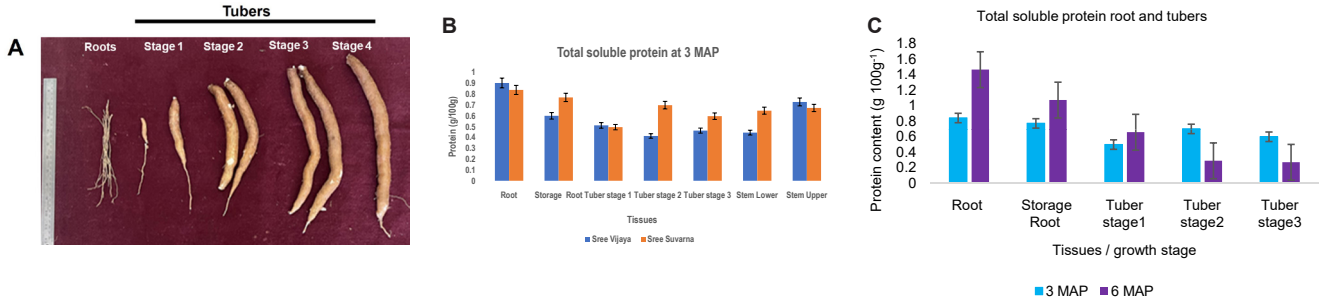
Molecular characterization of nutrient homeostasis in tubers for biofortification of cassava

Nutrient profiling in cassava

Eleven cassava genotypes were selected for nutrient (protein and β-carotenoid) profiling. various tissues such as roots, tubers at different growth stages, stems and leaves from upper and lower regions, of seven cassava genotypes at 1, 2, 3, 6 and 8 months after planting (MAP) were tested. Total soluble protein content estimated using Lowry's method in the dried and powdered tissues at 3, 6 and 8 MAP from Sree Suvarna and Sree Vijaya showed that, leaves had the highest protein content followed by stem. Tubers had the lowest protein content at 3 MAP. Total soluble proteins were higher in tubers of Sree Suvarna (0.43-1.04 g 100 g^{-1}) when compared to Sree Vijaya (0.24-0.62 g 100 g^{-1}) at 3 MAP. There was no significant difference in the protein content between the two varieties ($P>0.05$). Comparison of total soluble protein content in Sree Suvarna at 3 and 6 MAP showed that the protein content decreased with the tuber development stage and age or growth of plant (Fig. 9).

In silico comparison of tuber specific protein

In silico comparative analysis of tuber-specific proteins such as patatin and sporamin in cassava genome indicated that unlike patatin of potato with 23 amino acid N terminal signal sequence MATTKSFLILFFMILATTSSTCA, cassava protein (A0A2C9TZX6_MANES, 44 kDa, 408 AA)



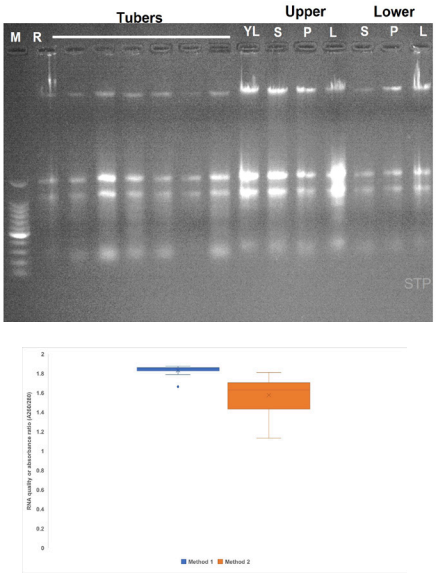
A. Tubers at different developmental stages at 8 months after planting; B. Total soluble protein content (g 100g^{-1} dry weight) in various tissues of Sree Suvarna and Sree Vijaya at 3 MAP; C. Total soluble protein content in roots and tubers of Sree Suvarna at 3 and 6 MAP.

Fig. 9. Total soluble protein content in various tissues of cassava varieties

showed maximum (77%) homology to *Dioscorea zingiberensis* patatin and did not possess an N terminal signal sequence. Sporamin A and sporamin B protein genes of sweet potato had 23 amino acid vacuolar targeting and 21 amino acid N terminal sequences, respectively. However, both sporamin A and B proteins did not show significant similarity with any gene in cassava genome. Absence of tuber-specific or vacuolar targeting or N terminal signal sequences in cassava proteins may be responsible for the low protein content in tubers.

Standardization of RNA isolation protocol

Trizol® method was unsuitable for RNA extraction from starch-rich tubers since sticky agglomerate is formed with Trizol® reagent. Hence, two modified protocols were tested for RNA isolation from cassava tubers and other tissues. The modified method 1 yielded RNA of good quality ($A_{260/280}$ = 1.664-1.873) and quantity than second method ($A_{260/280}$: 1.132-1.181) and was chosen for differential gene expression analysis in all tissues of cassava such as roots, tubers, leaves and stem (Fig. 10).



A. RNA isolated using modified method 1 from various tissues such as roots (R), tubers at various developmental stages, young leaf (YL), stem (S), petioles (P), and leaves (L) of the upper and lower region of the plant. B. Box plot showing absorbance ratio at 260 and 280 nm (A 260/280) of isolated RNA in two methods

Fig. 10. Standardization of RNA isolation from tubers and other tissues of cassava

Differential gene expression analysis

Primers were designed for nine candidate genes possibly involved in protein metabolism and for control gene ubiquitin and PCR conditions were standardized. Differential gene expression analysis for nine genes was carried out by semiquantitative RT-PCR using RNA isolated from various tissues of Sree Vijaya and Sree Suvarna with the *ubiquitin* (*UBQ*) gene as control. Three genes involved in protein degradation, inhibition of protein degradation and methylation were differentially expressed in cassava tissues (Fig. 11).

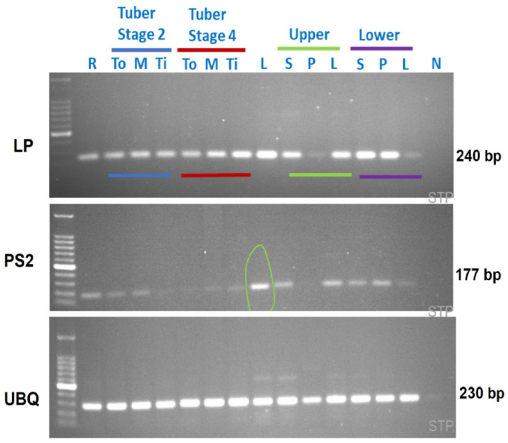


Fig. 11. Differential gene expression analysis in cassava
Semi-quantitative RT-PCR using candidate genes in various tissues of Sree Vijaya variety. R: roots, To: top, M: middle, Ti: tip of tubers, L: leaves, S: stem, P: petioles of upper and lower region of cassava plant and N: negative control. *UBQ* is the control gene *ubiquitin*

Standardization of protocol for Isolation of total soluble proteins and protein expression analysis

Two protocols with two extraction buffer compositions were tested for isolation of total soluble proteins from all tissues including tubers of Sree Suvarna and Sree Vijaya. Protein quality and quantity were compared using one-dimensional SDS-PAGE and Bradford assay, respectively. Protein quality was high and bands were distinct in the phenyl methyl sulphonyl fluoride (PMSF)-based extraction buffer although protein concentration was lower when compared to second method. Protein profiles did not vary in root and various tuber stages. A protein band of 17-20 KDa was differentially expressed in roots, tubers at various developmental stages and lower stem, but absent from aerial plant parts such as leaves and the upper portion of the stem (Fig. 12). The protein was extracted from the gel and when analyzed by LC-MS (liquid chromatography-mass spectrometry), exhibited maximum similarity to small heat shock protein. Small heat shock proteins are known to be involved in protein folding and heat response and possibly in protein metabolism in cassava.

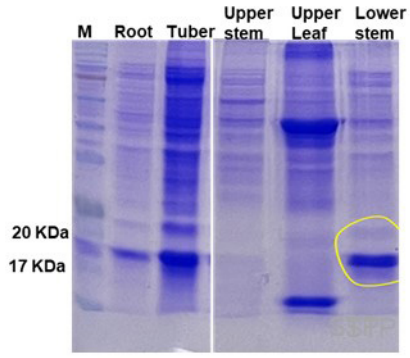


Fig. 12. SDS-PAGE of total soluble proteins isolated from various tissues of cassava variety Sree Suvarna. M - high molecular weight protein ladder

Estimation of beta carotenoid content

Beta carotenoid content was estimated from freshly harvested tubers of two breeding lines of cassava (NV 23-1 and NV 23-3), and five varieties (Sree Suvarna, Sree Swarna, Sree Prabha, Sree Reksha and Vellayani Hraswa) at 5 MAP. After extraction with hexane and acetone, the absorbance of extract was measured at 450 nm in spectrophotometer. NV 23-3 had high beta carotenoid in tubers (292.3 µg 100 g^{-1}) comparable to beta carotenoid content in tubers of Sree Swarna (332.8 µg 100 g^{-1}) and Sree Prabha (352.7 µg 100 g^{-1}), while NV 23-1, a line with white tubers had 212.35 µg 100 g^{-1} beta carotenoids in tubers. After cooking, the yellow colour of the tubers increased and was more distinct.

Phenomics approaches for physiological trait-based breeding for drought and PPD tolerance in cassava

The phenomics project focuses on applying advanced AI technologies to interpret phenotypic data for enhancing the understanding of plant traits to improve cassava breeding processes for developing drought tolerant varieties. For drought tolerance, 25 C_2 - clones from the cross between H-97 x 9S-127 were planted in controlled and drought conditions. From this, 15 C_2 clones and the parents are used for recording physiological characters *viz*., plant height, leaf retention, leaf area index (LAI), canopy temperature at 15 days interval, along with drone image using RGB camera. However, the chlorophyll content, carotene content, osmolytes content, photosynthesis rate and chlorophyll florescence were recorded at 60 days interval.

Under physiological characters, variation was noted for all the characters studied between plants raised under drought, control and parents.

Photosynthesis

Net photosynthesis variation: There was a significant diversity in the photosynthetic rates among cassava genotypes, with rates ranging from 10 ± 1.8 µmol m^{-2} s^{-1} in D21/10 to 30 ± 3.9 µmol m^{-2} s^{-1} in D21/17, highlighting a notable genetic variation in photosynthetic capability.

Stomatal conductance: Stomatal conductance varied among genotypes from 0.2 ± 0.019 m mol m^{-2} s^{-1} in D21/16 to 0.5 ± 0.0087 mmol m^{-2} s^{-1} in 9S127, reflecting differences in water vapor exchange which can affect the plant's water use efficiency and adaptability to environmental conditions.

Transpiration rates: There was a broad range observed in transpiration rates across cassava genotypes, from 4 ± 2.6 mmol m^{-2} s^{-1} in D21/16 to 9 ± 0.61 mmol m^{-2} s^{-1} in D21/17, indicating diverse water loss rates which can influence drought stress response.

Intercellular CO_2 concentration (Ci): Ci showed

variability from 200 ± 31 ppm in D21/14 to 400 ± 89 ppm in D21/16, suggesting differences in CO_2 uptake and internal utilization, which are critical for photosynthesis efficiency and growth.

Non-photochemical quenching (NPQ): NPQ varied among the genotypes, ranging from 0.2 ± 0.37 in D21/14 to 0.7 ± 0.06 in D21/4, illustrating differences in the capacity to dissipate excess light energy as heat, which is crucial for protecting the photosynthetic machinery under high light conditions.

Drone Imaging

Aerial images of cassava fields were collected on the same day using drones. The drone captured real-time data as videos using a high-resolution drone camera (4K Video). Drones were flown at an altitude of 3 meters above the crop canopy, ensuring consistent, uniform, and detailed imagery. Each 5 to 10 second video captured by the drone was converted into approximately 500 - 1000 frames and these frames were classified based on the date of observation and plant characteristics. These images will form the inputs of machine learning models to extract meaningful insights to predict the phenotypic characteristics of the plants which determine drought resistance. In the same experiment, C_2F_1 clones were planted as row trial in control and treatment conditions and the above observation are all recorded along with drone imaging.

Breeding and evaluation for development of high yielding nutritionally enriched, photo-insensitive, processable and multipurpose sweet potato varieties

Yield trials were conducted for 41 selected biofortified sweet potato hybrids during *kharif* and *rabi* 2024. In the *kharif* trial, harvesting was done at 90, 100 and 120 days. At 90 days, H-39/9 and H-110/28 recorded a high yield of 250 g plant^{-1} (Fig. 13). At 100 days, H-582/29 was the high yielder and at 120 days, H-38/15, H-575/10, H-37/40 was the high yielders with 225 g plant^{-1} and 175 g plant^{-1}, respectively. During *rabi* season, harvesting was done at 80 and 90 days to find out the early bulking types. At 80 days, H-580/108, H-43/83, H-678/36, H-447/1 and H-575/10 exhibited maximum bulking with H-43/83 recording the highest tuber yield of 500 g per plant followed by H-678/36 with a yield of 400 g per plant^{-} (Fig. 14). At 90 days, H-580/108, H-582/29, H-38/15 was the high yielders. Among the white fleshed hybrids, H-526/7 and S-1401 were the high yielders at 90 days.

Fig. 13. H-110/28 a superior hybrid containing both anthocyanin and carotene

Fig. 14. H-678/36, a superior early bulking hybrid

Six high yielding biofortified hybrids of sweet potato rich in carotene and low in starch H-447/1, H-39/9, H-43/126, H-514/1, H-50/14 and H-50/26 were identified for salad purpose. H-447/1 was the highest yielder (40.7 t ha^{-1}) followed by H-50/26 (37.0 t ha^{-1}). H-447/1 recorded a carotenoid content of 12.1 mg/100FW and starch content of 8.3%.

On Farm trials were laid out with five promising biofortified hybrids of sweet potato for yield along with the released varieties as control in seven locations [Venkadampu (L1), Plamoottukkada (L2), Mavilakkadavu (L3, L4), Vlathankkara (L5), Malappuram (L6), Arattupuzha (L7) and Karakulam (L8)]. H-38/15 is an orange fleshed hybrid (14.5 mg 100g^{-1} FW of β-carotene); H-110/28 is a hybrid containing both β-carotene (9 mg 100g^{-1} FW) and anthocyanin (60 mg 100g^{-1} FW); H-38/46, a white fleshed hybrid with anthocyanin pigmentation (10 mg 100g^{-1} FW) in the pith region and starch of 20%; H-43/83, a high starch (22.5%) hybrid with β-carotene (2.2 mg 100g^{-1} FW) and H-536/6, an orange fleshed hybrid with β-carotene (4.64 mg 100g^{-1} FW) and good culinary quality. The average yield (t ha^{-1}) from seven locations showed that all the four hybrids viz., H-38/15 (29.1), H-38/46 (26.5), H-43/83 (31.4) and H-110/28 (27.7) performed equally well compared to the controls (Table 5).

Table 5. Yield data across seven locations in Kerala of biofortified sweet potato hybrids

Hybrids	Mean yield (t ha^{-1})								Mean yield (t ha^{-1})
	(L1)	(L2)	(L3)	(L4)	(L5)	(L6)	(L7)	(L8)	
H-110/28	31.6	27.6	29.0	20.8	23.7	33.2	36.5	19.6	27.7
H-38/46	25.0	26.6	33.2	13.8	23.0	26.6	36.1	27.5	26.5
H-38/15	21.6	24.9	41.5	24.2	33.6	20.8	34.0	32.4	29.1
H-43/83	23.3	32.1	41.5	27.7	21.6	33.3	43.2	28.2	31.4
H-536/6	24.9	29.1	8.3	10.4	21.3	18.3	29.1	8.0	18.7
Bhu Sona	11.6	9.1	12.5	9.0	10.4	7.2	16.6	22.0	12.3
Sree Kanaka	22.2	19.9	33.2	18.3	20.8	12.5	13.0	7.3	18.4
Bhu Krishna	7.2	7.3	8.3	9.4	6.6	9.0	8.6	9.7	8.3
Sree Arun	16.5	20.8	14.5	13.3	15.4	12.5	14.9	13.7	15.2
CV									28.32
CD (5%)									5.908

Harnessing the genetic potential of wild *Ipomoea* spp. through wide hybridization for improvement of sweet potato

Wild *Ipomoea* germplasm collected was maintained. For manipulation of ploidy in wild species, 100 seedlings of *I. mauritiana* were treated with 0.25-2% colchicine through cotton plug method and planted in pots. 100 seeds of *I. trifida* were treated with 0.25-1% colchicine and seeds sown in portrays. But none of them showed any difference with original ploidy. Hybridization was made between *I. batatas* x *I. mauritiana* and between *I. batatas* x *I. trifida.*

Breeding for development of high starch, anthocyanin and β-carotene rich varieties in sweet potato and high yielding nutritional rich varieties in yam bean

Sweet potato

Two hundred and four progenies from 48 sweet potato F_1 hybrids were grown in polybags for evaluation of tuber formation, flesh colour and skin colour. Among these, only 131 produced tubers. Among the 48 hybrids, 55 progenies produced purple fleshed tubers from 28 hybrids, 43 progenies produced orange fleshed tubers from 19 hybrids and 33 progenies produced white fleshed (white, cream, yellow) tubers from 20 hybrids. These 204 progenies were grown in the field for evaluation of yield and other biochemical traits.

Nutritional analysis of 14 sweet potato parental lines was carried out and the results revealed that the protein content ranged from 1.32 g 100 g^{-1} (Kanjangad Local) to 2.35 g 100 g^{-1} (KS-22) and vitamin C was found to range from 19.47 mg 100g^{-1} (CP-108-14) to 24.53 mg 100g^{-1} (KS-12). The obtained antioxidant capacity (IC_{50}) ranged from 19.38 µg ml^{-1} (KS-12) to 74.65 µg ml^{-1} (108-14). Minerals like P and K ranged between 0.287% (Kishan) to 0.436% (KS-22) and 0.385% (SV-3-17) to 0.974% (KS-27), respectively. Fe and Mn content were found to be between 73.21 ppm (Bhu Sona) to 126.32 ppm (KS-22) and 48.63 ppm (S-19) to 189.47 ppm (CP-108-14), respectively.

Yam bean

Twelve yam bean genotypes (IC-2514, YBBL-20, YBBL-13, EC100566, RM-1, DPH-10, DUS-8x9, EC100567, EC100551, EC100546 and RM-2) were raised along with 36 newly developed yam bean hybrids for evaluation of yield and other traits. Nutritional examination of the 12 yam bean parental lines showed that, the protein level ranged from 1.06g 100g^{-1} (DPH-20) to 1.97 g 100g^{-1} (DPH-10) and vitamin C content ranged from 8.23 mg 100g^{-1} (YBBL-13) to 19.82 mg 100g^{-1} (DPH-10). The measured range of antioxidant capacity (IC_{50}) was between 532.73 µg ml^{-1} (EC100546) to 742.63 µg ml^{-1} (DPH-10). Minerals such as P and K fell within the range: 0.185% (IC2514) to 0.234% (RM-1) and 0.192% (EC100566) to 0.246% (YBBL-20), respectively. Conversely, the level of Fe and Mn was found to range from 126.12 ppm (EC100557) to 158.96 ppm (DPH-20) and 48.63 ppm (EC100567) to 71.32 ppm (IC2514), respectively.

Genetic improvement for drought tolerance in sweet potato and high yielding, disease tolerant nutritionally rich lines in taro

Sweet Potato

Selected genotypes of sweet potato for drought tolerance namely, DB/21/57, RS-III, B × 7, SP-123 and S-162 were planted along with checks Bhu Sona,

Bhu Krishna and Kishan for evaluation. Maximum yield per plant were recorded in B × 7 (1.35 kg) followed by D/21/57 (1.26 kg), RS-III (1.20 kg) and S-123 (1.10 kg), whereas lower yield was observed in check varieties Bhu Sona (0.48 kg), Bhu Krishna (0.92 kg) and Kishan (0.83 kg). These four drought tolerant lines were planted in crossing block for hybridization. Seven single crosses were made and

Fig. 15. Sweet potato genotype SP-95/4 identified for earliness, β-carotene, uniform shape tuber and high yield

planted in field for evaluation. A promising sweet potato genotype, SP-95/4 was identified with early maturing (75-80 days), orange flesh (β-carotene content of 8.50mg $100g^{-1}$), uniform tuber shape, average number of tubers (3.00 $plant^{-1}$), average tuber weight of 373.33g $plant^{-1}$, average tuber yield (19 t ha^{-1}) and good cooking quality (Fig. 15). This genotype recorded higher yield compared to checks, Bhu Sona (7.20 t ha^{-1}), Bhu Krishna (7.52 t ha^{-1}) and Kishan (8.50 t ha^{-1}).

Taro

Clonal generation and selected high yielding nutritionally rich genotypes of taro were evaluated for yield and nutritional traits along with checks Muktakeshi and Sree Telia. The promising genotypes for each trait are presented in Table 6. The selected high yielding genotypes, CE-558 and CE-334357 recorded high yields (10.45 and 10.12 t ha^{-1} respectively) compared to checks Sree Telia (7.48 t ha^{-1}) and Muktakeshi (7.96 t ha^{-1}) and others lines (18×TCR-369, Nycle×224, 12×TCR-429, 12×IC022067, TCR-369×TCR-429, TCR-813×IC419746, CE-416937 and CE- 087949).

Table 6. Potential clonal generation in taro

Nutrional traits	Genotypes	Quantity
Free radical scavenging (DPPH)	18×TCR-369, CE-334357, 12×TCR-369, 12×IC022067	57.23%, 54.02%, 52.87%, 52.37%
CUPRIC assay	18×TCR-369, 12×TCR-429, 12×IC-022067, 12×TCR-369	26.11, 25.87, 25.62, 24.95 µmol trolox g^{-1}
Total phenolics	18×TCR-369, 12×IC022067, 12×TCR-429, CE-334357	6.05, 5.98, 5.84, 5.02 mg gallic acid g^{-1}
Sugar content	12×TCR-369, 12×TCR-429, CE-087949, CE-334357	2.45%, 2.11%, 2.09%, 2.06%
Starch content	12×TCR-369, 12×TCR-429, CE-334357, CE-558	52.88%, 48.22%, 45.79%, 44.91%
Protein content	12×IC-022067, 12×TCR-369, Nycle×224, 18×TCR-369	13.11%, 11.25%, 8.98%, 8.67%
Phosphorous	12×TCR-429, 12×IC022069, CE-334357, CE-558	405.21, 370.13, 342.59, 323.45 mg $100g^{-1}$
Potassium	12×IC022069, 12×TCR-429, CE-087949, CE-334357	1159.26, 1136.17, 1041.85, 1008.52 mg $100g^{-1}$
Iron	12×TCR-429, 12×TCR-369, CE-3 34357, 12×IC-022067	13.9, 12.45, 12.37, 9.87 mg $100g^{-1}$
Copper	Nycle×224, TCR-813×IC-419746, 12×TCR-369, CE-416937	1.20, 1.02, 0.82, 0.79 mg $100g^{-1}$
Zinc	Nycle×224, 18×TCR-369, CE-558, TCR-813×IC419746	12.77, 10.50, 9.98, 7.95 mg $100g^{-1}$
Manganese	Nycle×224, TCR-813×IC419746, CE-416937, CE-334357	6.12, 5.04, 4.77, 4.65 mg $100g^{-1}$
Yield	CE-558, CE-334357, CE-087949, CE-416937	10.42, 10.09, 9.12, 9.05 t ha^{-1}
High Zinc source	CE-558	10.48 mg $100g^{-1}$
High Iron source	CE-334357	12.43 mg $100g^{-1}$

Breeding for earliness, quality traits and salinity tolerance in sweet potato

A total of 48 sweet potato genotypes were screened under *in vitro* conditions to assess salinity tolerance at varying NaCl concentrations, with eight genotypes exhibiting tolerance at 0.5% NaCl. These genotypes, were evaluated in the field to assess their yield and related traits. Among these, genotypes SP19 (0.69 kg plant^{-1} and 18.33 t ha^{-1}), SP5 (0.67 kg plant^{-1} and 20.10 t ha^{-1}), SP18 (0.79 kg plant^{-1} and 17.40 t ha^{-1}), SP27 (0.60 kg plant^{-1} and 20.60 t ha^{-1}) and SP1 (0.72 kg plant^{-1} and 15.95 t ha^{-1}) recorded superior performance with respect to tuber yield. The genotypes SP19, SP27 and SP29 exhibited early tuber maturity between 90 to 100 days. The nutritional composition analysis revealed SP9 as nutritionally superior, recording high levels of potassium (1.61%), calcium (0.24%), magnesium (0.12%), sulfur (0.11%), manganese (59.8 ppm), iron (720.85 ppm) and boron (9.71 ppm). Genotype SP20 recorded the highest zinc content (28.24 ppm), while SP1 and SP11 recorded high phosphorus (0.17%) contents, respectively. Based on the evaluations, high-yielding, early-maturing genotypes SP19, SP5, SP18, SP27, SP1 and SP29, along with nutritionally rich genotypes SP9 and SP20, were selected for further evaluation with standard checks.

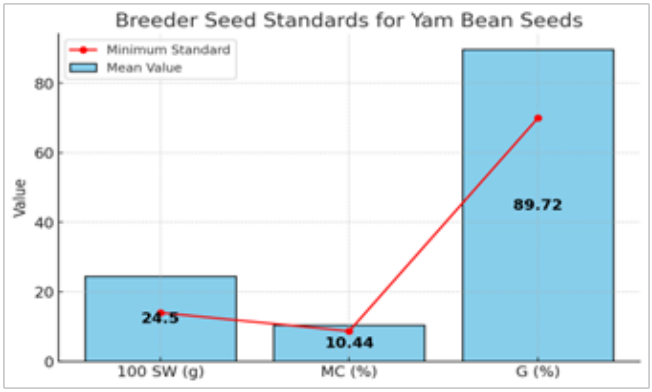
Genetic improvement of edible aroids for resistance to biotic stress and quality parameters

Under the genetic improvement programme of elephant foot yam, a set of elephant foot yam hybrid corms selected from F1 clonal population were evaluated for cooking quality, acridity and yield. Since roughness of petiole is an indication of acridity, hybrids with smooth to slightly rough petiole were selected for cooking quality. Based on cooking quality, five hybrids H-102-2015 (smooth petiole), H-107-2015 (slightly rough petiole), H-843/2/2-2017 (rough petiole), H-6-7-2017 (smooth to slightly rough petiole), H-6-34-2017 (slightly rough petiole) were identified as non-acrid. The best performers were H-6-7-2017 (smooth to slightly rough petiole) and H-6-34-2017 (slightly rough petiole) which gave a yield of 1-1.5 kg plant^{-1}. These were put for multiplication. Cooking quality evaluation indicated that H-102-2015, H-6-7-2017, H-6-34-2017 were non-acrid with good taste whereas, H-843/2/2-2017 and H-107-2015 were slightly acrid. In another set of elephant foot yam hybrids, one hybrid, AmH-22-99 showed early senescence and was replanted for checking for earliness. For standardization of *in vitro* shoot multiplication protocol in taro, sprouts were used as explants. Multiple shoots were obtained in MS media fortified with viz., BA (1 mg l^{-1}) and BA (2 mg l^{-1}) + IAA (0.5 mg l^{-1}). These combinations produced multiple shoots in ADMM/2024-1 (2 and 5 to 6, respectively). In MS media fortified with BA 2 mg l^{-1} and BA 1 mg l^{-1} + IBA 0.5 mg l^{-1}, Sree Rashmi produced 1-2 shoots and 2 shoots, respectively.

Developing breeder seed standards and precocity of genetic vigour for tropical tuber crops

Yam bean breeder seed standards

The breeder seed standards for yam bean were established based on the evaluation of 53 varieties/ landraces/genotypes. The established breeder seed standards include a minimum germination of 89.72%, 100-seed weight of 24.5g (RM1), and moisture content of 10.44% (Fig.16). The main parameter that determines the genetic purity of yam bean breeder seeds is the length-width (L/W) ratio and thickness of seeds. The vigour index, calculated as total seedling length × germination percentage, varied between 1500 and 2200 in the 53 experimental material representing released varieties, landraces and breeding lines.



100 SW (g) = 100 Seed Weight; MC (%) = Moisture Content and G (%) = Germination Percentage

Fig. 16. Breeder seed standard yam bean seeds bean seeds

Inducing genetic variability, characterization, grouping and developing breeding lines with large tuber size and short duration in Chinese potato

Gamma irradiation treatments given to Chinese potato variety Sree Dhara successfully induced

a wide range of genetic variations, resulting in significant differences in tuber size, plant height, yield, etc. The Table 7 presents statistical data on morphological traits including height, number of branches, leaf length and width, petiole length, girth, and spread in a plant study. These results suggest that the treatments significantly influenced morphological traits, with 15 Gy showing a notable positive effect on growth parameters. Field evaluations conducted during 2024 identified mutant progenies with unique traits such as variegated leaves, anthocyanin pigment and early maturity. Mutant progenies of country potato with pigmented leaves were identified from the gamma irradiated (15 Gy and 20 Gy) progenies of local landrace, Kulaparachal (ICl641830). An individual plant with albino and variegated leaf mutant was identified from the progeny population which received 30 Gy dose of gamma irradiation. The uneven coloration indicated changes in chlorophyll distribution, potentially linked to mutations in chloroplast DNA or regulatory genes. The 55 Gy treatment was characterized by early flowering and tuber formation, while other treatments showed no flowering or tuber development even three and a half months after planting the irradiated tuber sprouts. Another notable response observed in the progeny of 55 Gy showed the pistil with a visible stigma at the tip indicating a complete and functional female reproductive organ having potential for true seed set.

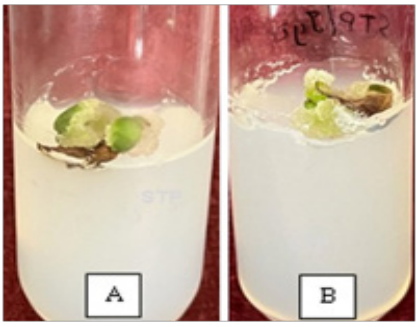
Table 7. Morphological traits variation observed in progeny of gamma irradiated Chinese potato

Statistics	Height (cm)	No. of branches	Leaf length (cm)	Leaf width (cm)	Petiole length (cm)	Girth (cm)	Spread (cm)
Mean	42.85	7.39	7.10	4.74	4.89	1.39	51.39
Maximum	72.2 (15 Gy)	10 (20 Gy)	9.5 (25 Gy)	6.3 (15 Gy)	7.5 (15 Gy)	1.8 (15 Gy)	77 (15 Gy)
Minimum	32.5	6	6	3.5	3	1	39
Stdev	11.41	1.20	1.13	0.81	1.28	0.22	10.48
CV%	26.63	16.17	15.88	16.99	26.15	15.98	20.39

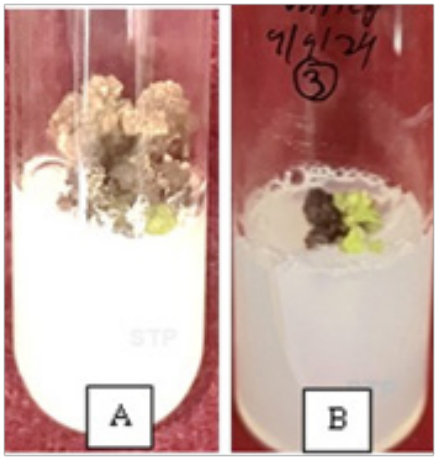
In vitro mutation study

Germinated sprouts from gamma-irradiated tubers from 15 treatments (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70 and 75 Gy) and untreated control sprouts were inoculated in shoot multiplication medium (MS + 1 mg l^{-1} BAP). However, multiplication was achieved in only one treatment (35 Gy) and control. Shoot induction and growth were reduced or absent in plants irradiated with 65 Gy gamma radiations and above doses (Fig. 17).

Regeneration of multiple shoots from gamma irradiated Chinese potato sprout explants in MS + 1 mg l-1 BAP 3 months after inoculation



Callus induction in leaf explants in red leaf mutant of Kulaparachal 3 weeks after inoculations A. Gamma-irradiated at 15 Gy B. Gamma-irradiated at 20 Gy



Shoot regeneration from callus in red leaf mutant of Kulaparachal at 15 Gy 3 months after inoculation B. Shoot regeneration from shoot bud of white variegated leaf mutant of Sree Dhara treated with gamma radiation at 15 Gy

Fig. 17. Effect of gamma-irradiated on callus induction and shoot regeneration in Chinese potato

Leaf and shoot explants from 2 varieties of Chinese potato viz., Sree Dhara with white and Kulaparachal (ICl641830) with red variegated leaf were inoculated in MS medium with 1 mg l^{-1} BAP for shoot multiplication. Callus induction was observed from leaf bits by 3rd week. Drying was observed initially in callus after subculturing and callus induction and shoot regeneration was observed in gamma-irradiated Sree Dhara (15 Gy, white variegated) and Kulaparachal (ICl641830) (15 Gy and 20 Gy) by 3 months after inoculation. Callus induction was better in 20 Gy gamma-irradiated red leaf mutant of Kulaparachal (ICl641830) landraces of Chinese potato.

Development of DNA barcode standards and RNA secondary structure predictions in sweet potato

DNA barcoding and RNA secondary structure predictions in three cultivated and five wild relatives of sweet potato were standardized using *matk*, *KimmatK*, *rbcL*, and *ITS* barcode primers (*ITS2* and *ITS4*) at chloroplast-plastid, and nuclear regions, respectively. Sweet potato gDNAs were isolated from young leaves following the GSure®Plant DNA extraction kit manual (GCC Biotech, Kolkata, India). Isolated gDNAs were quantified and checked for purity on 0.8% agarose gel. PCR amplification was performed using the barcode primers *matK*, *KimmatK*, *rbcL*, *ITS2* and *ITS4*. The purified PCR products were sequenced using Sanger sequencing (ABI Genetic Analyzer 3730, 48 capillaries, 50 cm) at M/S HKP Scientific Pvt. Ltd., Bhubaneswar. Consensus sequence formation and trimming were done using FinchTV V1.4.0, and multiple sequence alignment was performed on MEGAX (ClustalW V10.1.8). Phylogenetic relationships and evolutionary distance were studied using the minimum evolution method of *ITS2* and *ITS4* sequences. Maximum likelihood estimates of nucleotide substitution (transitional and transversional) were calculated using MEGAX software. DNA barcodes were generated using a Bio-Rad DNA barcode generator and *ITS4* secondary structures predicted in the RNAFold online tool. *MatK* (95-100%), among the chloroplast-plastid barcode primers was highly efficient in amplification and sequencing than *KimmatK* (90%) and *rbcL* (90-95%). DNA barcodes were developed using the DNA sequences at *matK* region (Fig. 18).

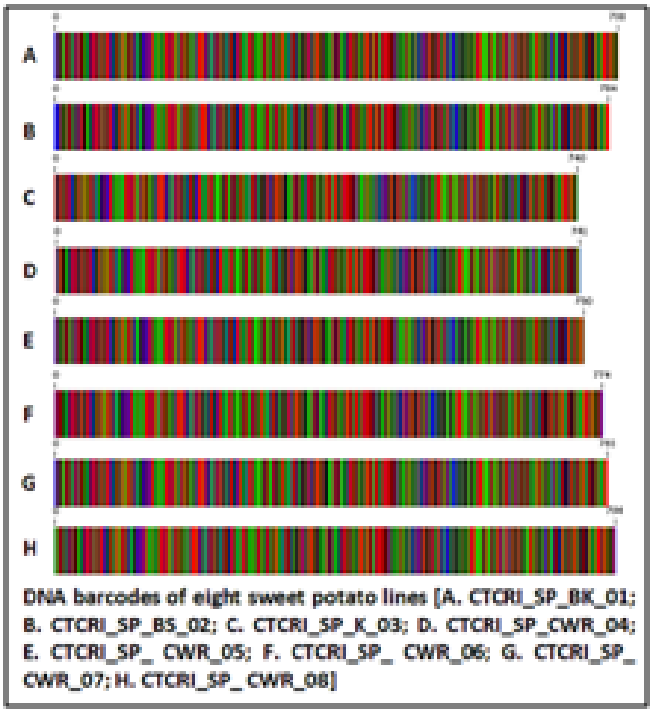


Fig. 18.DNA barcode of eight sweet potato lines

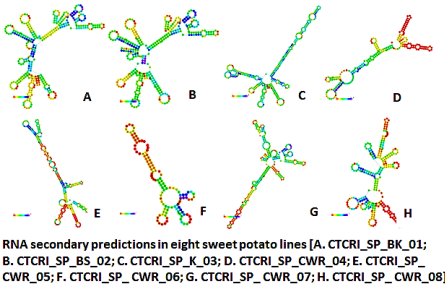


Fig. 19. RNA secondary predictions in eight sweet potato lines

The ribosomal nuclear *ITS2* and *ITS4* region exhibited significant inter- and intra-specific divergence, depicted in the DNA barcodes and the secondary structures derived based on the minimum free energy. *ITS4* demonstrated polyphyletic phylogeny and could be used as a reliable marker for genetic divergence studies to understand the mechanisms of RNA molecules (Fig. 19). Our results provide insights into the potential of the *matK* gene in DNA barcoding and the *ITS4* gene as a potent DNA barcode candidate in secondary structure predictions. These would help in genetic discrimination between species and genotypes while augmenting future breeding strategies in sweet potato.

Crop Production

Resource management and climate smart agriculture for sustainable production of tropical tuber crops

Crop diversification involving tropical tuber crops

Organic farming of tuber crops-based cropping systems

A split-plot field experiment assessed organic farming in a cassava-based intercropping system. Cassava (var. Sree Reksha) was intercropped with vegetables, chilli (var. Vellayani Athulya), cluster bean (var. Gloria), and tomato (var. Vellayani Vijai) under five management options: 100% organic, 75% organic + innovative practices (3% *Panchagavya* + cow urine), Integrated 1 (75% organic + 25% inorganic), Integrated 2 (50% organic + 50% inorganic), and the recommended package of practices (PoP).

Management practices did not significantly affect cassava, vegetable yields, or tuber equivalent yield (TEY). However, the highest yields were under 100% organic for cassava (48.53 t ha^{-1}) (Fig. 20), chilli (2.88 t ha^{-1}), and tomato (3.17 t ha^{-1}), while 75% organic + innovative practices yielded the most in cluster bean (2.36 t ha^{-1}). The highest TEY (54.73 t ha^{-1}) was under 100% organic. Cassava yield under organic was slightly higher (+1.55%) than PoP, chilli and tomato yields were 42% higher, and cluster bean yielded 24% higher under 75% organic than PoP. Though vegetable × management interaction did not significantly impact productivity, cassava + chilli under 100% organic (58.61 t ha^{-1}) and cassava + cluster bean under 75% organic + 25% inorganic (58.30 t ha^{-1}) achieved the highest TEY, demonstrating their potential for enhanced productivity in organic cassava-based systems.

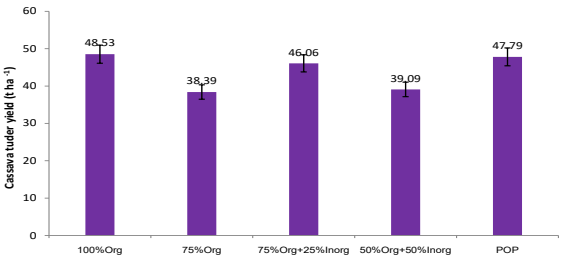


Fig. 20. Tuber yield of cassava intercropped with vegetables under different management options

Urban farming of tropical tuber crops

The first-season experiment (2023-24) to standardize major nutrients (N, P, K) for urban farming of sweet potato was conducted using a 3^3 factorial CRD with 27 treatments. The treatment NPK @ 70:37.5:70 kg ha^{-1} (0.25 g N, 0.134 g P_2O_5, 0.25 g K_2O per plant, equivalent to 0.54 g urea, 0.67 g rock phosphate, and 0.42 g muriate of potash) resulted in superior plant growth, number of leaves (178), above-ground biomass (1260.67 g), tuber yield per plant (1307.33 g), and tubers per plant (2.33). These results were on par with NPK @ 70:25:70 kg ha^{-1} (177 leaves, 1257 g biomass, 1292.67 g tuber yield, and 2.33 tubers per plant).

Weed management in tropical tuber crops

Integrated weed management (IWM) in sweet potato

A field experiment on integrated weed management in sweet potato was conducted during 2023-2024 at ICAR-CTCRI, Thiruvananthapuram, to assess the yield and economic impact. The study followed a Randomized Complete Block Design (RCBD) with eight treatments, integrating chemical, physical, and cultural methods and two controls (no weeding and weeded control. Pre-emergence herbicide pendimethalin (1 DAP) followed by post-emergence clodinofop (45 DAP) effectively reduced weed population (11.45, 15.35 m^{-2}), dry weight (12.88, 25.04 $g.m^{-2}$), and intensity (57.97, 64.90 m^{-2}), achieving 87.34, 87.59% weed control efficiency at 60 and 90 DAP respectively. Sweet potato plants showed superior growth (vine length: 1.64 m; secondary branches: 6.60) and yield (25.57 t ha^{-1}).

Dominant weed species observed were *Setaria glauca* (yellow foxtail), *Mimosa pudica* (sensitive plant), *Alternanthera paronychioides* (smooth joyweed), *Cyanotis axillaris* (spreading dayflower), *Cleome viscosa* (tick weed), and *Cyperus rotundus* (purple nutsedge).

Precision management of water and nutrients in tropical tuber crops

Water saving techniques in cassava

The third-season field experiment was conducted to evaluate water-saving techniques in cassava using drip irrigation at 50% cumulative pan evaporation (CPE) with eight treatments: porous ground cover mulching, biomulching, coir pith, foliar antitranspirant, Pusa hydrogel, organic gel Sujalam, Pusa hydrogel + ground cover mulching, and organic cultivation. Controls included drip irrigation at 50% and 100% CPE, furrow irrigation, and rainfed cropping. Porous ground cover mulching with 50% CPE drip irrigation yielded the highest tuber yield (51.2 t ha^{-1}), comparable to Pusa hydrogel + mulching and 100% CPE. Ground cover mulching improved yield by 10.1%, saving 50% irrigation water compared to 100% CPE. Water-saving treatments increased yield by 1–24.9% over the 50% CPE control, which performed on par with furrow irrigation despite using three times less water (Fig. 21). The rainfed crop yielded 13.88 t ha^{-1}.

Fig.21. Percentage increase/decrease in cassava tuber yield compared to irrigation at 50% CPE.

Treatments: porous ground cover mulching (T1), biomulching (T2), coir pith (T3), foliar antitranspirant (T4), Pusa hydrogel (T5), organic gel Sujalam (T6), Pusa hydrogel + ground cover mulching (T7), organic cultivation (T8), drip irrigation at 50% CPE (T9), drip irrigation at 100% CPE (T10), furrow irrigation (T11), and rainfed cropping (T12).

Fertigation studies in elephant foot yam

The second-season experiment aimed to optimize fertigation schedules in elephant foot yam using a split-plot design. The main plots were assigned four nutrient levels, ranging from 75-50-100 to 100-50-150 kg N, P_2O_5, and K_2O per hectare, while the subplots featured three different fertilizer application schedules. These schedules varied in the proportion of nitrogen and potassium applied at different growth stages, with adjustments made before 90, 120, and 150 days after planting (DAP) and continuing up to 180 DAP (Fig. 22). Fertilizer doses or schedules did not significantly affect corm yields. Yields ranged from 46.5 t ha^{-1} (M_1) to 58.3 t ha^{-1} (M_4) in main plots, while in subplot treatments the range was 50.9 t ha^{-1} (S3) to 56.0 t ha^{-1} (S_1). Interaction effects indicated that the lowest dose (75-50-100 kg N, P_2O_5, K_2O per ha), applied as 50% before 90 days of planting, 25% during 90–120 DAP, and 25% during 120–180 DAP, was optimal with a yield of 50.5 t ha^{-1}.

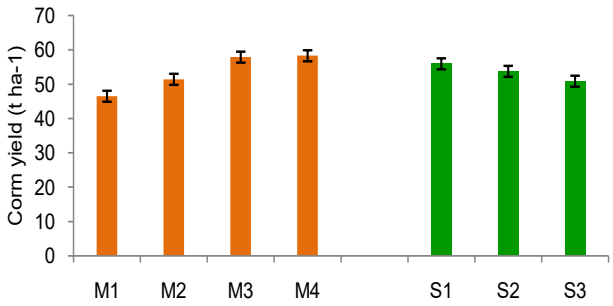


Fig. 22. Corm yield of elephant foot yam under main/ subplot treatments.

Main plot: Nutrient levels (kg N, P_2O_5, K_2O per ha): 75-50-100 (M_1), 100-50-100 (M_2): 100-50-125 (M_3), 100-50-150 (M_4)

Sub-plot; Fertilizer application schedules

50% N and K before 90 DAP, 25% during 90–120 DAP, 25% during 120–180 DAP (S_1)

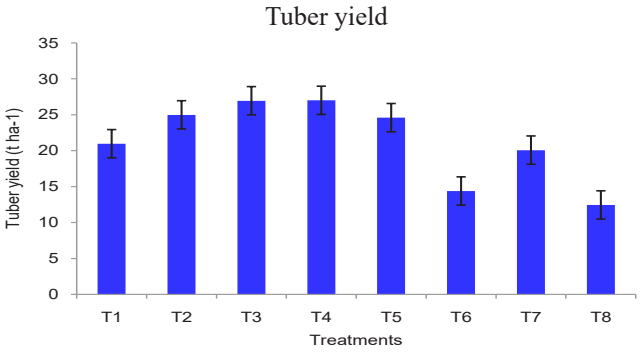
50% N and K before 120 DAP, 25% during 120–150 DAP, 25% during 150–180 DAP (S_2)

25% N and K before 90 DAP, 50% during 90–150 DAP, 25% during 150–180 DAP (S_3)

Water management studies in Chinese potato

A field experiment was conducted to standardize an irrigation schedule for Chinese potato for the first-season in RBD using eight treatments with drip, sprinkler and furrow irrigation and a rainfed control. Tuber yield was not significantly different across drip irrigation levels, except at 50% CPE. Drip

irrigation at 125% CPE recorded the highest yield (27 t ha^{-1}). Compared to this, sprinkler and furrow irrigation resulted in 46.6% and 25.6% lower yields, respectively (Fig. 23).



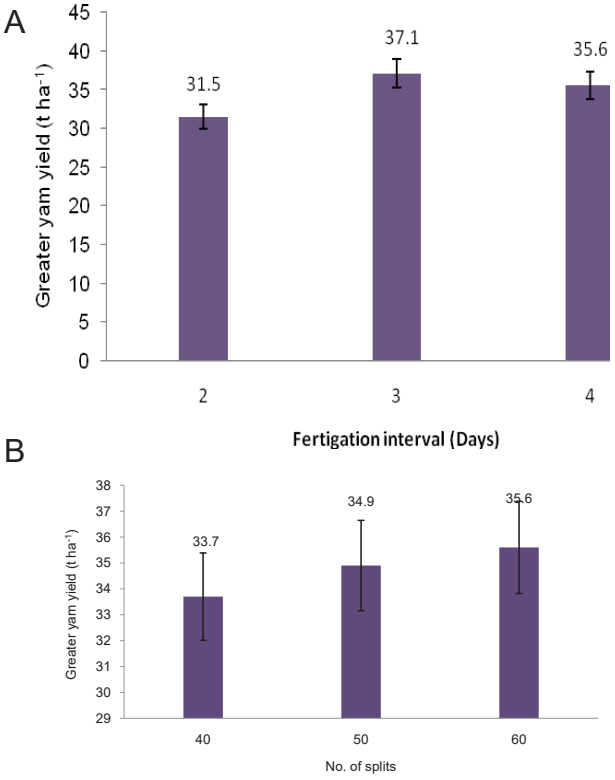
Treatments: 50% (T1), 75% (T2), 100% (T3), 125% (T4), 150% (T5)- CPE, Sprinkler irrigation (T6), Furrow irrigation (T7), Rainfed control (T8)

Fig. 23. Chinese potato tuber yield under different irrigation treatments

Drip irrigation and fertigation management in greater yam

Fertigation intervals and number of splits in greater yam

The effects of fertigation interval and number of splits on greater yam yield was assessed in a field experiment during 2023–2024. The trial employed a split-plot design with three fertigation intervals 2, 3 and 4 days in main plots and three fertigation splits 40, 50 and 60 in subplots, along with a control treatment of soil-applied N-P_2O_5-K_2O (100-60-100 kg ha^{-1}). Drip irrigation was provided at 80% CPE. Greater yam tubers (200 g) were planted at a spacing of 90 cm × 90 cm on May 19, 2023, and harvested on March 23, 2024 (300 days after planting). Results indicated that a 3-day fertigation interval produced the highest tuber yield (37.1 t ha^{-1}), followed by a 4-day interval (35.6 t ha^{-1}). Among fertigation splits, 60 splits achieved the highest yield (35.6 t ha^{-1}). Interaction effects revealed that the 60 splits at three days interval significantly increased tuber yield (40.4 t ha^{-1}), gross returns (₹ 605,500 ha^{-1}), net returns (₹ 396,600 ha^{-1}), and B: C ratio (2.90) highlighting it as the optimal fertigation schedule for maximizing greater yam productivity and profitability under drip irrigation (Fig. 24).



A: Fertigation intervals in days 2 (I_1), 3 (I_2), 4 (I_3);
B: Fertigation splits - 40 (S_1): 50 (S2): 60 (S_3)

Fig.24. Effect of drip irrigation on greater yam tuber yield

Sustainable nutrient management in tropical tuber crops

INM in greater yam + maize system and arrowroot

Response of nitrogen, phosphorus, and potassium on soil quality, yield, and proximate composition: The effect of inorganic nutrients on yam + maize cropping system was studied in the field during the 2023–24 *kharif* season in an Alfisol. . The soil was neutral (pH 6.76), medium in organic carbon (0.572%), low in available N, high in P_2O_5, and medium in K. Sixteen treatment combinations included graded doses of N, P_2O_5, K_2O, FYM, and biofertilizers (*Azospirillum* and phosphate solubilising bacteria (PSB). The highest tuber yield (27.62 t ha^{-1}) was achieved with FYM + N40 P30 K40, an 88.2% increase over control, while FYM alone increased yield by 50%, and *Azospirillum* + PSB + N40 P30 improved yield by 79.7%. Nutrient use efficiency (NUE) was maximized with *Azospirillum* + PSB + N40 P30, achieving the highest NUE (293 kg tubers/kg N) and PUE (390 kg tubers/kg P). In comparison, the highest potassium use efficiency (KUE) (94 kg

tubers/kg K) was with lower doses of K_2O (40 kg ha^{-1}). Post-harvest soils under FYM + ½ NPK had the highest enzyme activities, including Dehydrogenase activity (DHA) (1.591 µg TPF hr^{-1} g^{-1}) and urease (380.61 µg NH_4-N g^{-1} h^{-1}), with organic carbon showing a strong positive correlation with yield (r = 0.950**) and enzyme activities. Integrated use of FYM, biofertilizers, and ½ NPK enhanced soil biological and chemical properties, improving yield and sustainability of the greater yam system. The experiment is being continued for the third year (*kharif* 2024-25), with yam planted in June 2024 and scheduled for harvest in March 2025.

Screening nutrient efficient genotypes of sweet potato

Nitrogen use efficiency of five sweet potato genotypes (Sree Bhadra, Kishan, Kanjangad, Samrat, and Bhu Sona) was evaluated in field during 2023–24 Kharif season, under nine nitrogen management practices, including graded N levels, FYM, and biofertilizers. Sree Bhadra recorded the highest tuber yield (14.04 t ha^{-1}), followed by Kanjangad (13.52 t ha^{-1}) and Bhu Sona (13.05 t ha^{-1}). The highest yield (15.32 t ha^{-1}) was achieved with FYM + 50 kg N ha^{-1}, having 67.5% increase over the control. FYM + Azospirillum + 25 kg N ha^{-1} yielded 14.66 t ha^{-1}, with 60% improvement. Among genotypes, Sree Bhadra had the highest starch content (17.74%), while Kishan led in dry matter (25.56%) and total sugars (2.95%). Post-harvest soil analysis showed FYM + 50 kg N ha^{-1} improved organic carbon (0.602%) and available NPK (281.33, 61.15, and 274.26 kg ha^{-1}). Integrated nutrient management with enhanced soil enzymatic activities, with the highest DHA (1.591 µg TPF h^{-1} g^{-1}), FDA (5.297 µg g^{-1} h^{-1}), and urease (380.61 µg NH_4-N g^{-1} h^{-1}). These practices boosted tuber yield, quality traits, and soil health, promoting sustainable sweet potato production.

Standardization of package of practices for naturally biofortified varieties of tuber crops

Effect of lime on biofortified sweet potato varieties: A field experiment was conducted during 2024–2025, to study the effect of lime on five sweet potato genotypes (Sree Bhadra, Kishan, Kanjangad, Samrat, and Bhu Sona) under nine potassium management treatments, including graded K_2O levels, FYM, and potassium solubilizing bacteria (KSB). The trial followed three doses of two-factorial RBD with uniform nitrogen and phosphorus application and potassium. Sweet potato vines were planted in October 2024, with harvest scheduled for February 2025. Post-harvest soil analysis from 2023–24 trial indicated that Sree Bhadra had the highest organic carbon (0.566%), available N (275.04 kg ha^{-1}) and K (268.71 kg ha^{-1}), while Kanjangad recorded the highest available P_2O_5 (59.99 kg ha^{-1}). The application of FYM + 50 kg N ha^{-1} improved N, P, and K availability (281.33, 61.15, and 274.26 kg ha^{-1}, respectively). The highest exchangeable Ca (7.202 c mol (p+) kg^{-1}) and sulfur (7.597 mg ha^{-1}) were observed in Bhu Sona, while the highest Mg (5.822 c mol (p+) kg^{-1}) was in Samrat. Overall, FYM + 50 kg N ha^{-1} enhanced the efficiency of sweet potato productivity and nutrient use.

Nutrient management for naturally biofortified yam variety

A revised nutrient management experiment for a naturally bio-fortified yam variety (Sree Neelima) was conducted in 2023–24 using eight treatments. The crop was planted in May 2023 and harvested in February 2024. The treatment 90-50-100 kg NPK ha^{-1} resulted in higher yield per plant (3.76 kg), average tuber weight (2.76 kg), and total tuber yield (34.27 t ha^{-1}), which was statistically on par with 80-50-100 kg NPK ha^{-1}.

Land configuration effects on bio-fortified sweet potato varieties

The effect of land configuration on bio-fortified sweet potato varieties was evaluated for the third-season in field during 2023 using a split-plot design. Main plots included three ridge heights: 30 cm (60 cm row spacing), 45 cm (90 cm row spacing), and 60 cm (120 cm row spacing, two rows per ridge). Subplots comprised four varieties: Bhu Krishna, Bhu Sona, Bhu Kanti, and Bhu Ja. Treatments were replicated thrice with 5 t ha^{-1} farmyard manure and 50-25-50 kg ha^{-1} N-P_2O_5-K_2O. Planted on October 7, 2023, the crop was irrigated as needed and harvested after 120 days (February 4, 2024). Land configuration significantly influenced yield and economic returns. The 45 cm height ridge with 90 cm row spacing recorded the highest marketable tuber yield (13.3 t ha^{-1}), total yield (14.6 t ha^{-1}), gross returns (₹266,700 ha^{-1}), net returns (₹187,200 ha^{-1}), and B: C ratio (3.35). Among varieties, Bhu Krishna excelled, yielding 14.4 t ha^{-1}

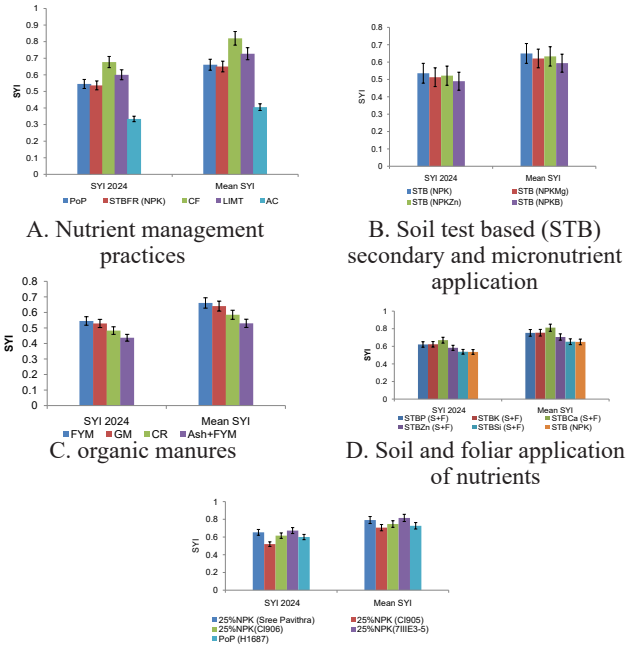
marketable tubers, 15.4 t ha⁻¹ total, with ₹287,000 ha⁻¹ gross and ₹206,700 ha⁻¹ net returns (B: C ratio 3.57). The best interaction was Bhu Krishna on 45 cm ridges (16.3 t ha⁻¹ marketable yield, ₹303,200 ha⁻¹ gross returns, ₹222,000 ha⁻¹ net returns, B: C ratio 3.73). No clear trends were seen in moisture, starch, sugar, or anthocyanin across land configurations, though beta-carotene was highest in 30 cm height ridge with 60 cm row spacing. Bhu Sona had the highest total carotene across all configurations. These results underscore the role of ridge height and variety selection, with Bhu Krishna offering superior yield, economic returns, and nutritional benefits in bio-fortified sweet potato cultivation.

Long term integrated nutrient management in tropical tuber crops

Long term effect of advanced integrated nutrient management (INM) practices on the sustainability of cassava

The effect of nutrient management approaches, organic manures, secondary and micronutrients, NUE genotypes, and soil and foliar application of nutrients on sustainable yield index (SYI), tuber yield, tuber quality, soil properties, dry matter production, and disease incidence was studied for the fourth year in the fouth phase of long term INM experiment. SYI for 2024 and the mean of four years was highest with customized fertilizers (CF), followed by low input management (LIMP), i.e. nutrient use efficient genotypes, green manuring *in situ* with cowpea as organic manure source, soil test based application of N, P, K, Mg, Zn and B and application of N, P and K efficient microbial fertilizers. Soil test-based fertilizer recommendations (SBTFR) and PoP yielded similar SYI, while absolute control had the lowest values. Secondary and micronutrients did not significantly affect SYI. FYM and *in situ* green manuring using cowpea had the highest SYI among organic manures. The NUE genotype 7III E3-5 achieved the highest SYI, followed by other genotypes except CI-905. Low input management (35.5 t ha^{-1}) and soil test-based NPK (32.5 t ha^{-1}) produced the highest yields. The nutrient recommendation as per PoP (29.4 t ha^{-1}) and CF (30.7 t ha^{-1}) were on par. Green manuring with cowpea (34.1 t ha^{-1}) performed well, and NUE genotype 7III E3-5 (40 t ha^{-1}) was on par with Sree Pavithra (39.5 t ha^{-1}). Soil and foliar application of Ca resulted in the highest yield (40 t ha^{-1}), followed by K (37.7 t ha^{-1}) and Si (37.8 t ha^{-1}) (Fig. 25A).

All treatments, except absolute control, performed similarly for leaf dry matter production (LDMP) and total plant dry matter production (TPDMP). Soil application of Zn and B increased LDMP and TPDMP. Post-harvest soil pH was lowest with CF (4.18). Low input management and absolute control indicated lower available P. Exchangeable Mg and Fe content were unaffected by treatments, except absolute control. NUE genotypes and soil/foliar nutrient applications showed no significant impact on soil properties. Calcium application reduced PDI (percentage disease incidence) of cassava mosaic disease (CMD) by 40.5% at 6 MAP, followed by K, Zn, Si, and P. At 9 MAP, PDI further reduced by 11.25%. No significant effects were observed on tuber quality, nutrient content, or nutrient uptake across treatments (Fig. 25B).



A. Nutrient management practices

B. Soil test based (STB) secondary and micronutrient application

C. organic manures

D. Soil and foliar application of nutrients

E. Nutrient use efficient genotypes

Fig. 25. Effect of different treatments on sustainable yield index (SYI)

Post-harvest analysis of soil samples showed that low input management significantly reduced soil bulk density (1.34 ± 0.006 Mg m^{-3}) compared to ash and FYM treatments (1.43 ± 0.013 Mg m^{-3}). This treatment also enhanced soil water holding capacity (39.92 ± 0.417%), comparable to STBFNPK + crop residue as organic matter (41.07 ± 0.621%) and other nutrient management or nutrient-efficient cassava variety treatments (Fig. 25 C-E).

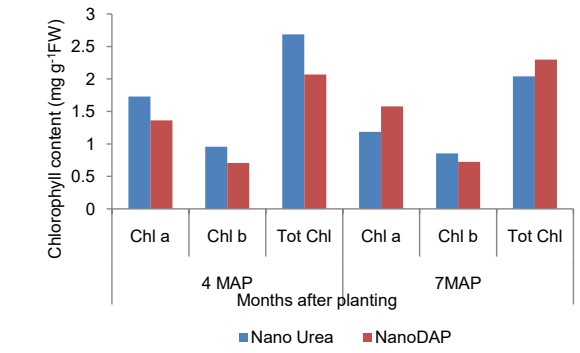
Diagnosis and correction of emerging soil-plant nutritional disorders in tropical tuber crops

The study highlighted role of boron in tuber yield under low soil B conditions in cassava. High pH (6.77), organic carbon (0.722%), exchangeable Ca (6.85 meq 100 g^{-1}), and leaf B (0.00281%) were positively correlated with better tuber yield. The second-season experiment, conducted under non-detectable soil B status, revealed tuber symptoms, including skin cracking, discoloration in the flesh, sub-rind discoloration, brown hollow depressions, and thinning of the rind. The mean tuber yield was low (0.922 kg $plant^{-1}$) with 0.112 ppm post-harvest soil B content and undetectable leaf and tuber B levels.

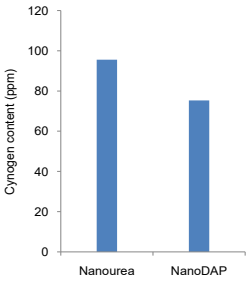
Standardization of nano urea and nano DAP for cassava

Nano urea: The first season experiment with cassava, variety Sree Reksha revealed that soil application of 100% N as per PoP through ordinary urea combined with 50% N as nano urea via foliar spray significantly increased tuber yield (54 t ha^{-1}), a 52% improvement over 50% N applied through foliar nano urea and 50% through soil-applied ordinary urea. However, 100% N applied through soil urea was on par with nano urea treatments. Nano urea marginally improved chlorophyll levels, soil available N, plant N and P uptake, and reduced tuber cyanogen. No significant differences were observed in other soil or plant parameters except tuber K.

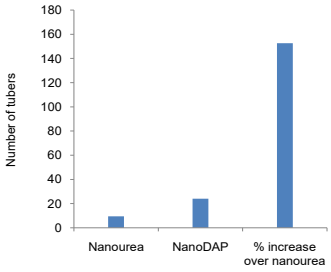
Nano DAP: The study, conducted with Sree Reksha, showed that applying either 25 or (half PoP) 50 kg P_2O_5 ha^{-1} as per PoP was equally effective as nano DAP applied as a 0.5% sett treatment and foliar spray (1000 ml in 500 liters at 45–60 DAP). Treatments had no significant effect on soil or plant parameters, except sett sprouting. Nano DAP reduced tuber cyanogen more effectively than nano urea and significantly increased tuber number. These findings suggest the potential of nano urea and nano DAP in enhancing cassava yield while minimizing cyanogen content (Fig. 26).



A. Chlorophyll



B. Tuber cyanogen



C.Tuber number

Fig. 26. Comparison of effect of nano urea and nano DAP on cassava yield and tuber quality

Soil carbon quality and conservation studies in tropical tuber crops

A field experiment initiated in August 2023 assessed the impact of organic manure (0, 100% recommended dose of manure [RDM]), recommended dose of Fertilizer [RDF] (0, 50, 100%), and zeolite 4A (0, 0.5, 1.0%, w/w; pH 5.95; CEC 76 cmol (p^+) kg^{-1}) on soil quality, crop growth and cassava yield. The highest leaf area index (3.44) was observed with 100% RDM, RDF and 1.0% zeolite. At 7 months after planting (MAP), labile soil carbon (C) declined from 3 MAP across fertilizer doses (e.g., 7.29 to 6.93 g kg^{-1} at 0% RDF). However, 0.5% zeolite maintained or increased labile C (8.52 to 9.58 g kg^{-1}). Recalcitrant C peaked at 30.66 g kg^{-1} under 50% RDF with 0.5% zeolite, while the lowest (16.415 g kg^{-1}) was at 0% RDF without zeolite. Zeolite reduced available nitrogen (N) and phosphorus (P) but increased potassium (K) availability (Fig. 27).

The highest tuber yield per plant (1.945 kg) was recorded under 50% RDF with 1% zeolite, while organic manure had no significant effect. Post-harvest soil analysis showed zeolite influenced

NPK availability due to adsorption and release properties. For the second season (planted August 2024), initial soil moisture, biometric observations, and soil quality at 3 MAP were evaluated. Soil moisture averaged 10.1% across organic manure and fertilizer levels but increased significantly with 1% zeolite (11.5%) compared to 0% (9.9%).

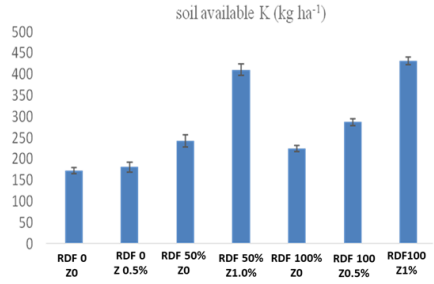


Fig. 27. Available potassium content in soil under different organic treatments, including manure RDF: Recommended dose of fertilizer; Z: Zeolite 4A

Climate change adaptation and mitigation in tropical tuber crops

Drought tolerance in tropical tuber crops through mineral nutrition

The influence of mineral nutrients (potassium nitrate, magnesium sulfate and solubor at three concentrations each) on drought tolerance in cassava (Sree Swarna) was evaluated for the second season. The trial was arranged in RBD with 10 treatments, including a control (NPK @ 100:50:100 kg ha^{-1}). The crop was planted in January 2024. Results showed that recommended fertilizer doses combined with foliar application of potassium nitrate at 1.0% significantly improved drought tolerance, achieving the highest storage root yield (4.28 kg plant^{-1}), which was on par with 0.5% solubor (3.67 kg plant^{-1}) and markedly higher than the control (1.66 kg plant^{-1}). Biometric and physiological measurements and cyanide content analysis in leaf and tuber samples further substantiated the role of mineral nutrition in enhancing drought resilience in cassava.

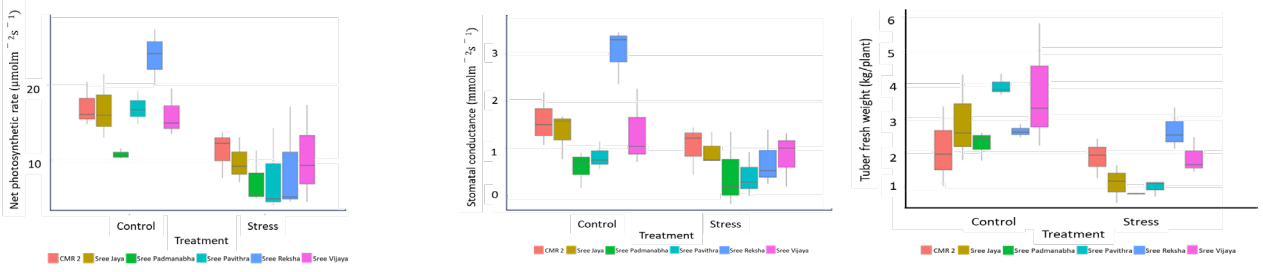
Studies on heat stress management in cassava

A second-season study (June 2023–January 2024) was conducted to evaluate the effect of chemical sprays on cassava under open (OPEN), humidifying (HUM+), and non-humidifying chamber (HUM-) conditions. Treatments included 0.2% salicylic acid, 0.2% calcium chloride, 1000 ppm benzyl adenine, and water control. Under open conditions, the highest tuber yield (20.575 t ha^{-1}) was recorded with 1000 ppm benzyl adenine, followed by calcium chloride (12.880 t ha^{-1}). In HUM+ conditions, calcium chloride produced the maximum yield (5.033 t ha^{-1}), whereas, in HUM-, yields were lowest with calcium chloride (0.288 t ha^{-1}). Biometric observations revealed high leaf area index (LAI) of 5.38 under benzyl adenine in open conditions, compared to an average LAI of 3.39, 2.61, and 1.96 in OPEN, HUM+, and HUM- conditions, respectively.

Physiological studies related to climate change in tropical tuber crops

Effect of drought stress on the growth, biomass, and yield of cassava

A field experiment to evaluate the effect of drought stress on six cassava genotypes revealed significant impacts on gas exchange parameters. Drought stress reduced photosynthesis (Pn), stomatal conductance (Fig. 28), and transpiration rates across genotypes ($p < 0.01$), leaf respiration rates also significantly affected ($p = 0.01$). While genotypic variation significantly influenced stomatal conductance ($p < 0.01$), it had no notable impact on photosynthesis, leaf respiration, or transpiration ($p = 0.12$, 0.57, and 0.03, respectively). Interaction effects between genotype and treatment were significant only for stomatal conductance ($p = 0.03$), indicating genotypic differences in stomatal



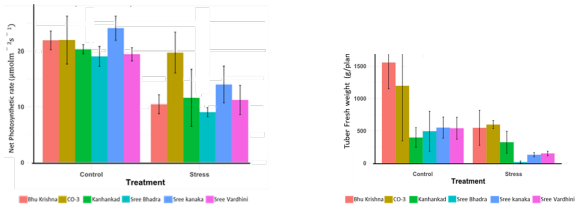
A. Net photosynthetic rate B. Stomatal conductance C. Tuber yield

Fig. 28. Effect of drought on gas exchange parameters of cassava

behaviour under drought conditions. Chlorophyll fluorescence parameters (Fv/Fm, Fv'/Fm', PhiPS2, and qP) were mostly unaffected by drought, except for non-photochemical quenching (NPQ), which significantly increased ($p = 0.03$), suggesting enhanced heat dissipation as a photoprotective mechanism. While most genotype-treatment interactions were insignificant, PhiPS2 exhibited marginal significance ($p = 0.05$), indicating genotype-specific responses in PSII efficiency under drought stress.

Effect of drought on growth, biomass, and yield of sweet potato genotypes

Under drought stress, soil moisture declined from 13.76% (control) to 9.78%, confirming experimental drought conditions. Genotype and genotype-treatment interactions significantly affected leaf area index (LAI) and organic carbon (OC), whereas overall effect of drought on LAI was insignificant. Drought-tolerant genotypes like Sree Kanaka maintained high LAI (4.1 ± 0.19), while Kanjangad showed a sharp decline (2.6 ± 0.16). All genotypes exhibited increased osmolyte concentration under stress, reaching ~1200 ± 100 mmol/kg with Bhu Krishna, CO-3, and Sree Kanaka, indicating osmotic adjustment. Drought stress significantly reduced photosynthetic rate (Pn) (Fig. 29), stomatal conductance (Conduc), and internal CO_2 concentration (Ci) ($P < 0.01$), reflecting moisture limitations and stomatal closure, whereas respiration rate (Respir) remained stable. Maximum quantum efficiency of PSII (Fv/Fm) declined, showing stress-induced PSII damage. Genotype-specific differences were significant in photochemical quenching (qP) and quantum yield of PSII (PhiPS2). Transpiration rate



A. Net photosynthetic rate B. Tuber yield

Fig . 29. Effect of drought on sweet potato genotypes

(Trmmol) and vapour pressure deficit (VpdL) also declined ($P < 0.01$), affecting water use efficiency.

Drought significantly reduced plant fresh weight (PFW) and stem fresh weight (St FW) ($P < 0.01$), while vine length (VL) remained unaffected ($P = 0.88$), indicating resilience in vine growth. Genotype and genotype-treatment interactions influenced stem dry weight (St DW) and fresh weight, reflecting water retention and biomass conversion differences. Leaf number and fresh weight (LFW) showed minor variability, suggesting stable leaf production under stress. Root fresh weight, root dry weight, tuber fresh weight, tuber number, and tuber dry weight declined significantly ($P < 0.01$), highlighting severe impacts on root and tuber productivity. Variations in tuber dry weight conversion emphasized genetic differences in drought tolerance.

Effect of plant growth regulators and day length on growth and yield of sweet potato

A controlled pot experiment was conducted on two sweet potato varieties (Sree Arun and Bhu Krishna) to evaluate the effects of ethephon and salicylic acid, combined with varying day lengths, on growth, photosynthesis, and yield parameters. Day length significantly influenced net photosynthesis, leaf respiration, and stomatal conductance, indicating substantial effects on gas exchange. Treatment combinations significantly affected leaf respiration but not transpiration rates, which remained unaffected by either factor. Chlorophyll fluorescence parameters, including the maximum quantum yield of PSII (Fv/Fm) and excitation energy capture efficiency (Fv'/Fm'), were strongly influenced by day length. However, treatment combinations had no significant effect. Photochemical quenching (qP) was significantly affected by both day length and treatment combinations, whereas non-photochemical quenching (qN) showed no significant changes. Day length also significantly affected leaf number and fresh weight, reflecting its critical role in biomass accumulation. Treatment combinations significantly influenced leaf fresh weight and vine weight, while vine length was marginally affected by day length. The number of tubers was strongly influenced by day length but remained unaffected by treatments, indicating a specific response to photoperiod adjustments.

Submergence tolerance in cassava

Submergence stress, significantly affected physiological and biochemical traits in cassava, reducing chlorophyll and carotenoid content. CMR-2 had the highest chlorophyll under control (4.5 mg g^{-1} FW), which declined sharply under stress, while

Sree Pavithra maintained higher levels (2.8 mg g^{-1} FW). Membrane stability index (MSI) and relative water content (RWC) also decreased, though Sree Apoorva retained the highest MSI (60%) and Sree Athulya had the highest RWC (94%). Increased osmolyte concentrations, particularly in Sree Apoorva (600 mmol kg^{-1}), indicated osmotic adjustment. Antioxidant enzyme activities differed across genotypes, though Sree Swarna exhibited the highest DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity (89%), reflecting strong antioxidant defense. Under stress conditions, gas exchange parameters such as photosynthetic rate (Pn), stomatal conductance, and intercellular CO_2 concentration declined. But, Sree Apoorva maintained the highest photosynthetic rate at 20 µmol CO_2 m^{-2} s^{-1}. Chlorophyll fluorescence parameters (Fv/Fm, PhiPS2) declined, while non-photochemical quenching (NPQ) increased, indicating photoprotective responses. Correlation analysis showed positive links between Pn and Fv/Fm, phenolic content, and antioxidant activity, while Pn negatively correlated with catalase activity, highlighting the effects of oxidative stress on photosynthesis.

Quality planting material production of tropical tuber crops

Developing innovative techniques for seed production in tropical tuber crops and quality planting material production in cassava, sweet potato, and Chinese potato

Virus-free planting materials were produced through procedures involving indexing, micropropagation, hardening, and minisett multiplication under protected environment (Table 7). Seed villages were established in Kerala, Tamil Nadu, Andhra Pradesh, Odisha, and North Eastern India through farmer-participatory approach, including training for mass multiplication. Seed producers were identified for production of quality planting material of tuber crops and area expansion in non traditional areas. Quality planting materials viz., cassava, sweet potato, Chinese potato, yams were produced and distributed to farmers across major tuber crop-growing states.

Table 8. Quality planting material production of tuber crops during the crop season 2024-25

Sl.No.	Name of the Crop	Varieties	Quantity of planting material produced
1.	Cassava (No. of stems)	Sree Vijaya	38,000
		Sree Jaya	39,000
		Sree Reksha	55,000
		Sree Swarna	14,000
		Sree Sakthi	6,000
		Sree Pavithra	14,000
		Local (M4, Hraswa)	Quintal, 26,500
		Total	1,92,500
2.	Elephant foot Yam (ton)	Gajendra	15.00
		Sree Padma	16.00
		Total	31.00
3.	Greater Yam (ton)	Sree Keerthi	8.00
		Sree Nidhi	4.50
		Sree Neelima	2.00
		Orissa Elite	7.00
		Total	21.50
	White yam (ton)	Sree Priya	3.50
		Sree Subhra	4.50
		Total	8.00
	Lesser yam (ton)	Sree Latha	3.50
		Total	33.00
4.	Taro (ton)	Sree Telia	2.00
		Sree Hira	2.00
		Muktakeshi	3.00
		Total	7.00
5.	Sweet Potato (No. of vine cuttings)	Bhu Sona	16,00,000
		Bhu Krishna	15,50,000
		Kisan	3,50,000
		Sree Arun	1,50,000
		Sree Kanaka	1,50,000
		Total	38,00,000
6.	Chinese potato (No. of vine cuttings)	Sree Dhara	20,000
7.	Yam Bean (kg)	RM-1	150

Standardization of growth media and crop management in nursery

A field experiment was conducted during the 2024 to standardize growth media and crop management for cassava (var. Sree Reksha) using single-node and two-node minisetts. The study followed a randomized block design (RBD) with four nursery growth media: potting mixture (soil: FYM 2:1), coco peat + soil + FYM (2:1:1), coco peat + soil (1:1), and soil bed. Foliar sprays included urea (0.1%) and 19:19:19 (0.1%) after 15 days of planting, along with a control. Earliest sprouting was in the potting mixture, soil+FYM followed by coco peat + soil + FYM, coco peat + soil, and soil bed at five, six, seven

and eight days respectively. Fifty percent sprouting was achieved in 10, 12 , 14 and 16 DAP in potting mixture, soil + FYM, coco peat + soil + FYM, coco peat + soil and soil bed respectively for two-node minisetts (Fig. 30). The potting mixture (soil: FYM 2:1), produced seedlings with plant heights of 7 cm at 15 days and 22 cm at 30 days and had the highest establishment rate of 89% in two-node minisetts, compared to 51% in single-node treatments . After one month, the seedlings from each treatment were transplanted into the field. The establishment was fastest, at seventh day in the potting mixture, followed by coco peat + soil, coco peat + soil + FYM, and soil bed at eight, nine and 11 DAP. Plant growth parameters, including height, number of leaves, and stem girth, were highest in the potting mixture (Fig. 31). Two-node minisetts outperformed single-node in field performance.

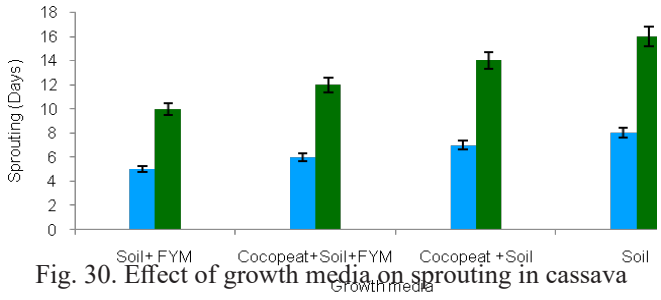


Fig. 30. Effect of growth media on sprouting in cassava

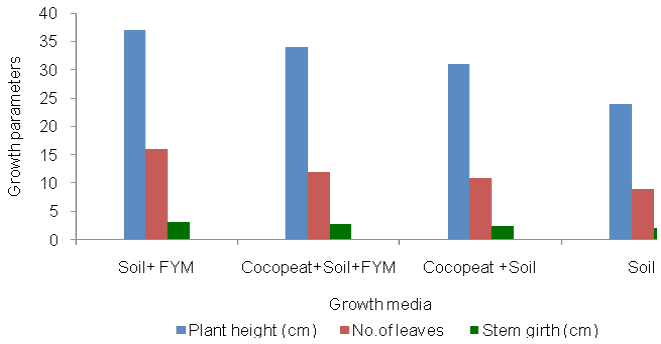


Fig. 31. Effect of growth media on plant growth parameters in cassava

Determination of the ideal stage of stem cutting for planting material production in cassava

The ideal stem-cutting stage for planting material production in cassava (vars. Sree Reksha and Sree Vijaya) was standardised. Five treatments were tested in a randomized block design using cuttings taken four, three, two, and one month before and at the time of harvest. The stem cuttings were immediately planted, and growth parameters were recorded.

Stem cuttings taken four months before harvest showed better field establishment and growth than those taken three months prior. In these, Sree Reksha sprouted in eight days and Sree Vijaya in 13 days, whereas in three-month-old cuttings, sprouting occurred in seven and 14 days, respectively.

Development of protocol for clean seed production in sweet potato under protected cultivation

An experiment was conducted to standardize a protected cultivation protocol for sweet potatoes using a climate-controlled glasshouse with a recirculatory dripponics system. Four varieties, viz., Bhu Krishna, Sree Kanaka, Sree Arun, and Kanjangad were grown under regulated conditions (28±2°C, 60% humidity). Vegetative growth and yield traits were recorded and analyzed. Significant variations were observed among varieties and growth stages. Bhu Krishna had the longest vine (274.08 cm), the most secondary branches (27.67), and the highest vine multiplication ratio (150.4) (Fig. 32). Kanjangad had the highest leaf area index (6.414), while Sree Kanaka recorded the lowest values for multiple traits, including vine length (105.83 cm) and root fresh weight (77.91 g). Root fresh weight was the highest in Bhu Krishna (170.42 g), followed by Sree Arun (162.08 g).

Tuber yield varied significantly across varieties. Sree Arun produced the highest yield (2290 g plant^{-1}), followed by Sree Kanaka (993.75 g), Kanjangad (947.5 g), and Bhu Krishna (952.5 g at 4 MAP). Sree Kanaka and Sree Arun tuberized within a month, while Bhu Krishna and Kanjangad tuberized in the second month. At 2 MAP, Sree Arun had the highest tuber weight (497.5 g plant^{-1}), while Bhu Krishna had the lowest (71.25 g plant^{-1}). Tubers from protected cultivation had better or on par sensory attributes compared to those of soil-grown ones. Sree Arun maintained consistent quality across cultivation methods, with enhanced sweetness under protected conditions. Bhu Krishna excelled in color, aroma, taste, and acceptability in soilless conditions, while Sree Kanaka tubers from soil cultivation were superior in taste, sweetness, texture, and mouthfeel (Fig. 33).

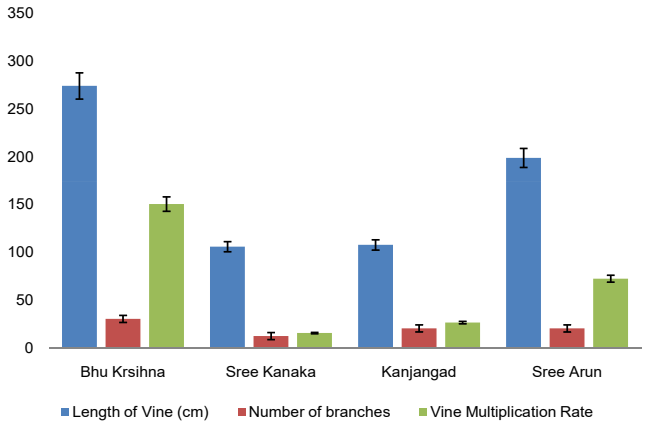


Fig. 32. Vine parameters of sweet potato varieties in protected cultivatio

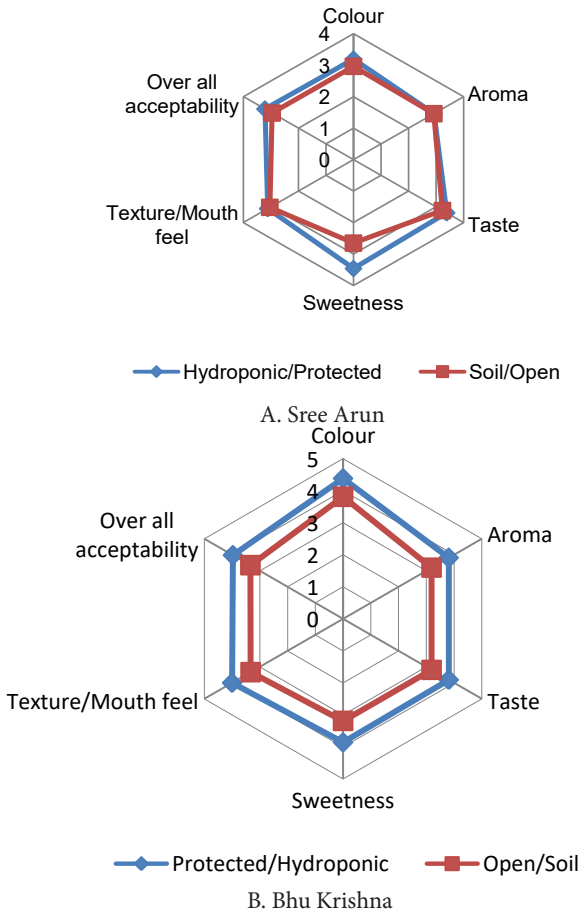


Fig. 33. Organoleptic properties of boiled sweet potato tubers grown under protected Vs. open cultivation

Field demonstrations for quality planting material production of tuber crops

A total of 139 field demonstrations were conducted to establish seed villages for improved varieties of cassava, sweet potato, elephant foot yam, yams and Chinese potato varieties in Kerala, Tamil Nadu, and Meghalaya. Forty seed villages for cassava, sweet potato, yam, taro, and Chinese potato were set up in Kerala, Tamil Nadu, Odisha, and Meghalaya. In Tamil Nadu, a total of 77 farmers participated in seed village field demonstrations for cassava varieties, viz., Sree Athulya, Sree Reksha, Sree Sakthi, and Sree Kaveri across Salem, Namakkal, Erode, Tirunelveli, and Tenkasi districts in Tamil Nadu. Twelve farmers in Thrissur district in Kerala produced quality planting material of Chinese potato (var. Sree Dhara), Ten field demonstrations of Sree Reksha, a cassava variety were held in Thiruvananthapuram in Kerala. Twenty farmers from West Jaintia Hills and Ri Bhoi participated in cassava and sweet potato seed village programs. Improved planting materials of cassava varieties Sree Vijaya, Sree Pavithra, and Sree Swarna, along with sweet potato varieties Sree Arun, Sree Kanaka, Bhu Sona, and Bhu Krishna, were distributed for field demonstrations in Meghalaya.

Quality planting material production through the establishment of seed villages

Establishment of seed villages across Kerala, Tamil Nadu, Odisha, Meghalaya, and Mizoram significantly enhanced the availability of quality planting materials for cassava, sweet potato, Chinese potato, yams and elephant foot yam. A total of 47 seed villages covering 184 acres were set up in the 2024 crop season in Tamil Nadu, Kerala, Odisha and Meghalaya under seed village ensuring disease-free and high-yielding varieties for sustainable tuber crop production. \ Trainings were provided in nursery management, disease-free seed production, and scientific cultivation practices. Regular field inspections ensured quality control, facilitating the expansion of improved tuber crop varieties into non-traditional areas and supporting long-term farmer-led propagation efforts.

Decentralised Seed Multiplier (DSM) for quality planting material production of tuber crops

The Decentralized Seed Multiplier (DSM) program aims to establish a network of tuber crop farmers for quality planting material production of tuber crops under the guidance of ICAR-CTCRI. Farmers involved in on-farm demonstrations, seed villages, and front-line demonstrations of tropical tuber crops on less than one hectare area were approved as decentralized seed multipliers. A team of scientists

regularly monitoring planting material production, and provides agro-advisories, and ensures adherence to ICAR-CTCRI seed quality standards. A total of 117 farmers have been registered as decentralized seed multipliers, covering cassava (9), sweet potato (20), elephant foot yam (28), greater yam (29), taro (23), Chinese potato (2), and yam bean (6).

Investigations on rapid multiplication of yams and aroids

Refinement of micro/minisett multiplication method in yams: The experiment continued with four sett sizes and six pretreatments. Yield data showed a statistically significant increase with larger sett sizes (Fig. 34). The highest tuber yield was recorded in S_4 (50 g) at 2.012 kg, followed by S_3 (30 g) at 1.327 kg and S_2 (20 g) at 1.049 kg. Corresponding yield per hectare was 74.44 t (S_4), 49.09 t (S_3), and 38.83 t (S_2), confirming the advantage of larger sett sizes in yam multiplication.

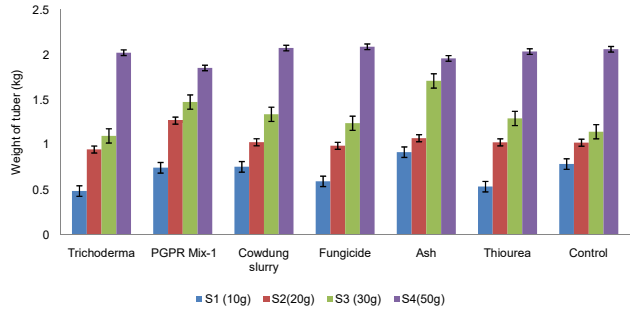


Fig . 34. Effect of sett size and pretreatments on tuber yield of greater yam

Field validation of yam minisett nursery performance (OFT): Two on-farm trials (OFTs) were conducted to validate the field performance of yam portray nursery raised from minisetts at two locations. Madhu K., from Marangodu, Uzhamalakkal, Nedumangad, achieved a mean yield of 1.355 kg per plant, resulting in a yield of 50.14 tonnes per hectare with the Sree Nidhi variety under rainfed system.Sujith, from Menamkulam, Kazhakoottam, recorded a mean yield of 5.184 kg per plant, yielding 191.808 tonnes per hectare with Sree Nidhi, and a mean yield of 1.392 kg per plant, producing 51.50 tonnes per hectare with the Sree Neelima variety under fertigation system.

Accelerated multiplication of yams through container growing system : An experiment using grow bags evaluated six media combinations of two yam varieties, Sree Nidhi and Sree Neelima. Tuber yield varied significantly. In Sree Nidhi, the highest yield was in M3 (1143 g/plant), followed by M2 (1103 g/plant) and M4 (1080 g/plant), while M5 (800 g/plant) and M6 (965 g/plant) had the lowest. For Sree Neelima, M6 (880 g/plant) had the highest yield, followed by M3 (836 g/plant) and M2 (792 g/plant), with the lowest in M5 (500 g/plant) and M4 (550 g/plant).

Refinement of miniset propagation of elephant foot yam: Sett size and pretreatments significantly influenced corm yield in elephant foot yam (Gajendra). Larger setts yielded more, with S4 (200 g) producing 1.42 kg and S3 (150 g) yielding 1.12 kg, while smaller setts S2 (100 g) and S1 (50 g) produced 0.75 kg and 0.41 kg, respectively. Larger setts (S3, S4) yielded 10 times their weight, while smaller setts (S1, S2) yielded 7–8 times. Pretreatment also impacted corm yield (0.8–1.1 kg), with Trichoderma and ash treatments proving the most effective (Fig. 35).

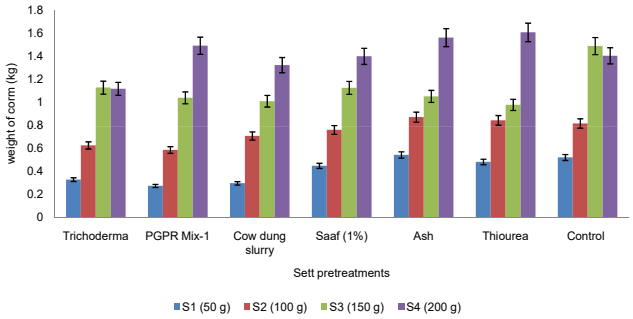


Fig. 35. Effect of sett size and pretreatments on corm yield of EFY var. Gajendra

Crop Protection

Development of innovative technologies for the intensification of pest management in tuber crops through bio-rational approaches

Management of important pests and documentation of emerging pests in tuber crops

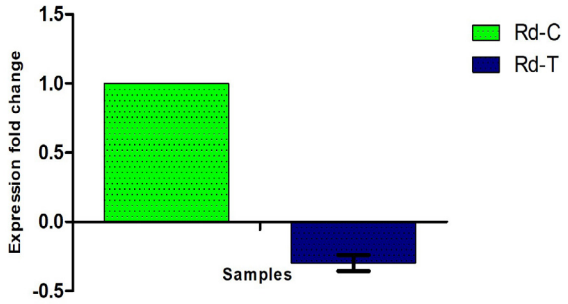
Cassava leaf distillate against borer pests

The effectiveness of cassava leaf distillate was evaluated against the borer pests *Rhizopertha dominica* and *Cylas formicarius*. The insects were exposed to the distillate in fumigation chamber. The study utilized a cohort of tenth-generation individuals from a laboratory-maintained culture. For each bioassay, 40 adult insects of *R. dominica* and *C. formicarius*, reared in cassava chips and sweet potatoes respectively were utilized. The insects were exposed to the distillate in fumigation chamber and repeated thrice. The bioassays recorded mortality times of 4 min for *R. dominica* and 5 min for *C. formicarius*.

Cassava leaf distillate on *Cytochrome C oxidase* expression in borer pests

The effect of cassava leaf distillate was assessed by examining the expression of *cytochrome C oxidase* gene in *R. dominica* and *C. formicarius* using real time PCR with SYBR green master mix on a Light Cycler 96 (Roche). There was a significant reduction in *cytochrome C oxidase* expression in both insect species upon fumigant exposure. Specifically, *C. formicarius* exhibited an average 9-fold decrease, while *R. dominica* showed nearly a 3-fold reduction (Fig. 36 & 37). These findings confirm the inhibition of cytochrome C oxidase mRNA expression in insects after fumigant treatment.

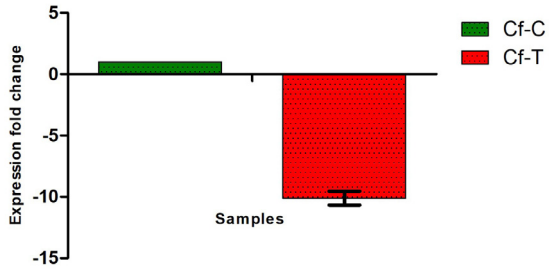
Rd-Cyox (Oligo Name)			
Insect 1 (Untreated)	1	1	1
Insect 2 (Treated)	-0.384109468	-0.329507911	-0.188207115



Rd-C : *Rhizopertha dominica*-Control,
Rd-T : *R. dominica*-Treated.

Fig. 36. Effect of cassava leaf distillate on *cytochrome C oxidase* expression in *Rhizopertha dominica*

Cf-Cyox (Oligo Name)			
W1 (Untreated)	1	1	1
W2 (Treated)	-9.787868615	-11.22007367	-9.438822645



Cf-C : *Cylas formicarius*-Control, Cf-T : *C. formicarius*-Treated.

Fig. 37. Effect of cassava leaf distillate on *cytochrome C oxidase* expression in *Cylas formicarius*

Newer mites infesting tuber crops and study on endosymbionts

The presence of *Tetranychus kanzawai* is confirmed as a pest in cassava using morphological identification keys and also by sequencing of PCR product (MT-CO1region) (Fig. 38). *T. kanzawai* or the Kanzawa spider mite, is a pest that harms cassava in warm climate. It is small, red or reddish-brown, and 0.4-0.5 mm long. These mites feed on plant sap, causing yellowing, bronze discoloration, and defoliation in cassava lead to stunted growth and reduced tuber production under severe infestation.

The bacterial endosymbionts were isolated from the mites. The colony morphology was observed using stereo microscope and the selected colonies

Fig. 38. Kanzawa spider mite

were purified and subjected to gram staining, which identified three gram-positive rod-shaped and one gram-positive cocci isolate. For species identification, PCR analysis was carried out for bacteria using 16s rRNA primer, which identified CYMI1 as *Bacillus cereus* and CRMI3 as *Bacillus mycoides* respectively through sequencing followed by NCBI-BLAST.

Entomopathogenic nematodes

Fourteen soil samples were collected and baited for the isolation of entomopathogenic nematodes (EPNs) from Thiruvananthapuram district, Kerala. Three samples tested positive for EPNs. The isolates were designated as CTCRIS2, CTCRIS3 and CTCRIH2. Based on morphological characterization, CTCRIS2 and CTCRIS3 were identified as *Steinernema* spp. & CTCRIH2 was identified as *Heterorhabditis* sp. Molecular characterization of entomopthogenic nematode isolate CTCRIS2 using ITS region-based markers revealed its specific identity as *Steinernema siamkayai* as it has shown 99.05 % similarity. The sequence has been deposited in the NCBI database under the Genbank accession number PP141117.

The primary endosymbiont associated with entomopathogenic nematode, *S. siamkayai* CTCRIS2 was isolated and purified. Based on morphological and biochemical characterization, the endosymbiotic bacteria associated with this nematode was identified as *Xenorhabdus stockiae* . The antimicrobial activity of *X. stockiae* was tested against plant pathogenic fungi using dual culture technique. Maximum inhibition was observed in *Phytophthora colocasiae* (65%) followed by *Fusarium* sp. (54%) and *Colletotrichum gloeosporioides* (51%).

Characterization of sweet potato weevil (*Cylas formicarius* (Fabricius) resistance genes in sweet potato and related *Ipomoea* spp.

Gene expression in *Ipomoea* spp upon sweet potato weevil infestation

Tuberous *Ipomoea mauritiana* was identified as resistant to sweet potato weevil infestation. Transcriptome sequencing of roots of *I. mauritiana* and *I. batatas* of sweet potato weevil infested and control samples was performed on Illumina NovaSeq 6000 platform, with the read length of 150 bp and bioinformatic analysis was done. The transcriptomes analysis of the gene up and down expression groups were made based on logFC values. From analysis, 72 genes were identified from the *I. batatas* samples and 52 genes were identified from *I. mauritiana* samples.

Leaf proteins of *Ipomoea mauritiana* against sweet potato weevil

The crude leaf protein was extracted from *I. mauritiana* and was tested against adult sweet potato weevils by leaf dip method. The mortality of the weevils was observed for crude extract isolated after 48 h at a concentration of protein ranges from 4-5 mg ml^{-1}. Further the effects of crude protein of *I. mauritiana* were studied by estimating various enzymes from sweet potato weevil after treatment. The significant reduction in the amount of insect protein was observed after treatment with crude leaf protein (Fig. 39). The lipid peroxidation activity of enzyme was 0.084712666 enzyme units (U) in control whereas in treated sample it is lesser 0.064959 U. The glutathione peroxidase (GPx), was 0.028200 U in control whereas after treatment the enzyme activity was 0.0222866 U. Similarly significant reduction was observed in the glutathione reductase (GSH) with value of 0.048271 in control in comparison with treated sample it is 0.719901 U. The superoxide dismutase activity (SOD), glutathione s- transferase (GST) of sweetpotato weevil was also higher in treated samples when compared with the control which reveals the insecticidal activity of crude protein extract. The evaluation of insecticidal activity of leaf protein extract from the wild *I. mauritiana* against sweetpotato weevil is the first of its kind to identify the presence of insecticidal proteins in its leaves.

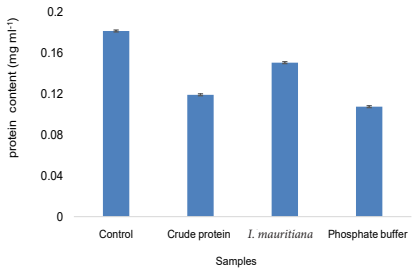


Fig. 39. Protein content in *Cylas formicarius* after treatment with *I. mauritiana* leaf proteins

Screening of newer molecules and biocontrol agents for the management of nematodes in tuber crop

The efficacy of four treatments, Fluopyram 34.48% SC (0.5 ml l^{-1}), Fluensulfone 2% GR (1g $plant^{-1}$), neem cake (500 g $plant^{-1}$) and *Trichoderma harzianum* (20 g $plant^{-1}$) along with control was evaluated for the management of root knot nematode, *Meloidogyne incognita* in farmers' field at Kayamkulam and Alappuzha, Kerala. Fluopyram treated plants showed the least corm damage (galls) (6.4%) and yielded best (2.5 kg $plant^{-1}$) followed by Fluensulfone, 15.8% damage and 2.03 kg per plant yield, neem cake and *Trichoderma harzianum* recorded 13.7 and 15% damage with 1.3 and 1.2 kg yield per plant, when compared with control (18.27% damage and 0.78 kg $plant^{-1}$ yield). The nematode gall index was rated according to Taylor and Sasser (1978), and the treatment with Fluopyram was rated as 2 (moderately resistant) and rest as 3 (moderately susceptible).

Identification of plant parasitic nematodes

The protocol for isolation of genomic DNA from plant parasitic nematodes was standardised. The *Meloidogyne* sp. (EMK1) infecting elephant foot yam was identified as *Meloidogyne javanica* (99.86% similarity) through ITS amplification, sequencing followed by NCBI blast analysis. The sequence was deposited in the NCBI database under the GenBank accession number PP756339. Phylogenetic tree was constructed using Neighbour joining method of MEGA 11(Fig. 40).

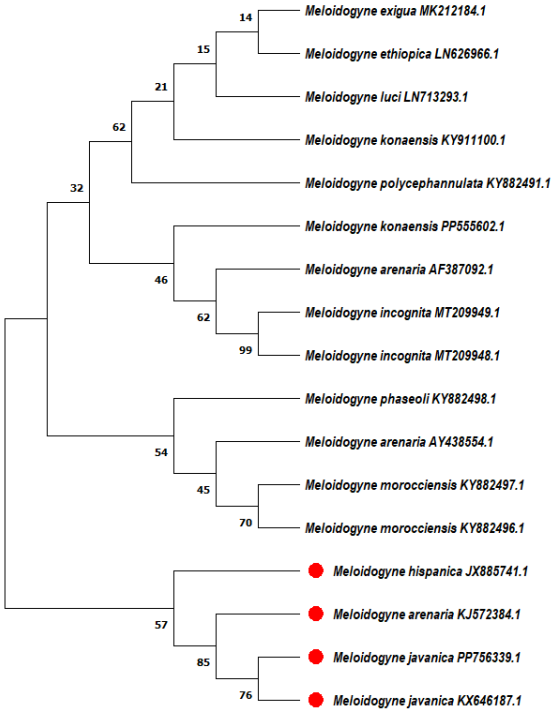


Fig. 40. Phylogenetic relationship of the isolated *Meloidogyne javanica* with other closely related species based on Neighbour joining method of MEGA 11

Surveys were conducted in Chinese potato fields across Acchampatti village (Kadaiyanallur block) and Ayanthiruvaleeswaram village (Ambasamudram block) in Tirunelveli district, as well as Kalyanipuram and Dharmapuramadam villages (Kadayam block) in Tenkasi district, Tamil Nadu. The root-knot nematode (*Meloidogyne* sp.) was the most prevalent nematode detected in soil samples, with population densities ranging from 0.5 to 2 nematodes per gram of soil in the surveyed fields

Development and refinement of integrated disease management and forecasting system for improved tuber crop production

Emerging fungal diseases and management strategies for major diseases of aroids

Sample collection and isolation of pathogens associated with leaf and pseudostem rot in elephant foot yam

Seven types of symptoms were observed in leaf samples exhibiting signs of leaf rot/blight and pseudostem rot. These samples were collected from various experimental fields of ICAR-CTCRI and farmers' fields in Kollam and Ernakulum districts of Kerala. Leaf rotting, with or without yellowing, was the most predominant symptom observed during the year. Out of the seven symptoms, five had been observed in previous years. The two new symptoms identified during the year were brown streaking on leaves that progressed to rot, observed at ICAR-CTCRI, and elliptical spots surrounded by a yellow halo across the leaves, observed at Kottarakkara, Kollam.

Koch's postulates were successfully fulfilled with 11 cultures isolated from the samples collected during the year. The majority of the isolates were identified as belonging to the genera *Colletotrichum* and *Fusarium.*

Management of leaf and pseudostem rot in elephant foot yam

Eleven treatments, including corm treatment and spraying with various fungicides as well as *Jeevamrit*, biocpsule of *Trichoderma asperellum* and *Trichoderma* enriched vermicompost were evaluated for their efficacy in managing leaf and pseudostem rot in elephant foot yam variety Gajendra. The lowest per cent disease index (PDI) was observed in the plants treated with Jeevamrit (4.0), which was on par with *Trichoderma* biocapsule (5.6) and Difenoconazole (7.73). The highest yield was also recorded in Jeevamrit treated plants (52.9 t ha^{-1}), followed by the bio-capsule of *T. asperellum* (51.7 t ha^{-1}). In contrast, the control plants exhibited significantly higher PDI of 28.8 and produced only 20.12 t ha^{-1} (Fig. 41).

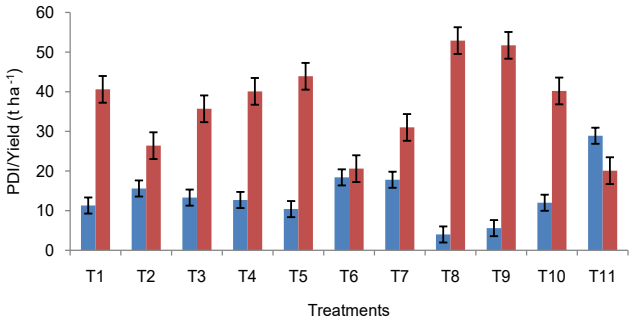


Fig.41. Effect of organic and chemical agents on per cent leaf and pseudostem rot index and yield in elephant foot yam. Treatments: Carbendazim 12% + Mancozeb 63%WP (0.2%) (T_1), Hexaconazole 5% SC (0.1%) (T_2), Tebuconazole 50%+ Trifloxystrobin 25% WG (0.1%) (T_3), Propiconazole (0.1%) (T_4), Difenoconazole 25% EC (0.1%) (T_5), Propiconazole 13.9% + Difenoconazole 13.9% EC (0.1%) (T_6), Carbendazim 50%WP (0.1%) (T_7), Jeevamrit (10%) (T_8), biocapsule of *Trichoderma asperellum* (T_9), *Trichoderma* enriched vermicompost (T_{10}) and control (T_{11})

Refinement of management strategy for taro leaf blight

Ten treatments, including corm treatment and spraying with different fungicides as well as potassium silicate, biocapsule of *T. asperellum* and *Bacillus* sp were evaluated for their efficacy in managing taro leaf blight. The lowest percent disease index (PDI) was observed in plants treated with Metalaxyl 4%+Manconzeb 64% (7.51) and Cymoxanil 8% +Mancozeb 64% (7.84), which were on par with potassium silicate (10.6) and Famoxadone 16.6% + Cymoxanil 22.1% SC (11.96). Comparatively, the control plants exhibited a significantly higher PDI of 24.6 (Fig. 42).

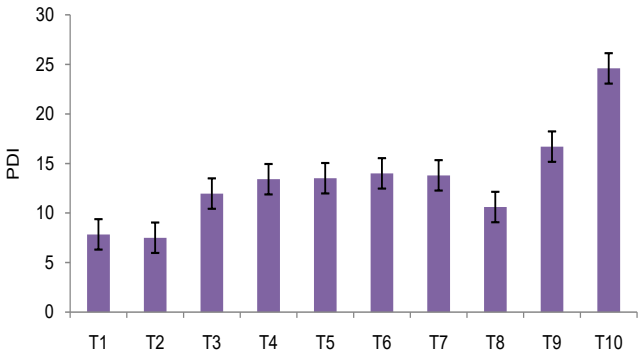


Fig. 42. Effect of organic and chemical agents on per cent taro leaf blight index.

Treatments: Cymoxanil 8%+Mancozeb 64% (0.1%) (T_1), Metalaxyl 4%+Manconzeb 64% (0.1%) (T_2), Famoxadone 16.6%+Cymoxanil 22.1% (0.1%) (T_3), Potassium phosphite (0.3%) (T_4), Metalaxyl-M 3.3% +Chlorothalonil 33.1% (0.1%) (T_5), Copper oxychloride (0.2%) (T_6), Biocapsule of *T. asperellum* (T_7), Potassium silicate (0.2%) (T_8), biocapsule of *Bacillus* sp (T_9) and control (T_{10})

Assessment of variability in temperature tolerance among *Trichoderma* Isolates

Temperature tolerance is crucial to optimize the effectiveness of *Trichoderma* across different climates. Ninety-seven *Trichoderma* isolates were assessed for temperature tolerance by incubating the cultures at six different temperatures: 15, 20, 25, 30, 35, and 40°C. The growth rate ranged from 0.43 cm/day (isolate T_{91} at 15ºC) to 3.8 cm/day (isolate T_{89} at 35ºC). The mean mycelial growth of the isolates at 30ºC was significantly higher than at all other temperatures, followed by 35ºC (Fig. 43). The lowest growth rate was observed at 15ºC, which was significantly lower than the mycelial growth rates recorded at all other temperatures. Fifteen isolates, T_3, T_{19}, T_{20}, T_{52}, T_{59}, T_{63}, T_{66}, T_{73}, T_{79}, T_{81}, T_{87}, T_{92}, T_{94}, T_{95}, and T_{96} exhibited a growth rate difference of less than 0.5 cm/day across temperatures of 20ºC, 25ºC, 30ºC, and 35ºC. These isolates may be suitable for regions with significant temperature variations across different seasons.

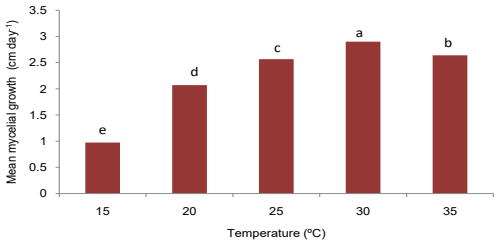


Fig. 43. Mean mycelial growth rate of *Trichoderma* isolates at different temperature

Fungal pathogens and disease management in cassava and yams

Cassava stem and root rot

Isolation and identification: The pathogens associated with cassava stem and root rot were identified as *Fusarium* spp through morphocultural characters and further to species level using mitochondrial small subunit, RNA polymerase 2 (*rpb2*), and translation elongation factor 1-alpha (*tef1*) gene sequencing. Four isolates belong to *Fusarium solani* species complex (FSSC), *Fusarium falciforme* (3), *Neocosmospora suttoniana* (1). Six new isolates were obtained from different farmers'fields in Kerala during 2024.

Management: Cassava stem and root rot (CSRR) management trial with *Trichoderma asperellum* (CTRI-Tr 15), an endophytic *Bacillus subtilis* biocapsule, and ICAR-Fusicont (ICAR-CISH) reduced 89, 72 and 58 % of disease incidence respectively compared to control. Based on field trails during 2023-2024 with seven treatments, FLD with three best treatments, phosphogypsum, customised fertiliser, CTCRI package along with polyhalite and farmer's practice were initiated at six locations in Kerala, where the disease is endemic.

Screening for resistance: Sixteen varieties of cassava, released by ICAR-CTCRI along with a susceptible local check were screened *in vitro* through stem inoculation and *in vivo* testing in net house using a virulent *Fusarium falciforme*. Among these, six varieties, viz., Sree Suvarna, Sree Athulya, Sree Pavithra, Sree Reksha, H-97 and Sree Visakham could withstand the infection *in vitro*. From the above, two CMD-resistant varieties, Sree Reksha and Sree Suvarna, along with Sree Pavithra, known for its excellent culinary quality, are currently being evaluated for field resistance in farmers' fields at three locations in Kerala. So far, no disease incidence has been observed in these varieties.

Microbiome studies: Totally 12 root samples were collected from CSRR infected and healthy cassava plants from wet land and microbes were isolated from rhizoplane using standard methods for further cultural and meta barcoding analysis to study the biotic correlation. A total of 106 and 103 bacteria; 85 and 54 fungi were isolated from healthy and infected samples respectively and maintained to evaluate against cassava stem and root rot.

Management of greater yam anthracnose

Effect of fungicides: In a field trial, different fungicides Carbendazim (50% WP), Azoxystrobin (18.2%) + Difenoconazole (11.4% SC), Difenoconazole 25% EC and Tebuconazole+ Trifloxystrobin were evaluated against anthracnose in greater yam (cv. Orissa Elite) for the second season (2024-2025). All fungicides reduced anthracnose intensity, whereas highest reduction was by Azoxystrobin + Difenoconazole (65%) (1 ml l^{-1}), which was followed by Difenoconazole (60%) (1 ml l^{-1}) and Carbendazim (53%) (0.5 g l^{-1}).

Effect of endophyte and its characterization: The fresh vegetable waste based liquid formulation and biocapsule of a potent endophyte CTCRI EB12 selected against greater yam anthracnose were evaluated in field with different delivery methods against the disease. The maximum reduction of 21% was observed with the combination of soil (250 ml $plant^{-1}$ by mixing one biocapsule in 100 litres of water) and tuber treatment (Mixing one biocapsule in 100 litres of cowdung slurry).

The whole-genome sequence suggests that CTCRI EB12 is an isolate of *Bacillus subtilis*. The isolate contains genes encoding several enzymes, which are involved in the hydrolysis of fungal cell walls, contributing to the organism's antifungal properties. In addition, they also possess genes related to nutrient metabolisms which enhance plant growth.

The endophytic bacterium CTCRI EB12 was successfully transformed with the pEGFP plasmid, resulting in the generation of a GFP-tagged, designated as CTCRI EB12T. The transformant retained its antagonistic activity (82.6 %) against *C. gloeosporioides* (CTCRI Cg23), indicating that the transformation did not compromise its biological functions. Following root colonization, CTCRI EB12T was predominantly observed in the stem, with similar levels of colonization detected in the petiole and leaf.

Virus and phytoplasma diseases of tropical tuber crops and their management

Cassava mosaic disease (CMD)

Editing Geminiviral genome for developing resistance to cassava mosaic disease: Transformation of model plant *Nicotiana benthamiana* and

agroinfection of friable embryogenic calli (FEC) of CMD susceptible cassava variety H226 with recombinant *Agrobacterium* clones harbouring CRISPR/Cas9 single as well as multiplex editing cassettes targeting Rep region of SLCMV was done. Transgenic *Nicotiana benthamiana* plants were regenerated under selection pressure (Kanamycin) and confirmed using PCR with npt II gene specific primers. The number of events obtained was 7,4 and 10 for the constructs, T1-4sgRNA, T2-2sgRNA and A2-1sgRNA respectively. Seeds were collected from mature plants and T1 lines were raised. sgRNA oligos targeting CP and IR regions of SLCMV were cloned in to shuttle vectors and corresponding sgRNA transcription units were further assembled in binary vector pDGE2 through gateway cloning.

Sweetpotato leaf curl disease

CRISPR/Cas9 gene editing strategies to control SPLCV: *N. benthamiana* leaf disc transformation was done with *Agrobacterium* strain EHA105 harbouring single gRNA Tu (IR) in pDGE62, two gRNA TUs (IR & C1C4), four (IR, C1, V1V2, C1C4) and eights gRNA Tus (c1c4, cr2, viv2, c2c3, c1c41, cr1, c1, v1) in pDGE1. The rooted plants were established in growth chamber and confirmed primarily by PCR analysis with *npt*II primers. The plants were transferred to soil and being maintained in growth chamber (Fig. 44).

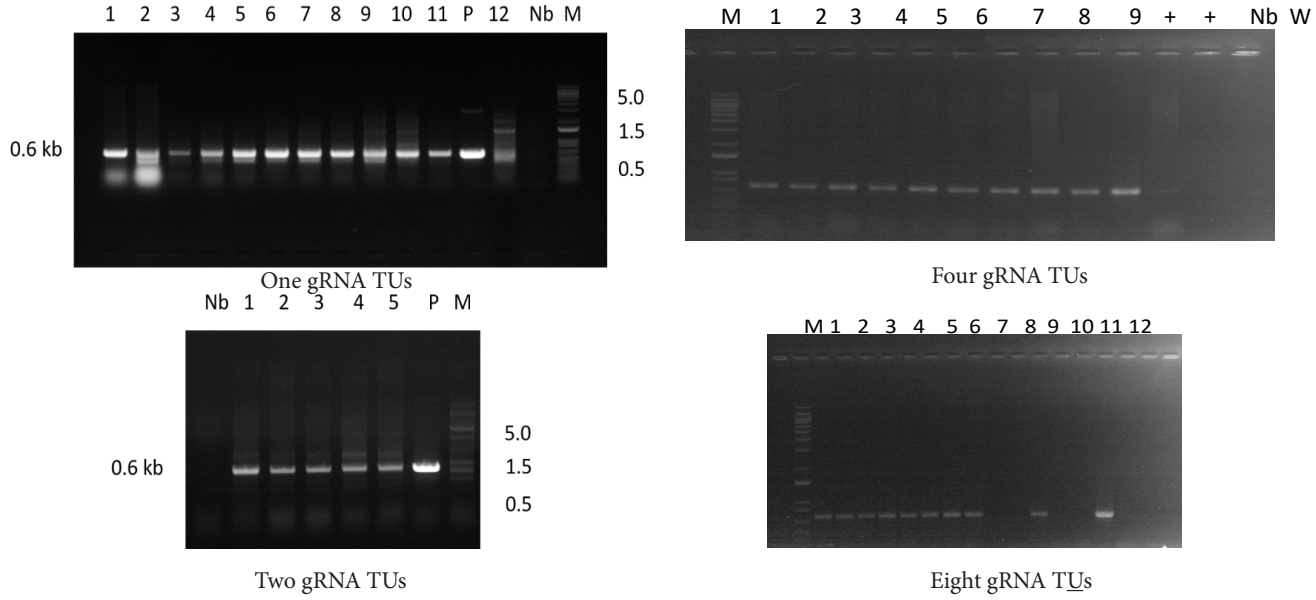


Fig. 44. PCR analysis of the transgenic plants harbouring different gRNA TUs with nptII primers

Mass production and effective utilization of bioagents to manage fungal diseases of tuber crops

Isolation and diversity of endophytic microorganisms in greater yam and sweet potato cropping systems

Endophytic organisms were isolated from diverse plant parts, including leaves, stems, and flowers of greater yam and sweet potato across various locations within the regional station of ICAR-CTCRI, Bhubaneswar. A total of 18 endophytic microorganisms were successfully isolated, comprising six bacteria and twelve fungi. The fungal endophytes belonged to the genera *Trichoderma*, *Cephalosporium*, *Fusarium* and *Curvularia* and bacterial isolates belonged to *Bacillus* and *Pseudomonas* species. Floral tissues exhibited significant endophytic diversity, suggesting that different plant parts harbour unique microbial communities adapted to their specific microenvironments.

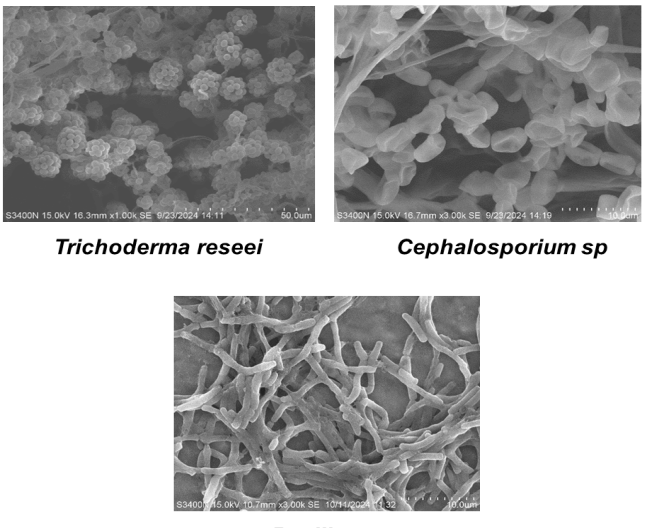
Effect of endophytes on sweetpotato growth

A pot culture experiment was conducted to evaluate the impact of three endophytes, *Trichoderma*, *Cephalosporium*, and *Bacillus* on the growth and nutrient uptake of sweet potato under five treatment conditions: soil application before planting, foliar application, soil application, and a combination of soil and foliar application along with control. Plant growth parameters, including the number of leaves, vine length, root length, and soil nutrient content,

were measured to assess the efficacy of the treatments. The combination of soil and foliar application consistently outperformed other treatments, showing significant improvements in most growth parameters. Sweetpotato plants under the above treatment exhibited the highest vine length, root length, and nutrient uptake. Notably, the absorption of essential nutrients such as nitrogen (ranging from 294.05 to 335.96 kg ha^{-1}) and potassium (28.95 to 35.5 kg ha^{-1}) was significantly enhanced under this treatment. Furthermore, micronutrients such as calcium (Ca) and magnesium (Mg) were also efficiently absorbed.

Characterization of endophytic microorganisms using SEM technique

The selected endophytes, including *Trichoderma* spp. (ESP 2- EF), *Cephalosporium* spp. (ESP 9-EF), and *Bacillus* spp. (ESP 17-EF), were examined using scanning electron microscopy (SEM) (Hitachi Company, Model: S3400N Type II). SEM analysis provided high-resolution images of the surface morphology, allowing detailed visualization of the cellular structures and growth patterns (Fig. 45). The SEM images of *Trichoderma* revealed typical hyphal structures with distinct septa and conidiophores bearing conidia, confirming its filamentous nature and reproductive structures. The surface texture of the hyphae appeared smooth, with branching typical of this genus. For *Cephalosporium*, the SEM images exhibited slender, elongated hyphae with a distinct morphology compared to *Trichoderma*, characterized by thin, long filaments. The reproductive structures were observed as spore-bearing structures, showcasing the typical spore arrangement of this genus. *Bacillus* spp., the bacterial endophyte, displayed rod-shaped cells typical of Bacilli under SEM, arranged in chains or scattered singly. The surface of the bacterial cells appeared smooth, with clear cell wall delineation.



Trichoderma reseei ***Cephalosporium sp***

Bacillus cereus

Fig. 45. SEM images of the potential endophytes isolated from sweetpotato and greater yam

Identification of the bacterial endophytes using Automated Microbial Identification system

The potential endophytic bacterial culture was identified using the Automated Microbial Identification (AMI) system (BIOMERIEUX Company, Model: VITEK2 Compact). This system evaluates bacterial utilization of various carbon sources, including sugars, carboxylic acids, amino acids, and peptides. A total of 71 carbon sources and 23 chemical assays, such as pH tolerance, salt tolerance, and chemical sensitivity, are tested. The results, analyzed through a "yes–no" reaction matrix and compared to a comprehensive database, identified the isolate (ESP 17-EF) as *Bacillus cereus*. The AMI system proved to be an effective tool for identifying and elucidating the biological characteristics of these bacterial endophyte.

Development of cost-effective protocols for mass production of *Trichoderma* using tuber substrate

The shelf life and cost-effective mass multiplication potential of *Trichoderma* were evaluated using seven tuber peel derived from tropical tuber crops under *in vitro* conditions. Spore counts and colony-forming units (CFU) were monitored at regular intervals to assess viability and growth dynamics over 90 days. Among the substrates tested, cassava and sweetpotato tuber peel waste were identified as the most effective media for *Trichoderma* inoculant production, with sweetpotato achieving the highest spore viability of 6.3×10^8 CFU/g at 90 days. Sweetpotato showed superior performance in supporting *Trichoderma* growth and longevity, substrates like cassava, and greater yam demonstrated moderate to high initial CFU counts but reduced viability at later stages.

Crop Utilisation

Development and refinement of postharvest handling, storage and processing techniques for minimization of losses in tropical tuber crops and production of value added products

Non-conventional applications of cassava starch in construction and building materials

Particle board from cassava stems and agro residues

Particle boards were prepared from cassava stems using urea formaldehyde as resins, hot water blanched and stem-coir pith composites (Fig. 46). Particle boards were prepared from cassava stem using urea formaldehyde as resin by changing the resin concentration from 30 to 45%, operating die temperature 110 to 130°C and die pressure 35 to 55 bar. The physico-functional properties, viz., moisture content, density, water activity, colour parameters, viz., 'L', 'a', 'b', total colour difference, yellowness index, water absorption after 2 and 24 h soaking in water, hygroscopicity at 75, 85 and 95% relative humidity, mechanical properties, viz., ultimate force, ultimate stress, modulus were calculated. The ultimate force ranged from 80.03 to 243 N, ultimate stress from 9.86 to 3.11 MPa and modulus from1070 to 5670 MPa, density from 899 to 1161 kgm^{-3}, moisture content from 7.71 to 9.9%.

In the hot water blanched method, dried cassava stems were treated with hot water at 85-95°C for 30-90 minutes. Subsequently, particle boards were manufactured using a die temperature range of 100-120°C and a die pressure range of 35-55 bar. From the physico-functional properties analysis it was found that moisture content varied from 6.38 to 8.28%, density from 655 to 1250 kgm^{-3}, water absorption after 2 h from 5.72 to 64% and after 24 h from 11.61 to 76.74%. Thickness swelling varied from 4.57 to 15.61%, ultimate force from 70.03 to 308.33N, ultimate stress from 5.69 to 12.6 MPa and modulus from 2170 to 4130 Mpa.

In the stem-coir pith composites method, cassava stem was mixed with coir pith at 25, 50 and 75% and particle boards were prepared by changing the resin concentration from 20 to 40%, die temperature from 110 to 130°C and die pressure from 35 to 55 bar. The physico-functional and mechanical properties were analysed. Moisture content varied from 6.38 to 8.26%, density from 3.74 to 26.05%, water absorption after 2 h soaking from 3.74 to 26.05%, after 24 h soaking from 13.39 to 38.29% and hygroscopicity at different relative humidity levels did not have any significant change.

Fig. 46. Particle boards from cassava stem

A.Urea formaldehyde as resins B. Hot water blanched
C. Stem-coir pith composites

The optimized processing conditions and the properties of the particle boards developed are given in Table 9.

Effect of different resins, viz., urea formaldehyde, melamine urea formaldehyde and phenol formaldehyde on the properties of cassava stem-coir pith/ rice husk composites were analyzed by changing the coir pith/rice husk percentage from 20 to 40% in the composites. Moisture content of the particle board varied from 5.75 to 13.51%, water absorption after 2 h soaking from 6.57 to 39.43%, after 24 h soaking from 18.10 to 74.69%, thickness swelling from 5.09 to 9.08%, ultimate force from 8.33 to 205 N, ultimate stress from 8.57 to 25.2 MPa and modulus from 360 to 2760 MPa.

Table 9. Optimized processing conditions and the properties of cassava stem based particle boards

Parameters	Cassava stem (Optimized)	Hot water blanched cassava stem (Optimized)	Cassava stem-coir Pith composite (Optimized)
Processing conditions	130°C, 36.43 bar, 40% resin	116°C, 55 bar, 85.19°C blanching, 90 min	110°C, 35 bar, 34.13% coir pith, 40% resin
Moisture content (%)	8.60	7.82	7.14
Density (kg/m³)	1049	1017	1164
Water activity	0.44	0.47	0.60
Total colour difference	40.57	52.63	47.94
Yellowness index	40.57	44.33	36.09
Water absorption (2 h, %)	14.09	12.54	9.43
Water absorption (24 h, %)	29.49	20.22	17.95
Hygroscopicity (75% RH, %)	1.58	1.27	2.03
Hygroscopicity (85% RH, %)	2.90	2.07	2.60
Hygroscopicity (95% RH, %)	6.33	2.65	2.92
Thickness swelling (%)	-	4.57-15.61	-
Ultimate Force (N)	92.52	253.53	291.23
Ultimate Stress (MPa)	11.71	39.65	31.75
Modulus (MPa)	3632	21.61	20.75
Peak Load (N)	92.52	253.53	291.23

Cassava stem based particleboard were prepared from three varieties of cassava viz., Sree Reksha, Sree Vijaya and Sree Suvarna by changing the temperature as 110, 120, 130 °C ; amount of resin : 20, 30 and 40% and pressure of moulding: 35, 45, 55 bar. The quantity of stem used was fixed as 150 g and pressing time as 15 min. The density, moisture content, water absorption after 2 and 24 h and colour properties such as total colour difference and yellowness index and mechanical properties, viz., peak load, flexural strength and modulus of rupture of the particle board were observed (Table 10, Fig. 47).

Table.10. Properties of particle board prepared from different varieties of cassava

Parameters	Sree Reksha	Sree Vijaya	Sree Suvarna
Resin (%)	40	40	40
Die temperature (°C)	115.04	112.34	113.80
Pressure (bar)	42.32	35	55
Moisture content (%)	9.23	6.15	8.30
Density (kg/m³)	1101	1127.45	1195
Total colour Difference	36.40	33.95	40.54
Yellowness index	31.89	37.21	31.18
Water absorption (2 h, %)	11.90	14.64	3.34
Water absorption (24 h, %)	17.41	22.80	16.90
Peak load (N)	324.21	329.25	344.98
Flexural strength (MPa)	28.52	35.97	35.93
Modulus (N/mm²)	36.29	27.60	35.94

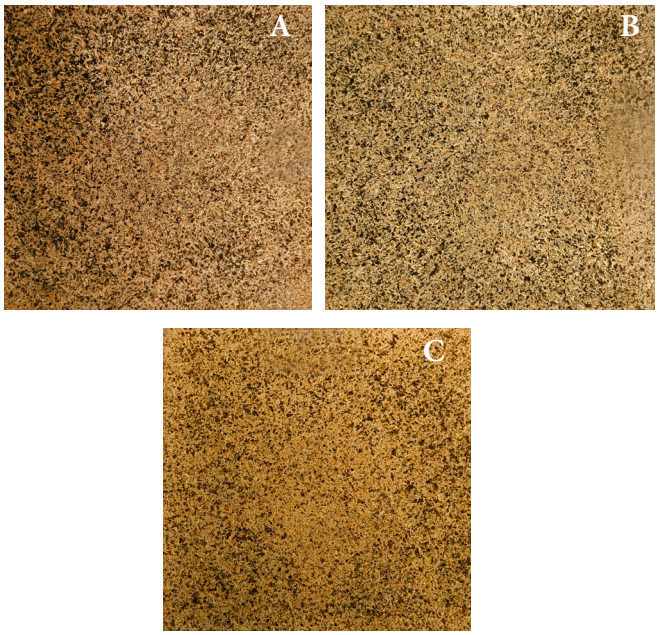


Fig. 47. Particle boards from the stems of different cassava varieties

A.Sree Reksha; B. Sree Vijaya; C. Sree Suvarna

Development of cassava and sweet potato based animal feed

Cassava peel from different varieties/lines, viz., Sree Reksha, Sree Suvarna, Sree Kaveri, Sree Shakthi, Plachikizhangu, MNS 247, MNS48, KBH-18 were analysed for cyanide content in the fresh and sun dried peels. The peel weight varied from 12.31 to 15.98% of the tubers. The cyanide content varied

from 249 to 1714 ppm in the fresh peels and after sun drying, it reduced from 142 to 1294 (23.92 to 66.20%), depending on the varieties (Fig. 48).

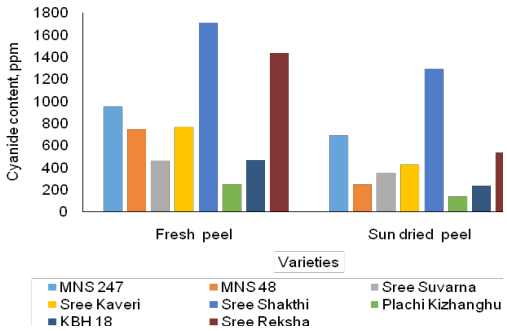


Fig. 48. Cyanide content in fresh and sun dried peel of different varieties of cassava

Hot water blanching of the peel on the cyanide content reduction was carried out by changing the blanching temperature from 50 to 100°C for different time interval from 5 to 20 min. The cyanide content of the peel from the variety, Sree Reksha varied from 1435 ppm in the fresh peel to 548 pm in the sundried peel. As the temperature of blanching increased, there was a significant reduction up to 80°C respective to time of blanching i.e., cyanide content decreased by 83.57 - 88.77% and thereafter not much changes, showing the optimal blanching temperature as 80°C. After 20 min of blanching, when temperature increased from 60 to 80°C, cyanide content was reduced by 86.28 to 89.81%, whereas at 50°C, reduction was only 45.94%. When the time of blanching increased from 5 to 20 min, cyanide content reduction was 20.38 to 45.94% at 50°C, 44.27 to 86.28% at 60°C, 83.57 to 88.77% at 70°C , 84.20 to 88.56% at 80°C , 84.44 to 88.46% at 90°C and 84.72 to 89.81 at 100°C blanching (Fig. 49).

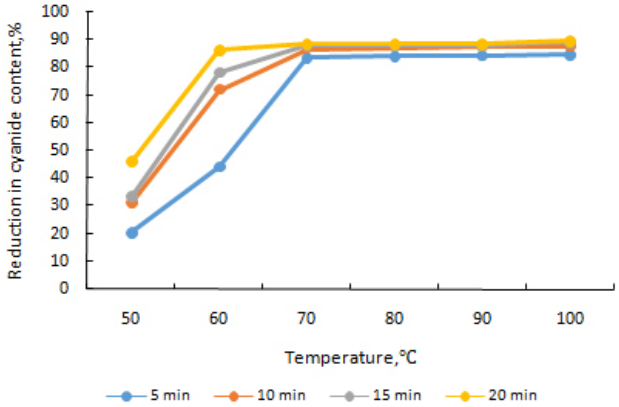


Fig. 49. Effect of blanching temperature and time on the cyanide reduction in cassava peel

Varietal influence on the qualities of sweet potato (*Ipomoea batatas*) vines

The variability in the biochemical quality, antioxidant activity and micronutrients content of the vines of the promising sweet potato varieties viz., Sree Arun, Sree Varun, Sree Bhadra, Bhu Krishna and Bhu Sona were analysed. Among the biochemical properties, the moisture content of the fresh vines varied from 79.13% (Sree Bhadra) to 86.77% (Bhu Krishna). The highest starch content was observed in Sree Varun (37.50%) and the lowest in Bhu Krishna (22.5%). The variety Bhu Sona recorded the maximum sugar content (13.39%) and Sree Arun exhibited the minimum (8.45%). The vines of Sree Arun had the highest fiber content of 11.06% compared to the lowest in Sree Bhadra (5.62%). The protein content ranged from 10.06% for Sree Bhadra, to 4.37% for Bhu Sona (4.37%). The fat content of the vines after removing the chlorophyll was maximum of 1.82% for Sree Bhadra and the minimum of 0.77% for Sree Arun. The cellulose content varied between 24.40% (Sree Varun) and 9.12% (Sree Bhadra), hemicellulose content 37.20% (Sree Arun) and 26.55% (Sree Bhadra) and the lignin content 17.08% (Sree Bhadra) and 4.20% (Sree Varun).

Regarding the anti-oxidant activity of different varieties, the highest percentage of inhibition in water extract was obtained for Bhu Krishna (80.08%) and the minimum for Sree Varun (64.11%) whereas in ethanol extracts, the highest percentage of inhibition by Bhu Sona (79.58%) and the lowest by Sree Varun (63.37%). Among the micro nutrients, iron content was maximum of 288.9 ppm in the variety Bhu Krishna, whereas minimum of 179.4 ppm in Sree Arun. Copper content ranged from 20.2 ppm (Sree Arun) to 18.1 ppm (Sree Bhadra), zinc content from 17.6 ppm (Sree Bhadra) to 22.7 ppm (Sree Varun), calcium from 3833 ppm (Sree Bhadra) to 2431 ppm (Sree Arun). Magnesium from 145.91 ppm (Sree Varun) to 121.83 ppm (Sree Arun).

Among the different quality attributes, there is a significant difference in the moisture, starch, fat, cellulose, hemicelluloses, lignin and antioxidant activity ($p<0.001$) and sugar, protein and ash ($p<0.01$), magnesium ($p<0.05$) among varieties, however, there

is no significant variations in iron, copper and zinc content.

Development of modified starches of cassava and functional characterization of lesser known tropical tuber starches

Economic analysis of cassava distarch phosphate and cassava starch phosphate carbamate

Economic analysis was performed for the two modified starches of cassava, viz., cassava distarch phosphate and ammonium cassava starch phosphate carbamate. The selling cost and B:C ratio of cassava distarch phosphate were estimated as ₹ 375 per kg and 1.397, respectively. The selling cost was estimated as ₹ 350 per kg with a benefit cost ratio of 1.433 for cassava starch phosphate carbamate. Cassava distarch phosphate with high viscosity and low pasting temperature is suitable for uses as thickener in food products which require high viscosity pastes with minimum heating. Ammonium cassava starch phosphate carbamate with high water absorption and dye adsorption capabilities can be potentially exploited as a sustainable material in water treatment for dye removal.

Synthesis of food grade succinylated cassava distarch phosphate

Succinylated cassava distarch phosphate, which can act as a fat substitute and emulsifier in food products, was synthesized by esterification of starch with succinic anhydride and subsequent cross linking with sodium trimetaphosphate. The modified starches were characterized by determination of substitution level, P content, pasting profile and other physicochemical properties. The succinylated distarchphosphates have significantly higher water binding capacity (131- 201%) than native cassava starch (77.1%). The swelling power and paste viscosity also were higher for the modified starches. The dual modification increased the paste stability as seen from the low viscosity breakdown. The lower percentage syneresis is beneficial in the preparation of refrigerated food products. The modified starch was successfully used as an emulsifier in no-fat eggless mayonnaise, where the product closely mimics the qualities of conventional mayonnaise. The mayonnaise prepared with the modified starch has less fat (5.2/100 g) and sugar (3.7/100 g) contents when compared to those of the commercial mayon naise (fat-35/100 g, sugar-5.22/100 g) used as a control.

Synthesis and characterization of porous cross-linked cassava starch

Cassava starch with enhanced porosity was developed using various preparation techniques, and the porous starch was subsequently subjected to cross-linking with sodium trimetaphosphate. The modified starch exhibited a marked increase in porosity, ranging from 50% to 82.1%, compared to 48% for native starch. The cross-linked starch samples demonstrated reduced swelling power and solubility relative to native starch. The oil absorption capacity (OAC) of the modified starch significantly improved, with the highest OAC reaching 210.1%, proportional to the concentration of STMP used for cross-linking. The modified starch showed potential for applications in food and cosmetics.

pH sensing cassava starch films for food spoilage detection

The pH fluctuations resulting from the release of gases such as sulphur dioxide, carbon dioxide, ammonia, hydrogen sulphide, and methane during food decay are crucial indicators of spoilage in various food products. Indicator films, based on these pH variations, can visually display colour changes. Typically, a pH indicator comprises a solid support material and a dye or pigment. Native cassava starch and its modified forms, including cassava starch succinate, starch phosphate, succinylated distarch phosphate, and starch-polyvinyl alcohol (PVA) composites, were evaluated as solid supports. Natural dyes, anthocyanin and curcumin, were incorporated into the films to create visual indicators. Strips of these films were tested as sensors in different packaged food items, such as cabbage, mushrooms, and fish, under both room temperature and refrigeration conditions. For curcumin-based films, the yellow colour transitioned sequentially to amber orange, tangerine, and finally to scarlet red as storage time increased. Anthocyanin-based films exhibited a colour shift from purple to blue and eventually to dark olive, corresponding to the spoilage of the packed food. Among the films tested,

those made from cassava starch composited with low concentrations of PVA demonstrated superior performance, characterized by reduced moisture absorption and enhanced mechanical integrity.

Design and development of pre and post-harvest machineries/storage systems in tuber crops

Machine vision based grading system for quality sweet potato chips production

A vision-based sweet potato grader machine has been developed, primarily focusing on diameter and length of sweet potato tubers for commercial grading purposes. The developed grader works based on the machine vision technology, offers several advantages over traditional manual grading methods. It enhances the speed and accuracy of the grading process, allowing for higher throughput and more consistent quality control. The developed machine has the capacity of grading 500 kg of sweet potato tubers per h. Additionally, it reduces labour costs and minimizes human error, thereby improving overall productivity and profitability for sweet potato producers and distributors.

Portable self-propelled cassava sett cutter

Traditionally cassava crop is cultivated by planting stem cutting using 10-15 cm length with 8-10 viable nodes. Cutting of cassava sett is mainly done in the cultivation field itself to make planting easier. About 12,500 cassava setts are required for planting one hectare of land. The manual method of producing cassava setts requires more human labourers and takes a lot of time. It takes 3 labourers for 15 h to prepare cassava setts for one ha of land. Therefore, a portable self-propelled cassava sett cutter was developed to make the process easier and to enhance the quality of cassava setts for planting (Fig. 50). The developed portable self propelled cassava sett cutter consisted of petrol engine (2 HP), rotary cutting blade (12 inch diameter), frame, hand pedal, pulleys, and a stopper. The portable cassava sett cutter is self-propelled, allowing it to be used in the cultivation field itself and has wheels for easy movement.

The stopper on the portable cassava sett cutter can be adjusted to produce cassava setts of varying lengths based on the needs. Additionally, the developed ma chine can produce mini cassava setts. Cassava setts are cut uniformly and roundly by the rotary blades, which rotate at 2500 rpm. The cutting efficiency, percentage of damaged setts and capacity of the portable cassava sett cutter are tested and found to be 98 %, 0.45 % and 5000 setts per hour, respectively. The percentage of labour saving is 85 % and the cost saving is 90 %. The cost of production for one hectare of setts is Rs. 400/-, while the manual method costs Rs. 4000/-. The fuel consumption is 0.6 litre per h.

Fig. 50. Portable self-propelled cassava sett cutter

Design and development of a multipurpose peeler for Chinese potato and taro

A multipurpose abrasive type peeler has been conceptualized, designed and fabricated to facilitate efficient removal of peel from soft skin tubers such as Chinese potato and taro (Fig. 51). The fabricated machine comprises seven cylindrical rollers, arranged in a U shape configuration, with each other measuring 75 mm in diameter and 900 mm in length. The rollers are equipped with hard nylon brushes to ensure optimal peeling efficiency. An integrated water supply system provides a continuous flow of water, thereby enhancing the peeling process. The developed machine is powered by a 2 HP electric motor, which is coupled to a spur gear mechanism to achieve optimal rotational speed. The performance evaluation trial is in progress.

Fig. 51. Multipurpose peeler for taro and sweet potato

Quality changes associated with post-harvest storage/processing and development of value-added functional foods from cassava and sweet potato

Pre and probiotic and bioactive compounds (anthocyanin and beta-carotene) rich frozen desserts from purple and orange flesh colored sweet potatoes

Frozen dessert developed from purple fleshed sweet potato puree concentrate (Fig. 52) showed higher anthocyanin content of 30.45 mg100 g^{-1}, protein content of 6.56 %, and a fiber content of 0.69 % under refrigerated storage conditions. In addition, the viable beneficial microbial count was ranged between 5.45 to 7.22 log CFU/ml at tenth day of storage. Similarly, frozen dessert developed from orange fleshed sweet potato puree concentrate (Fig. 52) showed higher beta carotene content of 12.41 mg/100 g, protein content of 4.62 %, and a fiber content of 0.47 % under refrigerated storage conditions. In addition, the viable beneficial microbial count was ranged between 4.52 to 5.87 log CFU/ml at tenth day of storage at 4°C. Beneficial *lactobacillus* based frozen dessert development was an effective post-harvest processing strategy for higher retention of anthocyanin content and its associated antioxidant and anti-hyperglycemic functionalities in sweet potato based functional foods.

Fig. 52. Pre- and probiotic and bioactive compounds (anthocyanin and beta-carotene) rich frozen desserts from sweetpotato

Development and characterization of beta carotene and anthocyanin rich gummy confections

Orange and purple sweet potato concentrate (OSPC and PSPC) were incorporated as a value-added food ingredient in convenient food products, using a model system of gummy candy. Formulation for gelatin gummies includes gelatin which ranges between 10 to 16 % and OSPC and PSPC between 5 to 20%. This study evaluated the physical characteristics, texture, colour, water activity, proximate composition, bioactive substances, and antioxidant activity along with sensory analysis to determine the general acceptability and palatability of gummies. The highest anthocyanin and beta carotene content were observed in pectin gummies (4.05 mg/100 g & 3.28 mg/100 g), while gelatin gummies had the lowest of both (1.02 to 1.42 mg/100 g & 0.29 to 0.74 mg/100 g). The beta carotene content shows an increasing trend as the percentage of puree increases. Gummies made with purple sweet potatoes exhibited higher antioxidant potential than gummies made with orange sweet potatoes. Among different pectin and gelatin gummy formulations, the highest antioxidant (1.08 mg GAE/100g FW) activity was with PSPC samples extracted in 12% ethanol. The pectin gummies were highly rated for their colour, while the gelatin gummies were highly rated for their texture in sensory evaluation. Gummies, incorporated with PSPC were more acceptable for taste.

Extension and Social Sciences

Developing methodologies and tools for assessment and transfer of tuber crops technologies

Technological interventions and documentation of farmers' innovations including ITKs in tropical tuber crops

Technological interventions in tuber crops

Forty one demonstrations on improved varieties of cassava and Chinese potato and 25 OFTs on site specific nutrient management (SSNM) in elephant foot yam and Chinese potato were conducted in Tamil Nadu and Kerala. Farmers were trained on managing mealybug, spiralling white fly and cassava mosaic disease in cassava, nematodes in elephant foot yam and integrated pest, disease and nematode management practices in Chinese potato.

Improved varieties : Cassava: Data from 10 FLDs (1 acre each) conducted during May 2023-February 2024 at Goodamalai and Sentharapatti villages in Salem district revealed that yield of Sree Athulya (39.68 t ha^{-1}) was higher (10.07 %) than the yield of local varieties (36.05 t ha^{-1}). The net income realized from Sree Athulya was ₹ 2,40,716 ha^{-1} (B:C ratio: 2.81) when compared to local varieties, which was ₹ 1,95,670 ha^{-1} (B:C ratio: 2.52). Technology gap, extension gap and technology index of Sree Athulya were 30.32, 3.63 and 43.31 respectively. Similarly, data from 10 FLDs (1 acre each) conducted at Kalkuruchi, Mettupatti and Naraikinaru villages in Namakkal district revealed that the yield of Sree Athulya (32.83 t ha^{-1}) was higher (12.66 %) than the yield of local varieties (29.14 t ha^{-1}). The net income realized from Sree Athulya was ₹ 1,82,845 ha^{-1} (B:C ratio: 2.67) when compared to local varieties, which was ₹ 1,28,413 ha^{-1} (B:C ratio: 2.16). Technology gap, extension gap and technology index of Sree Athulya were 37.17, 3.69 and 53.10 respectively. Sree Athulya out performed the local varieties in the demonstrated areas with higher benefit.

Five FLDs (1 acre each) on cassava mosaic disease (CMD) resistant variety of cassava, Sree Reksha was conducted at Koonavelampatti in Namakkal district and Goodamalai in Salem district of Tamil Nadu revealed that the average yield of Sree Reksha was 40.21 t ha^{-1}, which was (7.34%) higher than the yield of local varieties (37.46 t ha^{-1}). The net income realized from Sree Reksha was ₹ 2,41,783 ha^{-1} (B:C ratio: 2.88) when compared to local varieties, which was ₹ 2,09,326 ha^{-1} (B:C ratio: 2.59). Technology gap, extension gap and technology index of Sree Reksha were 39.79, 2.75 and 49.74 respectively. Five FLDs (1 acre each) on cassava mosaic disease (CMD) resistant variety of cassava, Sree Kaveri conducted at Mettupatti in Namakkal district of Tamil Nadu revealed that the average yield of Sree Kaveri in rainfed conditions was 30.12 t ha^{-1},which was (7.04%) higher than the yield of local varieties (28.14 t ha^{-1}). The net income realized from Sree Kaveri was ₹ 1,60,197 ha^{-1} (B:C ratio: 2.28) when compared to local varieties, which was ₹ 1,39,349 ha^{-1} (B:C ratio: 2.14). Technology gap, extension gap and technology index was estimated as 19.88, 1.98 and 39.76 respectively.

Chinese potato: Five FLDs (0.5 acre each) on Chinese potato conducted in Thrissur district revealed that the yield of Sree Dhara (13.40 t ha^{-1}) was 6.52% higher than the yield obtained from local variety (12.58 t ha^{-1}). The net income realized from Sree Dhara was ₹1,18,825 ha^{-1} (B:C ratio: 1.42) when compared to local variety which was ₹ 97,766 ha^{-1} (B:C ratio: 1.35). Technology gap, extension gap and technology index of Sree Dhara were 14.6, 0.82 and 52.14 respectively.

Results of six FLDs (0.5 acre each) on Chinese potato in Palakkad district revealed that the yield of Sree Dhara (12.61 t ha^{-1}) was 5.43% higher than the yield obtained from local variety (11.96 t ha^{-1}). The net income realized from Sree Dhara was ₹ 1, 32, 665 ha^{-1} (B: C ratio: 1.54) when compared to local

variety which was ₹ 1,06,966 ha^{-1} (B:C ratio: 1.45). Technology gap, extension gap and technology index of Sree Dhara was estimated as 15.39, 0.65 and 54.96 respectively.

Site specific nutrient management: Elephant foot yam: Five OFTs (0.5 acre each) in elephant foot yam conducted in Gobi taluk, Erode district revealed that the yield of SSNM treated plot of Gajendra (29.37 t ha^{-1}) was 11.46% higher than the yield obtained from farmer's practice (26.35 t ha^{-1}). The net income realized from SSNM treated plot of Gajendra was ₹ 6,63,432 ha^{-1} (B: C ratio: 3.02) when compared to farmer's practice, which was ₹ 5,45,750 ha^{-1} (B:C ratio: 2.45).

Chinese potato: Ten FLDs (0.5 acre each) in Chinese potato conducted in Tenkasi district revealed that the yield of SSNM treated plot of Sree Dhara (14.97 t ha^{-1}) was 8.24% higher than the yield obtained from farmer's practice (13.83 t ha^{-1}). The net income realized from SSNM treated plot of Sree Dhara was ₹ 2,20,218 ha^{-1} (B:C ratio: 2.50) when compared to farmer's practice, which was ₹ 1,81,322 ha^{-1} (B:C ratio: 2.26). Results of 10 FLDs (0.5 acre each) on site specific nutrient management in Chinese potato conducted in Tirunelveli district revealed that the yield of SSNM treated plot of Sree Dhara (15.74 t ha^{-1}) was 13.89% higher than the yield obtained from farmer's practice (13.82 t ha^{-1}). The net income realized from SSNM treated plot of Sree Dhara was₹ 2,50,134 ha^{-1} (B:C ratio: 2.65) when compared to farmer's practice, which was ₹ 1,92,844 ha^{-1} (B:C ratio: 2.29). The SSNM performed better than farmers' practice in all locations in both elephant foot yam and Chinese potato.

Perception of farmers on the effect of parasitoids for the management of mealybugs in cassava: Perception of farmers on the effect of parasitoids for the management of mealybugs in cassava was documented from 90 cassava growers involving 60 beneficiaries and 30 non-beneficiaries from four blocks in Salem district of Tamil Nadu. It was reported that the varieties, M4, Burma, White Thailand, Black Thailand, Mulluvadi and Kunkumarose were severely affected by mealybugs, whereas the varieties, Sree Athulya, Yethapur II, Vellayanai Hraswa, Sree Kaveri and H-226 were medium to less infested. Farmers perceived that the use of parasitoids resulted in the reduction in cost of pesticides (Rs. 12968 ha^{-1}), number of pesticides spray (2.4 times), increase in yield (9.4 tons ha^{-1}), starch content (5.9%) and increase in net income (Rs. 79880 ha^{-1}). Lack of timely availability and required quantity of parasitoids were the major constraints followed by erratic weather, spraying of pesticides in the vicinity, lack of scientific knowledge on the proper release and monitoring of multiplication of parasitoids.

Farmers' innovations and ITKs

Farmers' innovations and ITKs pertaining to varieties, agronomic practices, nutrient management, pest and disease management, mechanization, pre- and post-harvest processing, value addition, storage of planting materials and tubers etc. were documented from 75 tuber crops growers in major districts viz., Tenkasi (15) and Tirunelveli (15) in Tamil Nadu; West Garo Hills (15), Ri Bhoi (15) and West Jaintia Hills (15) in Meghalaya.

Upscaling tuber crops technologies for promoting food and nutritional security

Consumer acceptability studies in purple-fleshed taro

To develop sensory lexicon for the deep-fried chips developed from purple-fleshed sweet potato and taro, Bradley-Terry Paired Preference Test involving 120 semi-trained panelists from Kerala and Meghalaya was conducted.

The purple-fleshed taro chips had high preference over commercial potato chips (Odds ratio (OR) = 0.643) but showed low consumer preference over purple-fleshed sweet potato chips (OR = 0.464). The purple sweet potato chips had higher preference probability than purple taro (OR = 0.536) and commercial potato chips (OR = 0.675).

Monitoring of FLDs of cassava under commercial production systems

To promote industry-focused cassava varieties in the commercial cassava production systems of Tamil Nadu, six FLDs with Sree Athulya, Sree Reksha and Sree Kaveri were laid out in irrigated systems in the Kallakurichi district,Tamil Nadu. All the varieties performed well and Sree Athulya showed highest mean yield (43.75 t ha $^{-1}$), which is on par with Sree Reksha (42 t ha $^{-1}$), followed by Sree Kaveri (38 t ha $^{-1}$) (Table 11).

Table 11. Performance of cassava varieties under irrigated production systems in Kallakurichi, Tamil Nadu

Variety	Mean yield (t ha^{-1})	F
Sree Athulya	43.75^{a}	12.636*
Sree Reksha	42^{a}	
Sree Kaveri	38^{b}	

*Significant at the 0.05 level ($p<0.05$)

Means with the same letter are not significantly different from each other ($P>0.05$)

Nutrition-focused survey

Based on the health systems data collected from IFCT (2017), NFHS surveys, and ICMR RDA recommendations, a framework to match user data with food profiles, suggesting diet changes and recipes that address deficiencies, align with preferences, and meet RDA guidelines was developed. The mock data from NFHS surveys were used to conduct trial runs and based on the results, an architecture for recipe recommender application was designed.

Mapping of women's empowerment in tuber crops cultivation for engendering research and development

A research study was conducted to document the empowerment index of women involved in cassava. A total of 60 farmers and 60 farm women were selected from the West Garo hill and South West Garo hill districts of Meghalaya state. By using the interview schedule the data were collected from the respondents on one to one basis.

Socio economic profile of the respondents: Among the respondents, 45.00 per cent of men and 48.33 per cent of women were middle aged with a mean age of 44.01 years and 37.92 years respectively. Majority of the men (56.67%) and women (63.33%) had high school level of education and majority (83.33%) had nuclear family. Forty five percent had 4 to 6 members in their family. The mean farming experience was 26.13 years for men and 21.20 for women in agriculture, whereas in cassava cultivation, it was 24.28 and 20.33 years for men and women.. All women respondents had marginal area of land (< 2.5 acres) under cassava cultivation. More than 90 percent had livestock in their backyards. Men (55%) and women 65%) had medium level of aspirations in their life.

Extent of participation of men and women in Cassava cultivation : Both men (60%) and women (60%) had medium level of participation in cassava cultivation. The participation of men was more in land preparation (mean Score 2.65), selection of varieties (2.08), intercultural operations (2.18), identification of pests (1.17) and harvesting (2.40). Equal participation was observed in activities like application of fertilisers (1.05), irrigation management (1.72), identification of diseases and their management (1.0), grading and marketing (1.32), value addition (1.05) and storage of planting materials (1.63). The overall participation of men in cassava cultivation was 1.67 and women was1.54.

Empowerment index of women in sweet potato cultivation: The women empowerment index in agriculture developed by International Food Policy Research Institute (IFPRI) and United States Agency for International Development (USAID) Feed the Future was modified and used to assess the empowerment index. The index includes five domains namely decision making in production, access to productive resources, control over use of income, community leadership and time allocation. Each domain has sub indicators of empowerment. The results revealed that the decision making was similar for both the gender (men 2.63 and women 2.15). Ownership of assets was more for women (2.88) than men (1.25). Women (2.27) and men (2.30) had equal access to control in income. Men (2.37) had more access to and decisions on credit than women (1.93). The overall empowerment index of men was 0.708 whereas for women it was 0.709.

Needs, preferences and opportunities in cassava cultivation: The needs of the women were analysed and ranked. Demonstrations on improved varieties and technologies ranked first (mean score 2.52), followed by training on improved technologies (2.50), quality planting materials of cassava (2.35) and marketing facilities (1.72). Regarding preferences, good cooking quality (2.37) ranked first followed by high yield (2.30), good keeping quality (2.17), suitability to cropping system (1.70) and organic farming (1.68).

The opportunities that favoured women were short duration and women friendly nature of the crop (2.38), suitability to farming system (2.27), yield enhancement through adoption of technologies (2.05), scope for post harvest and value addition (1.95) and

suitability for agro climatic conditions (1.95).

Constraints in cassava cultivation: The constraints reported were non availability of quality planting materials (I rank), less access to extension programmes (II), lack of knowledge and access to credit (III), lack of marketing facilities (IV) and price fluctuation (V).

Impact assessment of technologies of tropical tuber crops

The impact assessment of technologies was conducted in Kerala and Karnataka, on cassava cultivation and technological interventions by ICAR-CTCRI. In Kerala, the Thiruvananthapuram districts was selected and data were collected from Parassala, Nemom, and Kilimanoor blocks. In Karnataka, the study was done in Belagavi district. Data were collected from 242 cassava and sweet potato farmers, on socio-economic profiles, varietal adoption, economic factors, marketing, and trait preferences. Cost-benefit analysis was performed to estimate the impact of tuber crop varieties, and the economic surplus method was applied to evaluate the economic benefits of cassava varieties.

Diffusion of cassava and sweet potato varieties

In Kerala, farmers were cultivating 19 cassava varieties, which includes improved varieties Sree Pavithra, Sree Reksha, Sree Jaya, Sree Vijaya, and Sree Visakham covering 14% of the total area. The remaining 86% area was covered by local varieties. Among the improved varieties, Sree Pavithra and Sree Reksha were the most prevalent, covering 10% of the area. The local varieties adopted widely were *Ullichuvala* (21%), *Noorumuttan* (15%), *Karuthakanthari* (8%), *Kottayam Karuppu* (7%), and *Kottayam Pacha* (7%), accounting to 60 per cent. Local varieties were popular due to their availability, yield, cooking quality, and demand among traders. In Karnataka, farmers cultivated three varieties of sweet potato namely Kanjanghad (79%), *Malakappuri* (20%), and other varieties (1%).

Economic benefits of cassava varieties

Economic benefits at the farm level from different cassava varieties showed that *Kottayam Pacha* had the highest yield (46.61 t ha^{-1}), followed by Sree Pavithra (42.87 t ha^{-1}), Sree Reksha (42.61 t ha^{-1}), and *Mankuzhulandan* (42.58 t ha^{-1}). In terms of net income, *Kottayam Pacha* was the most lucrative, yielding the highest net income of ₹ 9.78 lakhs, per hectare followed by Sree Pavithra, ₹ 8.99 lakhs. On an average, cassava yield was 38.24 t ha^{-1}, with an average price of ₹25 per kg, an average cultivation cost of ₹ 2.31 lakhs, and a net income of ₹ 7.43 lakhs per hectare (Table12).

Table 12 . Farm level economic benefits from different cassava varieties in Kerala

Variety name	Yield (t ha^{-1}	Price (₹ t^{-1})	Total cost (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})
Aarumasa Chuvappu	37.94	26000	225721	975156	749435
Aarumasa Vella	30.30	25000	231892	757467	525575
Kandhari Padappan	35.57	25000	231563	889200	657638
Karuthakanthari	34.35	26666	233158	911327	678169
Kottayam Black	37.96	23500	226295	895993	669697
Kottayam Green	46.61	26000	237262	1215858	978595
Kottayam Vella	39.18	25000	225511	975650	750139
Mankuzhulandan	42.58	25625	225990	1083404	857414
Nadan Chuvappu	40.76	25000	206986	1018875	811889
Njarukkan	29.74	27000	233292	815594	582303
Noorumuttan	37.39	24409	230103	916134	686031
Singapore Vella	31.70	25000	232448	792458	560011
Sree Jaya	33.04	25000	219768	825906	606138
Sree Pavithra	42.87	26000	235137	1134773	899636
Sree Reksha	42.61	25000	236984	1074327	837342
Sree Vijaya	29.64	25000	212482	741000	528518
Sree Visakham	36.47	21666	233827	773933	540107
Ullichuvala	38.57	26666	233394	1027108	793714
Vella Priyan	38.53	20000	217978	770640	552663
Total	**38.24**	**25465**	**231029**	**975027**	**743998**

Trait preferences

High tuber yield is the foremost priority, along with resistance to root rot, good cooking quality, short-duration, uniform tuber size and ease of harvesting.

Economic benefits of the cassava variety Sree Athulya: An economic analysis was conducted to assess the overall benefits of the cassava variety Sree Athulya at the state level in Tamil Nadu using the economic surplus method. Sree Athulya was compared to White Thailand, a popular cassava variety covering nearly 25% of cassava cultivation in Tamil Nadu. The total surplus for Sree Athulya ranged from ₹ 77.38 crores to ₹ 166.26 crores, with a

net present value (NPV) of ₹ 77.22 crores to ₹ 165.93 crores and an internal rate of return (IRR) of 39% for discount rates between 5% and 15%. Projecting the benefits of Sree Athulya to 2030, it is estimated to generate a total surplus of ₹ 513.14 crores, an NPV of ₹ 512.99 crores and an IRR of 41%. Sensitivity analysis was performed to test the robustness of the results, considering various adoption rates (20%, 25% and 30%) and yield changes (25%, 30%, and 35%). Increasing the adoption rate from 20% to 30% resulted in only a 1-2% change in IRR, but the total gain increased significantly from ₹ 138 crores to ₹ 486 crores. Similarly, an increase in yield from 25% to 35% significantly raised the total gain from ₹ 138 crores to ₹ 960 crores.

Development of intelligent smart technologies for tuber crops

A digital farm to demonstrate e-Crop based smart farming (eCBSF) and e-Crop based smart fertigation system (eCBSFS) was set up in Anad, Thiruvananthapuram . The farm was set up by ICAR-CTCRI in collaboration with Anad Farmers Service Cooperative Bank and one e-Crop device was installed. Cassava and banana were planted in 5 cents each and tomato, brinjal and bhindi in 2 cents each. Fertilizers and water applications for these crops are automatically done daily through drip system connected to eCBSFS, which works as per the signals received from e-Crop.

Generation and application of statistical and bio informatics tools for tuber crops research and development

Web based statistical analysis software: Agrianalytics@R

Significant updates were made for enhancing the functionality in Agrianalytics@R, the web-based application developed using R Shiny, for statistical data analysis and data visualization in agricultural research. The addition of the two modules will help agricultural researchers.

Two-Factor ANOVA with interaction: This module will be especially useful for researchers conducting experiments with multiple factors, like crop variety and treatment type. By supporting both CRD (Completely Randomized Design) and RBD (Randomized Block Design), it offers flexibility in handling different experimental designs. The results also provides DMRT/LSD letter display for comparison of main effects and interaction means.

AMMI Model for Genotype-Environment Interactions: This module helps in combined analysis of experiments over location/year using the AMMI model for studying genotype-environment interactions, which are critical in agricultural research for evaluating the performance of genotypes across various environments. The inclusion of ANOVA, PCA, and visualization options like plots makes it a comprehensive tool for understanding and presenting these complex interactions. This module utilizes the themetan package in R .

Institute flagship project

Genetic improvement of cassava through gene editing for modified starch

For *in planta* development of modified starch in cassava, the approach of CRISPR-Cas9 based gene editing was adopted. For developing waxy cassava with no amylose, a gene editing construct that targets *gbss* gene was sequence confirmed using promoter based primers and transformed on to friable embryogenic calli of cassava variety H226.

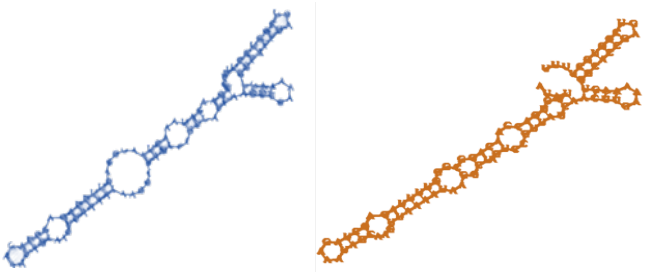


Fig. 53. Secondary structure of *SBEI* and *SBEIIb* guide RNAs

A gene editing construct targeting two genes, *SBEI* and *SBEIIb* was developed (Fig. 53). The guides were designed from the exonic region with zero off target effects in the coding sequence. The developed guides were assembled on to PHSE401 vector and confirmed through sequencing. After sequence confirmation, the construct was transformed to friable embryogenic calli of cassava variety, H226. Both transformations were carried out using particle bombardment at 450 psi and 650 psi and the transformed calli is maintained under selection.

For analysing the expression of *SBEIIb* in various tissues of cassava, a gene expression analysis was carried out. Primers were synthesised for *SBEIIb* and the expression of *SBEIIb* was analysed in various tissues including root, tubers at various developmental stages, leaf, petiole, stem, etc. using semi-quantitative RT-PCR. *SBEIIb* expression varied and was higher in tubers at the later stages of tuber development (mature).

Semi quantitative RT-PCR products using cDNA from roots (R), and tubers at various developmental stages such as tuber stage 1 (TS1), Top (To) middle (M), and tip (Ti) of stage 2 and stage 4, leaves (L), stem (S), petioles (P) of upper and lower part or plant are shown. N is negative control. UQ is control gene *Ubiquitin*. ML is 100 bp ladder (Fig. 54).

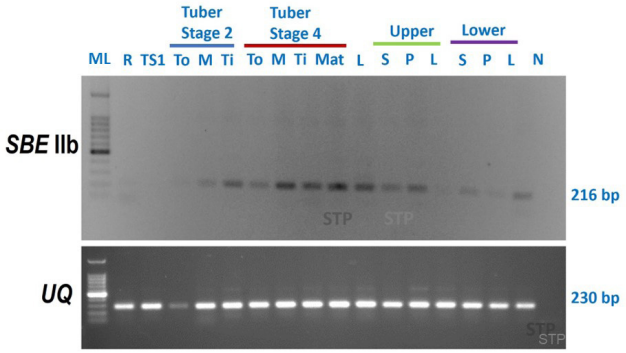
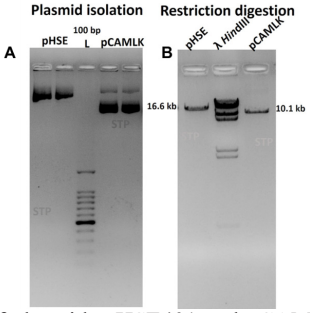


Fig. 54 Gene expression analysis of SBEIIb starch branching enzyme in various tieeues of cassava

Plasmids from pHSE401 and pCAMBIA vectors in *E. coli* (Addgene) were isolated from single colony cultures grown overnight in LB broth supplemented with kanamycin and hygromycin. Restriction digestion of plasmids was carried out with single cutter Eco RI to linearise the vectors and to confirm size of the plasmids (~ 16 and 10.5 kb) (Fig. 55) Glycerol stocks were prepared and stored.

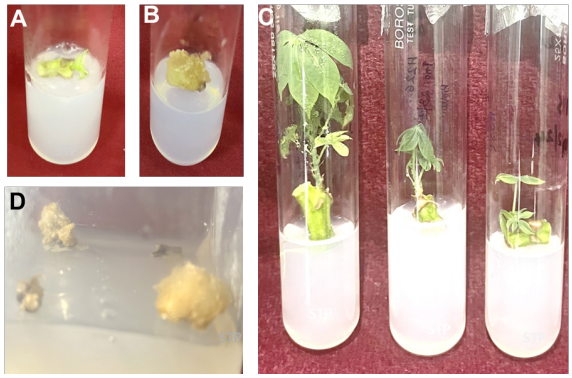


A. Isolation of plasmids pHSE401 and pCAMBIA lox-kan from *E. coli*

B. Restriction digestion with Eco RI to linearise the vector. pHSE is pHSE401 cloning vector with Cas 9 gene. pCAMLK is pCAMBIA lox-kan binary vector.
L is 100 bp ladder

Fig. 55. Isolation of plasmids and restriction digestion of plasmids of cloning vectors

For isolation of protoplasts *in vitro*-raised leaves or callus were required for which, leaf and shoot buds of 5 varieties, Sree Reksha, Sree Suvarna, Sree Vijaya, H226 and Sree Kaveri were inoculated in 3 different media viz., Murashige and Skoog (MS) media, Schenk and Hildebrandt (SH) and Gresshoff and Doy (GD) media with 12 mg l^{-1} pichloram (Fig. 56). H226 and Sree Suvarna showed response under *in vitro* conditions while the *in vitro* response was poor in other varieties.



(A) Sprouting of shoot of H226 variety in MS media. (B) Callus formation from shoot of H226 in Schenk and Hildebrandt (SH) media with 12 mg l^{-1} pichloram (C) Sprouting of shoot bud and formation of leaves at 3 weeks after inoculation in H226 in MS media (D) Callus formation in Sree Suvarna in Gresshoff and Doy (GD) media with 12 mg l^{-1} pichloram.

Fig. 56. Raising cassava leaf and callus explants for protoplast isolation and culture under in vitro conditions

Developmental Projects

1. **ICAR-CTCRI - Tribal Sub Plan: Livelihood Improvement of Tribal Farmers through Tuber Crop Technologies** (Funding Agency: ICAR-CTCRI; PI: M. Nedunchezhiyan; Co-PIs: Kalidas Pati, K. Hanume Gowda, J. Suresh Kumar, C. Pradeepika, B.G. Sangeetha)

   The ICAR-CTCRI Tribal Sub Plan initiated in 2020 with a total budget of ₹ 40 lahks (2022-23), aims to enhance livelihood opportunities for tribal farmers by adopting tuber crop technologies. In 2024, the project supported 385 tribal farmers across Gajapati (200), Koraput (120), and Kandhamal (37) districts of Odisha, Purulia (24) in West Bengal, and Manyam (4) in Andhra Pradesh. Quality planting materials were distributed, including 10,000 kg each of greater yam and elephant foot yam, 2,400 kg of colocasia, 12 lakh sweet potato vine cuttings, 20,000 cassava stems, 85 kg of yam bean, and 150 kg of French bean, ensuring sustainable crop production. Eight training programs were organized to equip farmers with advanced cultivation techniques. Initial harvest results showed sweet potato yields of 11.4-13.6 t ha^{-1} and yam bean yields of 16.5-18.3 t ha^{-1}, with other crops awaiting harvest. The project strengthens tribal livelihoods by promoting sustainable tuber crop farming and market integration.

2. **ICAR-CTCRI-SCSP: Empowerment of tuber crops farmers through sustainable use of resources and tuber crops technologies** (PIs: V. Ramesh (Till March 2024) and K. Sunilkumar; Co-PIs: S. S. Veena, D. Jaganathan, H. Kesavakumar, J. Sureshkumar, K. Krishnakumar (Till March 2024), M.S. Sajeev, V. Ramesh, C. Mohan, E.R. Harish, P. Prakash, S.N. Rahana)

Training: Total 12 training programmes organized on various tuber crops technologies during the period for the benefit of SC beneficiaries: eight in kerala and 4 in Tamil Nadu. Total 821 farmers benefitted from these the capacity building programmes. One hundred SC beneficiaries were selected from from BPL category from three blocks from Kerala and Tamil Nadu namely Parkkode, Pathanamthitta Distrcit, Ollukkara block in Thrissur district in Kerala and Gangavalli block, Salem district in Tamil Nadu and field demonstration of tuber crop technologies were carried out during the period. Further follow up of the previous year 100 FLDs on different tuber crops technologies were carried out , 50 in Tamil Nadu (22 farmers in Gangavalli block of Salem district 24 farmers in Chembanarcoil block of Mayiladuthurai and 4 farmers in Keelvelur block of Nagapattinam district) and 50 from Kerala (Adoor, kadambanad and Enadimangalam panchayaths of Parakkode block) and continued support by way of training and distribution of equipments for value addition as well as monitoring.

For educated and unemployed youths three one year long skill development programmes were completed on quality planting material production in tuber crops, mass production / multiplication of bio-control agents, *in vitro* conservation of tuber crops during 2024.

Inputs supply: Quality planting material of improved varieties of cassava viz. Sree Reksha and Sree Pavithra for 20 acres, sweet potato varieties (Sree Kanaka, Bhu Krishna, Sree Arun andGowri) for 10 acres and elephant foot yam variety Gajendra (20 acres) were supplied in such away, each farmers has demonstration in 50 cents for three crops together. Further minor farm equipments like sprayer, hose, spade, pick axe were given to individual farmers. The straight fertilizers such as urea, rock phosphate, muriate of potash were also supplied for total 100 demonstration plots (50acres). Biopestcides like Nanma, Menma and Shreya as well as Trichderma capsules were supplied for demonstration of pest and diseases management in 100 acres. Micronol –the

foliar micro nutrient solution was supplied for 100 acres for enhancing productivity.

Support for value addition/food processing : An electric dryer of 35 kg capacity with 7 SS trays was supplied under the capital head to the *Ollur Pattikajathi Sahakarana Sangham Limited R-751* for processing of cassava and other surplus produce by the beneficiary farmers. Twenty four slicers was supplied for cassava for minimal processing and value addition by benficaries themselves.

3. ICAR-CTCRI NEH: Scaling up biofortified tuber crops through 'Rainbow Diet Approach' in the North Eastern Hills region (Funding Agency: ICAR-CTCRI; PI: R. Muthuraj: Manas Ranjan Sahoo, P. S. Sivakumar, D. Jaganathan, T. Krishnakumar, V.B.S. Chauhan, R. Arutselvan)

4. ICAR-CTCRI, in collaboration with ICAR RC for NEH Region and KVKs, conducted multiple training programs across Meghalaya to promote improved tuber crop varieties, cultivation technologies, and value addition (Table 13). These initiatives aimed to strengthen seed village establishment and ensure regional food and nutritional security.

Table 13. Details of training in NEH on Scaling up biofortified tuber crops

Date	Location	District	Partici-pants	Key Highlights
3 Sep 2024	Jaidoh Village	West Khasi Hills	80	Farmers, entrepreneurs, and officials trained in tuber crop production.
4 Sep 2024	Sohphoh Village	West Jaintia Hills	75	Experts from ICAR-CTCRI and ICAR RC NEH delivered lectures.
25 Nov 2024	Lower Damalgre Village	South West Garo Hills	115	Conducted in collaboration with NEHU Incubation Centre.
28 Nov 2024	Lumdiengngan Village	Ri Bhoi	85	Organized with the Department of Horticulture.

During these programs, farmers received planting materials of improved cassava and sweet potato varieties, including Sree Jaya, Sree Vijaya, Sree Pavithra, Sree Reksha, Sree Arun, Sree Kanaka, Bhu Sona, and Bhu Krishna. Training materials, value-added products, and farm implements were also distributed. This initiative plays a crucial role in capacity building, seed village expansion, and sustainable tuber crop cultivation in the North Eastern Hills region, supporting the livelihoods of tribal farmers and promoting agricultural resilience

Externally Aided Projects

Crop Improvement

1. **Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in sweet potato and cassava** (PPVFRA, New Delhi; Lead Centre PI: M.N. Sheela (Till 31.05.24), C. Visalakshi Chandra; Co-PIs: K.I. Asha, A. Asha Devi, Shirly Raichal Anil and N. Krishna Radhika)

The gene bank of reference varieties of cassava (55) and sweet potato (52) are being conserved in the field. DUS Characterization of two cassava candidate varieties (*Pachikizhangu* and *Manna*) was completed for pre-harvest and post-harvest characteristics. Five cassava varieties namely *Noorumuttan*, *Sundarivella*, *Vellapiriyan*, *Yechan* and *Lakshmikuttai* collected from farmers of Kerala and Kaani tribal community, respectively were subjected to characterisation for tuber traits, cooking quality and PPD tolerance to facilitate registration.

2. Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in sweet potato and cassava (PPVFRA, New Delhi; Collaborating Centre PI: Kalidas Pati; Co-PI: K. Hanume Gowda)

Managed the field gene bank at the Regional Station, ICAR-CTCRI, Bhubaneswar, Odisha, which included 43 reference lines of sweet potatoes and 17 reference lines of cassava. Nineteen pre-harvest and six post-harvest characteristics of each reference line for sweet potato and 22 pre-harvest and eight post-harvest characteristics of each reference line for cassava have been identified and recorded. DUS testing trial has been conducted for one farmer's variety of cassava and report has been submitted to the PPV&FRA, New Delhi.

3. Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in yam bean and greater yam (PPVFRA, New Delhi; Lead Centre PI: M.N. Sheela (Till 31.05.24), S.N. Rahana; Co-PI: J. Sreekumar, P. Murugesan)

A gene bank of 23 reference v arieties of greater yam and 4 reference lines of yam bean is maintained at ICAR-CTCRI, Thiruvananthapuram. The DUS testing guidelines have been developed and published in the PPV&FRA website. The pre-harvest characteristics of each reference line have been recorded based on the DUS testing guidelines. All the reference varieties were harvested and replanted. Farmers were sensitized to do registration of greater yam and yam bean varieties.

4. Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in yam bean and greater yam (PPVFRA, New Delhi; Collaborating Centre PI: Kalidas Pati; Co-PI: R. Arutselvan)

Ten yam bean and 14 greater yam reference lines were kept in the field gene bank at the Regional Station, ICAR-CTCRI, Bhubaneswar, Odisha. Each reference line's pre-harvest traits for greater yam and yam bean have been identified and documented. The distinctive traits of each reference line for greater yam and yam bean have been identified and recorded for 15 traits in greater yam and 17 traits in yam bean. For greater yam, attributes such as stem color, petiole color, pigmentation, tuber shape and color, and tuber flesh color are considered for updating the DUS data. For yam bean, attributes such as stem color, flower density, sepal color, pod length, seed color and shape, and tuber shape are considered for updating the data.

5. Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in taro and elephant foot yam (Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), New Delhi; Lead Centre PI: KalidasPati; Co-PI: V.B.S. Chauhan)

In the field gene bank at the Regional Station in Bhubaneswar, Odisha, 21 taro and 18 elephant foot yam lines were kept as reference collections. Thirty-four pre harvest and 16 post-harvest characteristics of each reference line for taro and 20 pre harvest and 18 post-harvest characteristics of each reference line for elephant foot yam have been identified and recorded. DUS trial has been conducted for two candidate varieties of taro and report has been submitted to the PPV&FRA, New Delhi. Newly received five candidate varieties from PPV&FRA were planted for germination testing. Germination report has been sent after three weeks of planting in the pot.

6. ICAR-Bioversity international and CIAT Alliance collaborative work plan activity on germplasm exchange, improvement and testing advanced clean seed technology in cassava (Manihot esculenta Crantz) (CIAT-Bioversity International; PIs: M.N. Sheela (Till 31.05.24), T. Makeshkumar and S. Sunitha; Co-PIs: G. Byju, C. Visalakshi Chandra, K.I. Asha, K.M. Senthilkumar, P. Murugesan and R. Muthuraj)

In the evaluation of CMD resistant cassava breeding lines for earliness (Season-2), five lines (15S 41, 19S 6-4, 19S 4-2, 17S 48 and 17S 247) and check varieties (Sree Jaya, Sree Vijaya, Vellayani Hraswa) are being evaluated for earliness and other important traits.The agronomic traits such as plant height, leaf weight, stem weight, stem girth, tuber length, individual tuber weight, tuber girth were recorded at monthly intervals from the third month onwards. Cooking quality in terms of cooking time and sensory evaluation of boiled tubers were conducted for taste, texture, appearance, colour, mouth feel and mealiness using 9-point hedonic scale.

For studying the economic application of nutrients in early bulking cassava lines, a new field experiment was initiated with six early bulking cassava lines (V1: 19S-6-4, V2: CTS-48, V3: II-2-8, V4: 15S 255, V5: II-2-1, V6: II-1-10) along with Sree Jaya (control) under four levels of nutrients through drip fertigation. Of these, 19S-6-4 and II-2-8 showed early bulking (>300 g tuber yield) at two MAP.

7. ICAR-CIP collaborative work plan activity on crop improvement and varietal selection of sweet potato (International Potato Centre (CIP), New Delhi; PI: Shirly Raichal Anil; Co-PIs: C. Visalakshi Chandra, A.N. Jyothi, V.S. Santhosh Mithra, P. Sethuraman Sivakumar and R.Saravanan Raju)

From the biofortified hybrid seeds obtained from CIP, Peru through ICAR-NBPGR during 2018, a total of 210 hybrids were selected and maintained after evaluation. The *rabi* season data of the evaluation of hybrid clones from the last set of 4000 hybrids during 2023 -24,indicatedthat 40 hybrids with yield ranging between 10tha^{-1} to 29 tha^{-1} with dark orange to medium orange flesh colour and starch between 12-17% FW were obtained. The hybrid 682/4 gave significantly higher yield of 29 tha^{-1} but the starch was low (12%). The hybrid 678/36 was dark orange-fleshed with a yield of 13.88 tha^{-1} during *rabi* season. Import permit was obtained from ICAR-NBPGR for importing hybrid seeds from CIP for short duration hybrids which can be harvested at 90 days.

8. Microtuber production and gene prospecting for photoresponsive tuberization in *Ipomoea batatas* (L.) Lam. (DST-Science and Engineering Research Board (Core Research Grant), New Delhi; PI: ShirlyRaichal Anil; Co-PIs: N. Krishna Radhika and K.M. Senthilkumar)

For *in vitro* tuberization, higher sucrose concentrations showed thicker roots compared to the normal basal MS media containing IAA. H-526/7 cultured in 6% sucrose showed thick pink roots. One of the cultures showed positive result yielding micro tuber like structure. Thicker pink roots were observed in H-526/7 in MS media containing ancymidol with 8% sucrose. Roots were greenish in colour for H-526/7 and 38/46 when kept at 16 h photoperiod as compared to 13 h photoperiod (Fig. 57).

Under the photo responsive gene ortholog validation, a total of 13 primers were screened along with housekeeping gene (Ib αTubulin) as positive control. The expression of Dof Zn finger protein was stable in all the genotypes throughout the growth period, whereas the sporamin genes are expressed differently in all the genotype. With respect to photo responsive study, sporamin genes do not have a role in photo responsive tuberization.

The field experiments on tuberization showed that tuber yield (g plant^{-1}) was influenced by season in certain genotypes making them photosensitive. No seasonal influence was seen in genotypes H-526/7 and SD-11 making them photo insensitive. The

highest tuber yield per plant of H-526/7 was 581 g plant^{-1} in summer season and SD-11 was 396.75 g plant^{-1} in *kharif* season. Effect of genotype and season on tuberization is significant. Since the superior genotypes resulted in almost equal considerable average tuber yield during all the three seasons, the interaction effect of genotype and season were not significant.

Fig. 57 Micro tuber like structure in MS media

9. Collection and database creation of important named landraces of tuber Crops from Southern istricts of Kerala (Kerala State Biodiversity Board, Thiruvananthapuram, Kerala; PI: Asha K.I.; Co-PIs: M.N. Sheela (Till 31.05.24), A. Asha Devi, Shirly Rachal Anil and N. Krishna Radhika)

Germplasm were collected with passport data of 165 accessions in landraces of tuber crops comprising of 39 accessions in 34 landraces of cassava, five accessions in four landraces of sweet potato, 86 accessions in 60 landraces of greater yam, 19 accessions in 12 landraces of taro, 11 accessions in four landraces of elephant foot yam and five accessions of tannia from the custodian farmers in the selected southern districts of Table 58. Database preparation of these collected landraces was done. The 296 accessions of the landraces collected during the project period from different parts of Southern Kerala (Fig. 58) were conserved in the FGB for characterization using standard descriptors. Six awareness programmes were conducted to the custodian farmers

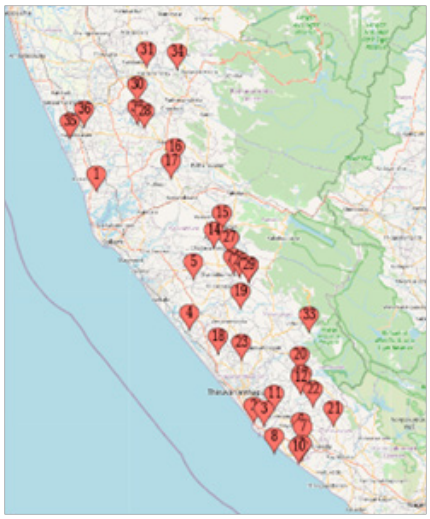


Fig. 58. Areas covered for germplasm collection in Kerala

10. Establishment of aeroponics system for production of mini tubers insweet potato and greater yam to fulfill the quality planting materials requirement of Odisha (RKVY, Dept. of Agriculture & Farmers' Welfare, Govt. of Odisha; PI: K. Hanume Gowda; Co-PIs: M. Nedunchezhian, V.B.S. Chauhan, R. Arutselvan and K. Pati)

A new project was approved under RKVY, Odisha with a budget of 1.4 crore in December 2024. The major objectives of the project was to develop a sustainable and efficient aeroponics system for production of minitubers of quality planting material in sweet potato and greater yam; to optimize growth parameters, nutrient formulation and environmental conditions for minitubers production in aeroponics system and to standardize the production process of minitubers in aeroponics in pilotedsmall scale for sweet potato and greater yam, ensuring consistent yield and quality.

Crop Production

11. All India-network programme on organic farming (AINP-OF) (ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut as Lead Centre; PI: G. Suja; Co-PIs: G. Byju, S. Sunitha, S.S. Veena, A.N. Jyothi, M.N. Sheela, and D. Jaganathan)

The primary objectives of the project were to evaluate organic, inorganic, and integrated management practices in cropping systems involving tuber crops, assess the response of greater yam varieties under organic production systems, develop an integrated organic farming system (IOFS) model involving tuber crops, and conduct geo-referenced on-farm characterization of organic growers. Cluster-based demonstration of the organic packages under SCSP and on-station and farmer-participatory evaluation of natural farming in cassava-based cropping systems are in progress.

Evaluation of organic, inorganic, and integrated management practices in cropping systems involving tuber crops: In the eighth season experiment, cassava and taro were harvested in

October 2024. The tuber yield of cassava was highest under the package of practices (POP) (35.94 t ha^{-1}), followed by 50% organic + 50% inorganic (34.86 t ha^{-1}). The net return and B: C ratios were highest under POP, followed by 100% inorganic and 100% organic (with premium price). In taro, the highest cormel yield (7.75 t ha^{-1}), net income, and B: C ratio (with and without premium price) were recorded under 100% organic management. The subsequent crops of vegetable cowpea, groundnut, green gram, and black gram are in the field.

Evaluation of the response of different varieties of greater yam to organic farming: During the second year, six varieties were tested, among which Orissa Elite (13.82 t ha^{-1}) and Sree Nidhi (11.84 t ha^{-1}) recorded the highest yields with net returns of ₹ 425,639 and ₹ 339,383 per ha, respectively.

Geo-referenced on-farm characterization of organic growers: A geo-referenced survey of 30 natural farmers in Thiruvananthapuram district, Kerala, revealed that 90% of farmers are members of Bharatiya Prakrithi Krishi Padhati (BPKP). Among them, 60% produce formulations on-farm, and 40% sell these inputs through eco-shops and Krishi Bhavans. The yield gap in cassava was 33.78%, attributed to higher on-station yield from the cassava variety Sree Reksha.

Development of integrated organic farming system (IOFS) model: Tuber equivalent yield of 40.34 t ha^{-1} and net returns of ₹ 107,947 were obtained from the tuber crop-based farming system from an area of 75 cents during the reporting period. Over six years (2018-2024), average net returns of ₹ 116,538 were recorded from the system, with a marketable equivalent yield of 22.67 t ha^{-1}. The system productivity was 209 kg ha^{-1} day^{-1}, while net income was ₹ 388,460 ha^{-1} (Table 14).

Evaluation of natural farming in cassava (on-station): In the third season, the field experiment evaluating natural farming in cassava + vegetable cowpea – green gram revealed that integrated crop management (ICM) practices produced significantly higher cassava yields (101.29 t ha^{-1}), followed by complete natural farming (NF). The highest tuber equivalent yield (105.19 t ha^{-1}) and production efficiency were also recorded under ICM practices. The highest net returns were obtained from ICM practices, followed by the AINPOF package and complete NF. The experiment is ongoing for the fourth season to obtain conclusive results and confirmation (Table 15).

Table14. Key performance indicators (mean of 6 years) of the IOFS model for 1 ha

Indicator	Value	Indicator	Value
Equivalent yield (kgha^{-1})	75567	Energy input (MJ) Energy output (MJ) Energy productivity (kg MJ^{-1})	92440 493517 0.817
System productivity (kgha^{-1}day^{-})	209	Economic Efficiency (Net return per rupee invested)	0.27
Net income (₹ha^{-1})	388460	System profitability (₹ha^{-1}day^{-1})	1079

Table 15. Productivity and production efficiency of different natural farming treatments

NF treatments		Yield (kg ha^{-1})				Production efficiency (kg ha^{-1} day^{-1})
		Cassava	Cowpea	Green gram	Tuber equivalent yield	
T_1	Control	56479	508.90	43.36	58770	161.03
T_2	Complete NF	71358	605.18	152.04	74690	204.63
T_3	AINPOF Package	69903	797.95	93.05	73650	201.79
T_4	ICM-1	78253	520.48	128.84	81110	222.21
T_5	ICM-2	101295	736.30	158.80	105190	288.20
	CD (0.05)	25.378	NS	71.897	25020.5	68.549

12. Adoption of biofortified varieties of tuber crops and promoting entrepreneurship development for livelihood and nutritional security of tribal farmers (Directorate of Horticulture, Govt. of Odisha; PI: M. Nedunchezhiyan; Co-PIs: R. Arutselvan, M.S. Sajeev, and B.B. Das)

Biofortified tuber crops (cassava, yam, elephant foot yam, yam bean, and colocasia) were demonstrated in 140 farmers' fields across Mayurbhanj and Rayagada districts during 2024-25. Seven decentralized seed multipliers were registered, and planting materials, including sweet potato vine cuttings and greater yam, were distributed to beneficiary farmers.

Four interaction meetings were conducted in Mayurbhanj (October 21-22, 2024) and Rayagada (October 27-29, 2024) to educate farmers on tuber crop production and value addition. Validation trials for Integrated Nutrient Management (INM) in sweetpotato, yam bean, colocasia, and greater yam were initiated across four locations, with three fertility treatments: Control, recommended dose of fertilizers (RDF), and FYM + ½ NPK. Crop harvest is scheduled for February 2025. A training program on value addition in tuber crops was conducted at Kadraguma village, Rayagada, on April 18, 2024, and was attended by 60 tribal women farmers. Demonstrations on arrowroot starch extraction from *Curcuma angustifolia* were conducted, and the Arrowroot Starch Extraction Unit was inaugurated.

A large-scale Tuber Crops-Based Farming System training under the TSP project was held at Khajuripadha village, Gajapati district, with 600 farmers, mostly women, in attendance. The session was facilitated by PREM NGO and included training on tuber crop technologies and the distribution of water pump sets and power weeders to farmers from Mohana and R. Udayagiri blocks of Rayagada district. This initiative continues to enhance livelihood security and entrepreneurship opportunities for tribal communities through sustainable tuber crop production and value-addition technologies.

13. Rural bioresource complex for tubers and millets in Kandhamal, Odisha (Funding Agency: DBT-KIIT; PI: Dr. Vishakha Raina, KIIT DU & Dr. M. Nedunchezhiyan, ICAR-CTCRI; Co-PIs: Dr. Sandeep Kumar Panda, Dr. Mrutunjay Suar, KIIT DU)

The Rural Bioresource Complex for Tubers and Millets, launched in 2023 with ₹ 10 lakh (2023-24) funding from DBT-KIIT, focuses on value addition and skill development in Kandhamal, Odisha. The project conducted two three-day training programs on "Value Addition in Tubers and Millets" at Raikia, Kandhamal district, attended by 60 women farmers in November 2024 and 72 women farmers in December 2024. These programs provided hands-on training in processing and value addition of tuber crops and millets, enhancing income opportunities for rural women. By equipping farmers with knowledge and processing skills, the project aims to improve food security, promote entrepreneurship, and boost the economic resilience of the tribal farming community in the region.

14. Development of biofortified sweetpotato value chain for industrial production in Telangana, Karnataka and Odisha (Consultancy extended to M/S Xobu Foods and Beverages Private Limited, Rajahmundry East Godavari AP IN 533105, Project team: Dr. G. Byju, Dr. M. Nedunchezhiyan, Dr. P. Sethuraman Sivakumar and Dr. V. Ramesh)

Soil Amelioration with fly ash and growth response in sweetpotato

A study assessed the effects of wet fly ash (WFA) alone and combined with phosphogypsum (PG) for ameliorating acidic laterite soils. WFA was sourced from Tuticorin Thermal Power Station (TTPS), Tamil Nadu, in July 2024 and was found to be loamy sand with low clay content and a pH of 6.0. The experiment used sweet potato variety Bhu Krishna under six treatment combinations, including a control. Treatments included fly ash (10 t ha^{-1}), FYM (12 t ha^{-1}), phosphogypsum (2 t ha^{-1}), and NPK fertilizers as per the Package of Practices (PoP). Observations taken 90 days after planting (DAP) indicated that the FYM+NPK+FA treatment recorded the highest vine length (166 cm) and number of leaves (358). The leaf area index (LAI) was maximum under FYM+NPK (3.21) and was on par with FYM+NPK+FA (2.57) compared to the control (2.28). The study highlights the potential of fly ash as a soil amendment in improving soil properties and sweet potato growth in acidic soils

Cop Protection

15. Development and application of diagnostics tio viruses infecting tropical tuber crops Disease Diagnostics in Tropical Tuber Crops (ICAR-CRP on Vaccines and Diagnostics; PI: T. makeshkumar; Co-PIs: M. L. Jeeva, R. Arutselvan and R. Muthuraj)

Evaluation of DAC-ELISA for specific detection of SLCMV and SPFMV from field samples: DAC-ELISA was performed using the polyclonal antibodies developed against the coat protein genes of *Sri Lankan cassava mosaic virus* and *Sweetpotato feathery mottle virus.* Out of 150 field samples tested for each virus, 130 and 113 were positive for SLCMV and SPFMV respectively.

RPA based detection of DsMV, SPFMV and SLCMV: RPA based detection of DsMV, SPFMV and SLCMV was done. Fifty leaf samples each from elephant foot yam, sweet potato and cassava were collected from the field and isolated nucleic acid. PCR using RPA primers specific for DsMV, SPFMV and SLCMV was performed. Single amplicon of ~500 , 400 and 700 bp was obtained for DsMV, SPFMV and SLCMV respectively. Among tested, 40 samples were positive for DsMV in elephant foot yam, 42 were positive for SPFMV in sweet potato and 48 were positive for SLCMV in cassava.

Efficiency of newly designed multiplex PCR primers for specific detection of SLCMV and ICMV: New primer sets were designed for simultaneous detection of SLCMV and ICMV infection in cassava and tested with cassava mosaic diseased samples which gave single amplicon of desired size for both SLCMV (385 bp) and ICMV (242 bp). This was further confirmed with 160 samples collected from field ,in that 145 were positive for SLCMV alone, 3 were positive for both SLCMV and ICMV and 2 were negative for both SLCMV and ICMV.

16. Establishment of mass production unit of bioagents for ecofriendly disease management in vegetable crops of Odisha (Rashtriya Krishi Vikas Yojana (RKVY), Govt. of Odisha; PI: R. Arutselvan; Co-PIs: Kalidas Pati, V.B.S. Chauhan K.Hanume Gowda, M. Nedunchezhiyan, K. Laxminarayana)

The project was initiated to establish biological control mass production unit at Regional Station, ICAR-CTCRI, Bhubaneswar, Odisha, to develop broad spectrum and eco-friendly bio-formulations for integrated disease management for vegetable crops, to improve the antagonistic communities associated with major vegetable crops and product popularization among farming communities in Odisha state. The construction of mass production unit of bioagents and the procurement of equipments and consumables were initiated

Crop Utilisation

17. Abiotic stress-hormesis to enhance the phenolic-linked antioxidant protective system in biofortified sweet potatoes for designing functional food ingredients (DST-SERB, Govt. of India; PI. Pradeepika)

Development of functional food ingredients (functional puree and powder/flour) from orange and purple bio-fortified sweet potato varieties has been attempted. The sweet potato flours from biofortified sweet potato tubers studied for beta carotene and anthocayanin and their stability during different processing conditions (applying abiotic stress). The beta carotene content (21.22 mg 100 g-1) was higher in the samples treated at 100°C compared other treatments 160°C (beta carotene content was 18.40 mg 100 g-1) and 180°C (beta carotene content was 16.75 mg 100 g-1) in the study. However, the sweet potato tubers treated at 100°C to prepare functional flour showed raw flavour of final flour when compared to flour prepared using heat conditions like 160°C and 180°C. From these results, heat treatment of 160°C was optimized for developing beta carotene rich sweet potato flour.

Similarly, the sweet potato flours from biofortified sweet potato tubers studied for higher anthocayanin and their stability during different processing conditions was studied using abiotic stress conditions. Results are showed similar pattern as beta carotene rich flour development. The anthocayanin content (48.58 mg 100 g-1) was found to be higher in the samples treated at 100°C compared other treatments 160°C (anthocayanin content was 35.84 mg 100 g-1) and 180°C (anthocayanin content was 29.56 mg 100 g-1) in the study. Therefore, based on biochemical and textural properties, the heat treatment conditions like 160°C was optimized for the development of anthocayanin rich sweet potato flour. Other functional ingredient is puree, the experiments are undergoing to develop beta carotene and anthocayanin and their stability during different processing conditions.

18. Development of cassava custard (Contract research project, M/s KCM Agri Clinic, Tirunelveli, PI: C. Pradeepika; Co-PIs: A.N. Jyothi, M.S. Sajeev)

The developed cassava custard product showed significantly improved protein content, texture and consistency which are comparable with the control and market custard sample (corn based custard). The developed cassava custard product was licensed to M/s KCM Agri. Clinic, Thyagaraja Nagar, Tirunelveli-627007, Tamil Nadu, India on 11 July 2024.

19. Development of smart foods, bio-composites, green packaging and bio-energy from agro-residue (NASF, ICAR, Govt. of India, PI. M. S. Sajeev; Co-PIs: T. Krishnakumar, A.N. Jyothi, S.S. Veena)

Extraction of starch from the stem: Effect of addition of different enzymes viz., cellulase, hemicellulase and laccase on the extraction of starch from the stem from different cassava varieties, Sree Vijaya and Sree Reksha, were analysed. Among the enzymes, addition of cellulase enzyme gave maximum yield of 11.08% for Sree Vijaya and 8.47% for Sree Reksha. All the viscometric properties of the starch were drastically reduced. Cellulase enzyme treatment was conducted at different temperatures for different varieties viz., Sree Jaya, Sree Vijaya M4, Sree Swarna, and Sumo by removing the outer skin of the stem. The yield was increased as the temperature of the treatment increased and maximum yield was obtained at 50°C for all the varieties. Among the varieties, Sree Jaya recorded the maximum stem starch of 17.92%.

Plate from cassava: Cassava flour was added with banana flour (10 to 20 %) and oil and water were added as plasticisers at different proportions and different weight of the composite flours were taken for plate making by thermos-pressing method. The plates were further coated with epoxidized soybean oil, crosslinked with citric acid dissolved in DCM, ethyl acetate, methanol, acetone and chloroform. The optimum composition was obtained as oil (10%), fibre (15%), water (70%) with a total mixture weight (85 g) and coating with epoxidized soybean oil, crosslinked with citric acid dissolved in DCM and chloroform induced good hydrophobicity and hot water holding capacity. Different oils such as epoxidized soybean oil, soybean oil, sunflower oil and palm oil were also used as plasticisers for getting smooth surfaced plates. The incorporation of different PLA grades (101, 110, 721, 290) dissolved in in DCM, ethyl acetate, methanol, acetone and chloroform as a coating agents were also tried and the results showed better hydrophobicity and hot water holding capacity for the plates coated with PLA dissolved in DCM and chloroform.

Study was also carried out to observe the hydrophobicity of the newspaper coated with epoxidized soybean oil cross linked with citric acid dissolved in different solvents such as ethyl acetate, chloroform, dichloromethane, methanol and acetone. The water absorption, foldability and the strength of the coated papers are being analysed to find its suitability for different packaging applications.

20. AICRP on Post-harvest Engineering and Technology (ICAR, PI: M.S. Sajeev; Co-PI: T. Krishnakumar)

Rice analogue from cassava-foxtail millet based composite flour was prepared by adding different hydrocolloids as a binding agent, xanthan gum, guar gum, mix gum, gum arabic and tragacanth gum at a concentration from 0.1% to 0.5%. The influences of different gums on the physical, colour, biochemical, cooking and hygroscopic properties of rice analogue prepared from the above composite flour were studied (Fig.59).

Fig. 59 . Rice analogue from foxtail millet

Among the primary physical parameters, length of analog rice varied from 0.69 to 0.58cm, breadth 0.29 to 0.19 cm thickness 0.18 cm to 0.15cm, weight 0.01 to 0.01g, true density 1887.77 to 1062.47 kgm^{-3} , tapped density 839.53 to 526.07 kgm^{-3}, bulk density 600.90 to 492.45 kgm^{-3} and porosity 0.69 to 0.52.

The biochemical properties of the rice analogues were determined and the ash content ranged from 1.89 to 1.07%, sugar 4.49 to 3.1 , starch 38.29 to 25.71%, moisture 6.89 to 5.00 %, fibre 0.4296 to 0.2316 , fat 6.92 to 5.14%, protein 10.26 to 7.43%. Among the micronutrient, magnesium content ranged from 127.01 to 92.5 ppm, calcium content from 129.2 to 64.4 ppm, iron content from 272.9 to 167.3 ppm and zinc content from 39.4 to 27.2 ppm. Maximum cooking loss, swelling index and cooking time of rice

analogue were 34.25%, 4.30 7.4 min respectively with minimum of 4.89 % , 1.21, 3.3 min. The rice analogue added with xanthan gum 0.5% was the best combinations with moisture: 6.18%, fibre: 0.23%, fat: 6.18%, starch: 32.14%, sugar: 3.5%, ash: 1.3%, and protein: 6.5%, cooking loss: 4.89%, swelling index: 3.82, and cooking time: 7.4 min.

21. Development of value added products from Mudali (Colocasia esculenta) and Kone (Dioscorea) (Contract Research Project, M/s Spudnik Foods, Bengaluru, Karnataka, PI: M. S. Sajeev; Co-PIs: T. Krishnakumar, C. Pradeepika)

Taro samples collected from the tribal areas of Joida district, Karnataka were treated with tartartic acid, citric acid and acetic acid to reduce the acridity of the samples. The concentration of the organic acids was 0.25, 0.50, 0.75 and 1.0 % and time of treatments was 1 and 2 h. The biochemical properties and acridity levels were analyzed. Yam tubers were treated with acetic acid and citric acid at 0.25, 0.50, 0.75 and 1.0 % for one h for getting good quality flour and the quality attributes were analyzed.

22. Developing the Standard Operating Procedures (SOP) for good manufacturing practices and Hazard Analysis and Critical Control Points (HACCP) for tapioca starch and sago production (Contract research project, SAGOSERVE, Salem, Tamil Nadu, PI: A. N. Jyothi; Co-PIs: M. S. Sajeev, T. Krishnakumar, J. Sreekumar, P. Prakash)

Under the contract research project on the preparation of SOP for tapioca starch and sago, the plant layouts were prepared for inclusion in the SOPs. The sago samples collected from different factories were analyzed for heavy metal content. Sago samples stored for different durations were analyzed for microbial parameters, aflatoxins and heavy metals to determine the best storage duration without quality deterioration. The experiment on wet storage of cassava starch with permitted processing aids has been done in the factory site. Samples were taken at regular intervals and analyzed for pH, TDS, and acidityalong with microbial parameters.Experiments were conducted at factory site to study the efficacy of different processing aids for bleaching/whitening of starch for sago making. Concentrations were also optimized. A trial with sodium metabisulphite as bleaching agent conducted in one of the sago factories was found successful and resulted in sago with good colour and texture. Concentrations were also optimized. An experiment was conducted for the production of natural sago in one factory site and sample analyses are in progress.

Extension and social sciences

23. Soil health management in coconut based cropping system involving tuber crops for enhanced yield and income (Coconut Development Board, Kochi, Government of India; PI: D. Jaganathan; Co-PIs: G. Byju and G. Suja)

In Tiruppur district, ten coconut gardens with 50 cents each were selected for demonstrating the effectiveness of customized fertilizers (SSNM) and organic farming (OF) in cassava var. Sree Reksha and elephant foot yam var. Gajendra. Soil samples were collected prior to the validation trials and were analyzed. The soil nutrient status of the coconut gardens before initiating SSNM demonstrations revealed that soil pH was alkaline (8.06), organic carbon was medium (0.56 %), N was low (81.54 kg ha^{-1}), P was high (47.41 kg ha^{-1}) and K was high (783.91 kg ha^{-1}). Similarly, the soil nutrient status of the coconut gardens before initiating organic farming showed that soil pH was alkaline (8.42), organic carbon was low (0.35%), N was low (75.89 kg ha^{-1}), P was high (61.13 kg ha^{-1}) and K was high (671.24 kg ha^{-1}). The ten on-farm demonstrations were laid out during June 2024 and the crops will be harvested by February-March 2025.

A seminar on ‘Coconut and tuber crops based agrifood systems for resilience and sustainable income’ sponsored by Coconut Development Board, Kochi, Kerala, was organized on 29 August 2024 at Perumanallur, Tiruppur, Tamil Nadu by the Institute in collaboration with ICAR-CPCRI, Kasaragod; Krishi Vigyan Kendra, Tiruppur; Department of Agriculture and Horticulture, Tamil Nadu; Global Coconut Farmers Producer Company (FPC) & Makilam FPC, Tiruppur and M/s Linga Chemicals, Madurai. Nine

exhibition stalls were arranged and 300 farmers and other stakeholders attended the seminar.

24. IP & TM scheme: National Agricultural Innovation Fund (NAIF) component I: Innovation Fund (ICAR, New Delhi; PI: P. Sethuraman Sivakumar; Co-PIs: T. Krishnakumar and P. Prakash)

IP portfolio management: Two patents, electronic Crop IoT Device for smart farming (Patent No. 523325 dt.11.03.2024) and A power operated size based Chinese Potato grader and a method of grading there of (Patent No. 528150 dt.15.03.2024) were granted. Three patents were filed, viz., an apparatus for peeling an agricultural product (Application no: 202341088486 dated - 23.12.2023), a System and a method for automated fertigation of crops (Application no –202411030904; dated - 17.04.2024) and hydroponic nutrient formulation for sweet potato (Application no: 202411087376; Dated - 12.11.2024) and three copyrights - SIMCAS- A growth simulation model of cassava (Diary No: 37401/2024-CO/SW, dated 27.11.2024), MADHURAM- A growth simulation model for sweet potato (Dairy No: 37402/2024-CO/SW, dated 27.11.2024), SPOTCOMS- A growth simulation model for sweet potato (Dairy No: 37403/2024-CO/SW, dated: 27.11.20240 were filed.

Technology commercialization: Licensing of two technologies - Electronic crop- An IoT Device for smart farming to M/S. Tech Visit IT Pvt. Ltd., Mumbai, Maharashtra-400703 for Rs. 1770000/-. as well as elephant foot yam Flakes to M/s. Haritha Lekshmi Krishikoottam and Krishi Bhavan, Kollam, Kerala- 691012 for Rs. 29500/-. A total revenue of Rs. 1799500/- was generated through technology commercialisation.

Technology promotion programmes: Three IP and industry promotion programmes such a (i) IP talk on "Intellectual Property Management and Commercialization: Experiences of TiMED Incubator" on 30.04.2024; (ii) Workshop on 'Technology commercialization and licensing' for the students of College of Agriculture, Vellayani during 29.04.2024 to 30.04.2024 were conducted and 280 students/ stakeholders participated. Technology was promoted through two exhibitions (i) Bioconnect 2.0 Kerala 2024 (27-28 September 2024) and (ii) Branding Challenge 2.0 at Huddle Global 2024 during November 28-30, 2024.

25. IP & TM scheme: National Agricultural Innovation Fund (NAIF) component II: Incubation fund (ICAR, New Delhi PI: P. Sethuraman Sivakumar; Co-PIs: M. Nedunchezhiyan and T. Krishnakumar)

Six incubates were enrolled in the ICAR-CTCRI ABI during 20214. Three new Satellite incubation centres were started and four Entrepreneurship Development Programmes were conducted under the project (Table 16 to 18)

Table 16 . Incubatees enrolled

Sl. No.	Name of the startup/ companies	Domain	Date of enrolment
1	M/S J.J. Agencies	Food Processing	03.01.2024
2	M/S Geobites	Food Processing	13.05.2024
3	M/S Linga chemicals	Agricultural inputs Marketing	12.02.2024
4	M/S Kali Farmers Producer Company Limited	Agricultural inputs Marketing	20.05.2024
5	M/S Harithalekshmy Krishikoottam	Food Processing	24.07.2024
6	M/S Aati Pual Mushroom (OPC) Private Limited	Food Processing	14.08.2024

Table 17. Approved new satellite incubation centres

Sl. No.	Name of the incubation centre	Host organisation
1	KAU – ICAR-CTCRI ABI SIC Centre for Tribal Entrepreneurship	Regional Agricultural Research Station, Kerala Agricultural University (KAU), Pattambi, Palakkad
2	CAU(I) – ICAR-CTCRI ABI SIC Centre for Protection and Commercialisation of Traditional Knowledge and Farmer Innovations	College of Horticulture & Forestry, Central Agricultural University (Imphal), Pasighat, Arunachal Pradesh,
3	Assam University, Silchair – ICAR-CTCRI ABI SIC Centre for Indigenous and Local Community Entrepreneurship	Assam University ,Silchar - 788 011, Assam, India

Table 18. Entrepreneurship Development Programmes organized

Sl. No.	EDP Programme	Subject/ Focus Area	Mode	Date/ Time Period	Participants
1	Certified Agritech Professional Programme	EDP for students	Offline	March 18-20, 2024	100 students
2	Tuber Tech Ex 1.0- 6 months export-oriented incubation programme	Entrepreneurship Development	Online	March-August 2024	16 Agripreneurs, Startups
3	In-plant training/ Internship of Certified Agritech Professional Programme	EDP for students	Offline	April-August 2024	60 students
4	"Competency Building of Agripreneurs for creating and Managing Tuber Crops Based Businesses with Special Reference to Taro"	EDP for farmers	Offline	July 29-30, 2024	33 women Self-Help Group (SHG) members from Joida Taluk, Karnataka

Revenue generated: An amount of Rs 61,472/- was generated as revenue through incubate enrolment, sale of biocapsules and sales counter revenue.

26. Demonstration of applications of drones in agriculture (ICAR-New Delhi : PI: V.S. Santhosh Mithra; Co-PIs: Dr. G. Byju, M.S. Sajeev, D. Jaganathan, T. Makeshkumar, C. Mohan, E.R. Harish)

A total of 170 drone demonstrations were conducted across Kerala and Tamil Nadu. The demonstrations were held in different villages of Thrissur, Palakkad, Kasargode, Wayanad (Kerala) and Tenkasi, Tirunelveli, and Kanyakumari (Tamil Nadu) in collaboration with the Department of Agriculture of the states. The demonstrations covered cassava, paddy, banana, taro, and Chinese potato fields, where nano urea and cassava special micronol nutrient solutions were sprayed. In total, 428 farmers and stakeholders participated, gaining awareness of the efficiency of drone-based nutrient application

All India Coordinated Research Project on Tuber Crops (AICRP TC)

The All India Coordinated Research Project on Tuber Crops (AICRP-TC) has been operational since 1968 and currently functions across 21 centers in 18 states and one union territory, covering the northeastern, eastern, western, and southern regions of India (Fig. 60). The project focuses on major tropical root and tuber crops, including cassava, sweet potato, taro, dasheen taro, swamp taro, elephant foot yam, giant taro, lesser yam, greater yam, aerial yam, yam bean, winged bean, arrowroot, coleus, and others. Its primary objective is to develop region-specific, value-added varieties, along with agronomic and production system technologies. Additionally, the project aims to formulate effective pest and disease management strategies and promote tuber crop varieties and technologies to enhance productivity and ensure sustainable cultivation.

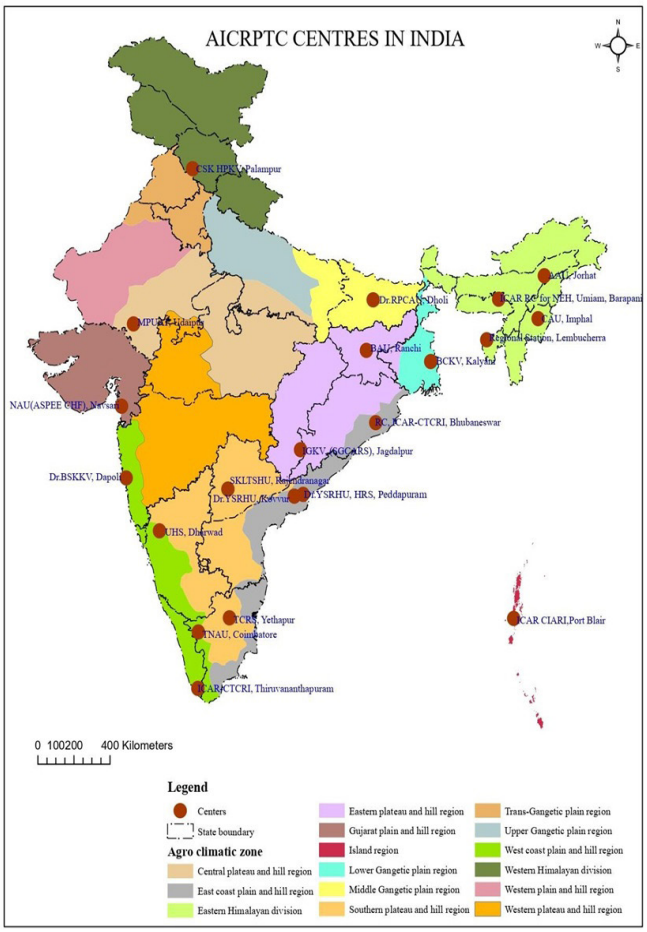


Fig. 60. AICRP-TC centers across different agro-climatic zones of India.

Maintenance of germplasm across different centers

A total of 92 new germplasm accessions were added, bringing the total number of conserved germplasm across 19 centers to 4,448. The National Repository for Tuber Crops at ICAR-CTCRI conserves 4359 accessions, while the Regional Station of ICAR-CTCRI, Bhubaneswar maintains 1270 accessions. Among the research centers, Dr. RPCAU, Dholi holds the highest number of accessions (1347), including 1054 accessions of sweet potato. A total of 2321 accessions have been assigned IC numbers, and during the year, 1282 accessions were characterized across different centers, bringing the total number of characterized accessions to 1776.

Varieties recommended for release

During the 24th Annual Group Meeting (AGM) of AICRP-TC, three new varieties, one in sweet potato and two in arrowroot were recommended for release. The sweet potato variety PASP-8 (TSp16-7), developed by Dr. YSRHU, Peddapuram Center, is an orange-fleshed variety with 29% dry matter content, 14.2% total starch, and 5.28% total sugar. It is rich in beta-carotene (6.93 mg/100 g) and exhibits excellent cooking quality. The variety has an average yield of 19.64 t ha^{-1}, with a potential yield of 28.36 t ha^{-1}. Recommended for cultivation in Chhattisgarh, Gujarat, Karnataka, and Telangana, PASP-8 is suitable for rabi season (Fig. 61).

Fig. 61. Sweet potato variety PASP-8

Two arrowroot varieties were recommended for national release during the 24th AGM of AICRP-TC. Sree Nakshatra (M-8/TAr18-12) is a selection from Kerala developed at ICAR-CTCRI, Thiruvananthapuram, and is recommended for cultivation in Chhattisgarh and Jharkhand. This variety recorded 26.63% total starch, an average yield of 32.25 t ha^{-1}, and a potential yield of 39.55 t ha^{-1}. Similarly, Sree Karti (M-11/TAr18-12), also selected from Kerala through ICAR-CTCRI, Thiruvananthapuram, has been recommended for national release and is suitable for Manipur, Tamil Nadu, and Kerala. It recorded an average yield of 23.57 t ha^{-1}, a potential yield of 41.46 t ha^{-1}, and a starch content of 21.52%.

Production technology

A crop production technology focusing on water-saving techniques in cassava was recommended for inclusion in the package of practices for different agro-climatic zones in India. Two specific treatments were suggested: (i) Drip irrigation at 50% CPE + ground cover sheet (120 gsm) was recommended for adoption in the Southern Plateau and Hills Region (Yethapur, Tamil Nadu), and (ii) Drip irrigation at 50% CPE + synthetic SAP was recommended for the East Coast Plains and Hills Region (Peddapuram, Andhra Pradesh).

Research-extension interface: Integrated farming systems involving tuber crops

Integrated farming system demonstrations involving tuber crops are being conducted across nine states and one union territory, viz. Assam, Meghalaya, Manipur, Tripura, Jharkhand, Chhattisgarh, Odisha, Karnataka, Kerala, and the Andaman and Nicobar Islands through various AICRP centers. These interventions, integrating improved tuber crop varieties with vegetables, pulses, cereals, fruit crops, piggery, pisciculture, and poultry, have resulted in a 2 to 5-fold increase in net income, a 2 to 3-fold increase in the benefit-cost (B:C) ratio, and enhanced year-round employment opportunities.

A tuber crop-based farming system model was demonstrated in Harminder Bay, Little Andaman, in 0.3 ha area incorporating tuber crops, vegetables, fruits, and spices integrated with piggery. Before the intervention, the net income was ₹77,000 with a B:C ratio of 1.26. Following the intervention, net income increased to ₹2,27,100 with a B:C ratio of 2.43. Employment generation improved significantly from 385 to 487 man-days/ha.

A 1.0 ha tuber crop-based farming system model was implemented in six tribal farmers' fields in Village-Marlenga, Bastar District, Chhattisgarh. Traditionally, farmers cultivated rainfed rice, millets, and maize, but the introduction of tuber crops provided additional income, increasing the B:C ratio from 1.33 to 2.53.

To further enhance farm income and employment opportunities, a 0.2 ha model of the tuber crop-based farming system was demonstrated in 20 tribal farmers' fields across villages in Mohana Block, Gajapati District, Odisha including Raldipanka, Belpada, Dhanupata, Ashoka, Keshpur, and B. Khajuripada. Previously, farmers in these villages primarily cultivated rice, yielding 610 kg per 0.2 ha, with gross and net returns of ₹12,200 and ₹4,200, respectively, and a B:C ratio of 1.53 with 50 man-days of employment generation.

In Lumdiengngan Village, Ribhoi District, Meghalaya, an integrated farming system was introduced to expand the cultivated area from 0.50 ha to 1.52 ha, resulting in an increase in net income from ₹82,078 to ₹3,94,455. Similarly, in Jamjuri, Gomati, Tripura, a demonstration over 1.15 ha led to an increase in net income from ₹1,40,500 (B:C ratio 1.33) to ₹5,45,200 (B:C ratio 2.80), with employment generation increasing from 65 to 125 man-days.

In two separate locations in Assam, integrated farming interventions led to a substantial increase in net farm income, from ₹9,600 to ₹3,10,179 per ha and from ₹14,400 to ₹2,71,843 per ha, with B:C ratios improving to 3.46 and 3.32, respectively.

Planting material production and distribution

Improved planting materials of tuber crops were multiplied and distributed to farmers through all AICRP centers. The centers collectively produced and distributed 125892 cassava stems, 3333385 sweet potato vine cuttings, 26 tons of elephant foot yam corms, 10 tons of taro cormels, 5 tons of greater yam tubers, 325 kg of lesser yam tubers, 1 ton of dasheen taro corms, 0.44 tons of arrowroot, 200 kg of yam bean, 52 kg of tannia, and 195 kg of aerial yam tubers as part of the planting material production program.

24th Annual group meeting of AICRP on tuber crops

The 24th Annual Group Meeting (AGM) of the All India Coordinated Research Project on Tuber Crops was held from June 25-27, 2024, at Navsari Agricultural University (NAU), Navsari, Gujarat. The meeting was inaugurated by Dr. Z.P. Patel, Honorable Vice Chancellor, NAU, Navsari, in the presence of Dr. Sudhakar Pandey, ADG, as Chief Guest; Dr. G. Byju, Project Coordinator and Director, ICAR-CTCRI; Dr. T.R. Ahlawat, Director of Research, NAU, as Guest of Honour; Dr. James George, former Acting Director, ICAR-CTCRI and former Project Coordinator; Dr. Archana Mukherjee, former Director, ICAR-CTCRI; and Dr. R.M. Naik, Principal & Dean, ASPEE College of Horticulture. In his presidential address, Dr. Z.P. Patel emphasized the immense potential of tuber crops for Indian farmers. Dr. R.M. Naik welcomed the dignitaries and participants, while Dr. G. Byju presented a summary report of the achievements from different AICRP centers. Dr. T.R. Ahlawat elaborated on the research achievements of the Navsari center, while Dr. Sudhakar Pandey emphasized the development of nutritionally rich varieties and technologies Dr. James George and Dr. Archana Mukherjee served as external experts.

During the AGM, 29 publications, including catalogues, booklets, technical bulletins, and folders, were released. The Best Center Award for 2023-2024 was presented to SKLTSHU, Rajendranagar, Telangana. In the Best Revenue Generation Center Awards category, Dr. YSRHU, Kovvur, Andhra Pradesh; UHS, Dharwad, Karnataka; and TCRS-TNAU, Yethapur, Tamil Nadu, secured the first, second, and third positions, respectively. Scientists from all the AICRP centres and made strategic recommendations during seven technical sessions and a plenary session. The Plan of Action for 2024-25 was also discussed and finalized. As part of the three-day program, a stakeholder interface was also conducted.

Summary of general recommendations

1. Research programs should be prioritized based on crops and traits
2. Duplicates in collected germplasm should be identified and eliminated
3. A pre-breeding program for elephant foot yam may be initiated at Kovvur center
4. Comprehensive guidelines for variety identification should be developed for each crop
5. Sweet potato trials should focus on resistance breeding and nutrient evaluation
6. Components of Good Agricultural Practices (GAP) should be evaluated
7. A monitoring calendar should be prepared for each center, indicating the best seasons for exploration trips
8. Mechanization aspects should be included in the training programs
9. More trials should be conducted on tannia and swamp taro
10. New varieties of crops other than cassava and sweet potato should be evaluated and released
11. A Survey and Surveillance Model should be developed using existing data to predict pest and disease outbreaks
12. New trials should be proposed and circulated in advance to ensure discussion and finalization during the AGM
13. An online meeting should be organized for cluster formation of SCSP beneficiaries
14. All approved technologies should be published in high-impact factor journals
15. Each center should increase revenue generation through commercial activities
16. A third-party evaluation will be conducted for AICRP-NEH and TSP programs

Technologies Assessed, Transferred, Consultancy and Patent Services

Consultancy and Patent Services

Technologies transferred

The Intellectual Property and Technology Management Unit and Professional Service Cell (IPTMU&PSC) under the guidance of the Intellectual Property and Technology Management Committee (IPTMC) has carried out the following technology transfer and contract activities.

Technology commercialisation

Technology licensed

Sl. No	Technology/ Know-How	Name of contracting party	Revenue (₹)
1.	Electronic crop IoT device for smart farming	M/s Tech Visit IT Pvt. Ltd., Vashi Plaza, Mumbai, Maharashtra	1770000
2.	Elephant foot yam flakes	M/s Haritha Lekshmi Food Products, Kollam Krishi Bhavan, Kollam, Kerala	29000
3.	Cassava based protein enriched noodles	M/s White Powder ME unit, Koottilangadi, Malappuram, Kerala	59000

Patents obtained / filed

Patents granted

Sl. No	Application/ Registration No.	Innovation/Inventors	Date of grant/ With effect from
1	1388/CHE/2014	Electronic crop IoT device for smart f`arming (Dr. V.S. Santhosh Mithra)	14 March 2024/ 17 September 2014
2	202241043900	A power operated size based Chinese Potato grader & a method of grading thereof (Dr. T. Krishnakumar, Dr. M.S. Sajeev, Dr. Pradeepika Chintha, Dr. R. Muthuraj, Dr. D. Jaganathan)	15 March 2024/ 01 August 2022

Patents filed

Sl. No	Application/ Registration No.	Innovation/Inventors	Date of Filing/ Registration
1	202411030904	A system and a method for automated fertigation of crops (Dr. J. Suresh Kumar, Dr. K. Sunil Kumar, Dr. G. Byju, Dr. S. Sunitha, Dr. K. Susan John)	17 April 2024
2	202411087376	Hydroponic nutrient formulation for sweet potato (Dr. J. Suresh Kumar, Dr. K. Sunil Kumar, Dr. G. Byju, Dr. K. Susan John, Dr. S. Sunitha)	12 November 2024

Copyrights filed

Sl. No	Application/ Registration No.	Product/Author	Date of Filing/ Registration
1	Diary No: 37401/2024-CO/SW	SIMCAS - A growth simulation model of cassava (Dr. V. S. Santhosh Mithra)	27 November 2024
2	Diary No: 37402/2024-CO/SW	MADHURAM - A growth sim ulation model for sweet potato (Dr. V. S. Santhosh Mithra and Prof. K. Somasundaram (Rtd), Gandhigram Rural Institute, Gandhigram, Tamil Nadu)	27 November 2024

3	Diary No: 37403/2024-CO/SW	SPOTCOMS - A growth simulation model for sweet potato (Dr. V. S. Santhosh Mithra and Prof. K. Somasundaram (Rtd), Gandhigram Rural Institute, Gandhigram, Tamil Nadu)	27 November 2024

Varieties released/submitted for release

a. Released by the Centre

1. Sree Nakshathra: First arrow root variety with high yield (32.25 t ha^{-1}) and starch yield (8.59 t ha^{-1}) for Chattisgarh and Jharkand
2. Sree Karti: Arrow root variety with high yield (23.57 t ha^{-1}) and starch yield (5.07 t ha^{-1}) for Kerala, Tamil Nadu and Manipur

b. Released by State

1. Sree Dhrona: A high yielding (35.0 t ha^{-1}), semi dwarf, white yam variety for Kerala
2. Sree Aadya: Arrow root variety with high yield (30.04 t ha^{-1}) and starch yield (5.95 t ha^{-1}) for Kerala
3. Sree Annam (CI-905): Nutrient-efficient cassava variety yielding up to 40 t ha^{-1} with 25% of the recommended NPK
4. Sree Manna (7III E3-5): Nutrient-efficient cassava variety yielding up to 40 t ha^{-1} with 25% of the recommended NPK

Technologies certified by ICAR

1. Method for assessing the impact of field interventions in Chinese potato (Lead Developer: P. Prakash; Associate Developers: D. Jaganathan, Sheela Immanuel, R. Muthuraj and P.S. Sivakumar)
2. Price forecasting model for sweet potato (Lead Developer: P. Prakash, Associate Developers : Pradeep Sharma, D. Jaganathan, Sheela Immanuel, Achal Lama, J. Sreekumar and P.S. Sivakumar)
3. Seed villages for scaling up of improved varieties of cassava in Tamil Nadu (Lead Developer: R. Muthuraj; Associate Developers: D. Jaganathan, P. Prakash and G. Byju)
4. Agronomic strategy to mitigate high temperature stress in sweet potato (Lead Developer: V. Ravi: Associate Developers: Sanket J. More., R. Saravanan, J. Sreekumar and J. Suresh Kumar)
5. Secondary and micronutrient based customized fertilizers for taro (Lead Developer: G. Byju: Associate Developers: J. Raju, M. Nedunchezhiyan, Kalidas Pati, Alam, S., Sharam, S., Veera Suresh, Ashish Narayan, K. Mamatha, Jayanta Tarafdar, Surjit Mitra and J. Suresh Kumar)
6. Organic management package for minimizing postharvest rot in elephant foot yam (Lead Developer: S.S. Veena; Associate Developers: M.L. Jeeva, G. Byju, J. Sreekumar, S. Sunitha, Sheriful Alam, S. Sengupta, Jayanta Tarafdar, D. Veera Suresh, Ashish Narayan, Himani Patel, K. Mamatha and Biswajith Das)
7. Integrated management package for minimizing postharvest rot in elephant foot yam (Lead Developer: S.S. Veena; Associate Developers: M.L. Jeeva, G. Byju, J. Sreekumar, S. Sunitha, Sheriful Alam, S. Sengupta, Jayanta Tarafdar, D. Veera Suresh, Ashish Narayan, Himani Patel, K. Mamatha and Biswajith Das)
8. Cassava and sweet potato resistant starch RS4 type (Chemically modified) (Lead Developer: A. N. Jyothi; Associate Developers: R. Remya and J. Sreekumar). Selected as one of the best ten technologies from Horticulture Sciences Division of ICAR, New Delhi

Professional services

Product development

MOA with ICAR-Indian Institute of Spices Research for manufacture and cost sharing of ICAR-CTCRI microbial biocapsules on 19 March, 2024.

Consultancy services

MoU signed with M/s KCM Agri. Clinic, Thyagaraja Nagar, Tirunelveli, Tamil Nadu for consultancy service on 'Cassava custard' on 08 October 2024 for ₹ 8,77,520

Revenue generated through technology commercialization and other professional services

Sl. No	Activity	Revenue generated (₹)
1	Technology licensing	18,58,500
2	Sale of technological products, machineries and value added products	3,58,445
3	Training/exposure visit programme	5,97,000
4	Students fees	10,17,346
5	ABI incubatee enrolment fees	35,400
	Total	38,66,691

Education and Training

ICAR-CTCRI has been recognized as an approved research center by ICAR-IARI, New Delhi, University of Kerala and Kannur University in Kerala, Tamil Nadu Agricultural University and Manonmaniam Sundaranar University in Tamil Nadu, Utkal University and Odisha University of Agriculture and Technology in Odisha, as well as Jawaharlal Nehru Krishi Vishwavidyalaya in Jabalpur, Madhya Pradesh, for conducting PG and Ph.D. research on tuber crops. The Institute has provided hands-on training to students and offered technical support for Ph.D. research and M.Sc. project work. Staff including scientists were trained in various personality and technical skills. Numerous on campus and off campus trainings have been imparted by the Head Quarters, Regional Station and techno incubation centre.

Sl. No	Particulars of programme	Number of students/ scholars
1	B.Sc./ B.Tech project	36
2	M. Sc. project	40
3	Ph. D	28

M.Sc. Projects

Sl No	Student name	Subject, College and University	Thesis title	Name of the guide
1	Ms. Archa Raj	M.Sc. (Biotechnology), A.J. College of Science & Technology, Thonnakkal, University of Kerala	Molecular profiling of the cassava landrace-Noorumuttan using SSR markers	Dr. K.I. Asha
2	Mr. Sharif Ali	M.Sc. (Life Science), Central University of Karnataka	Molecular characterization and micropropagation studies in taro (*Colocasia esculenta* (L.) Schott)	Dr. A. Asha Devi
3	Ms. Gopika Krishna	Integrated BS-MS degree, Indian Institute of Science Education and Research, Tirupati	Basic techniques in morphological characterization, *in vitro* culture and molecular studies in taro (*Colocasia esculenta* (L.) Schott)	Dr. A. Asha Devi
4	Ms. Jyothika Madhu	M.Sc. (Microbiology), Department of Biosciences, Marthoma College, Thiruvalla, MG University, Kottayam	Effect of insecticides on microbes and microarthropods in tuber crop ecosystems	Dr. E.R. Harish
5	Ms. Sreethu P Prasad	M.Sc. (Microbiology), St Mary's College for Women, Thiruvalla, MG University, Kottayam	Characterization of mites infesting tuber crops and their endosymbionts	Dr. E.R. Harish
6	Ms. Smrithy Prasad	M.Sc. (Microbiology), MES M K Mackar Pillay College for Advanced Studies, MG University, Kottayam	Assessment of biocontrol ability of endophytic microorganisms on *Fusarium* spp. associated with cassava stem and root rot disease	Dr. M. L. Jeeva

7	Ms. Gouri Nanda	M.Sc. (Food Technology and Quality assurance) St. Mary's College for Women, Thiruvalla, MG University, Kottayam	Synthesis, characterization and evaluation of succinylated cassava distarch phosphate as thickening agent	Dr. A.N. Jyothi
8	Ms. Reshma Rajesh	M.Sc. (Food Technology and Quality Assurance), St. Mary's College for Women, Thiruvalla, MG University, Kottayam	Development of pH sensitive cassava starch films as spoilage sensor in stored foods	Dr. A.N. Jyothi
9	Ms. Alina Rajendran	M.Sc. (Chemistry), Sree Narayana College, Kollam, University of Kerala	A comparative study of different methods to synthesize porous cassava starch	Dr. A.N. Jyothi
10	Ms. Anjali, S.	M.Sc. (Chemistry), Sree Narayana College, Kollam, University of Kerala	Synthesis and characterization of crosslinked porous cassava starch	Dr. A.N. Jyothi
11	Ms.C. Parvathy	M.Sc. Food Technology and Quality Assurance, St.Mary's College for Women, Thiruvalla, MG University, Kottayam	Development of protein enriched rusk using sweet potato-wheat composite flour	Dr. T. Krishnakumar
12	Mr. Besto John	M. Sc. (Ag) (Soil Science & Agrl. Chemistry), College of Agriculture, OUAT, Bhubaneswar	Effect of INM on soil quality, yield and proximate composition of greater yam	Dr. K. Laxminarayana
13	Mr. Stevin, C.C.	M. Sc. (Ag) (Soil Science & Agrl. Chemistry), College of Agriculture, OUAT, Bhubaneswar	Response of sweet potato genotypes to nitrogen management strategies in Alfisols of Eastern India	Dr. K. Laxminarayana
14	Ms. Aswathy, K.M.	M.Sc. (Biotechnology), Kerala University of Fisheries and Ocean Studies, Kochi	Morphological and molecular characterization of selected landraces and varieties of *Solenostemon rotundifolius* (Poir.) J.K. Morton	Dr. Murugesan P.
15	Ms. Mary Eveline, C.	M.Sc. (Food Technology), Kerala University of Fisheries and Ocean Studies, Kochi	Physicochemical and sensory characterization of frozen yogurt developed from orange and purple sweet potatoes	Dr. Pradeepika Chintha
16	Ms. Serin Sebastian	M.Sc (Food Technology), Kerala University of Fisheries and Ocean Studies, Kochi	Quality and antioxidant properties of beta carotene and anthocyanin rich gummy confections incorporated with biofortified sweet potatoes	Dr. Pradeepika Chintha
17	Ms. Robina Dominic	M.Sc. (Food Processing and Technology), St. Mary's College for Women, Thiruvalla, MG University, Kottayam	Development and characterization of anthocyanin and beta carotene rich gummy confections using biofortified sweet potatoes	Dr. Pradeepika Chintha
18	Ms. Jesslin, M.	M.Sc (Food Technology), Kerala University of Fisheries and Ocean Studies, Kochi	Investigation of nutritional, functional and rheological properties of orange sweet potato incorporated muffins	Dr. Pradeepika Chintha

19	Ms.Albi S Kokkattu	M.Sc. (Food Technology and Quality Control), School of Biotechnology, MG University, Kottayam	Detoxification of cassava peel and the potential use of cassava peel as fish feed	Dr. M.S. Sajeev
20	Mr. Mohammed Badusha, S.S.	M.Sc. (Food Technology and Quality Control), St George's College, Aruvithura	Development of particle boards from cassava stems of different varieties	Dr. M.S. Sajeev
21	Ms. Athira, M.	M.Sc. (Food Technology and Quality Assurance), St Mary's College for Women, Thiruvalla, MG University, Kottayam	Development of rice analogue from cassava-foxtail millet based composite flour added with different hydrocolloids	Dr. M.S. Sajeev
22	Ms. Aswathy, V.S.	M.Sc. (Food Technology and Quality Assurance), St Mary's College for Women, Thiruvalla, MG University, Kottayam	Development of cassava by hot air frying technology chips	Dr. M.S. Sajeev
23	Ms.Ashna C. Paul	M.Sc. (Food and Industrial Microbiology), College for Women, Amalagiri	Effect of edible gums on the properties of rice analogues from cassava-barnyard millet.	Dr. M.S. Sajeev
24	Ms.Simi, S.	M.Sc. (Biotechnology), A. J. College of Science and Technology, Thonnakkal, University of Kerala	Gene expression analysis of proteinase inhibitor in *Ipomoea mauritiana* Jacq and *Ipomoea batatas* (L.) in response to sweet potato weevil (*Cylas formicarius* Fab.) infestation	Dr. Sangeetha. B.G.
25	Ms.Namitha Bilu	M.Sc. (Biotechnology), St. Berchmans College, Changanassery, MG University, Kottayam	Morphological and molecular screening of *Ipomoea* spp. using proteinase inhibitor gene specific primers for sweet potato weevil resistance	Dr. Sangeetha, B. G.
26	Mr.Akshay, R. A.	M.Sc.(Biotechnology), St. Berchmans College, Changanassery, MG University, Kerala	Evaluation of the insecticidal acitivity of wild *Ipomoea* leaf proteins against sweet potato weevil (*Cylas formicarius* Fab.)	Dr. Sangeetha, B. G.
27	Ms. Kavya, T. K.	M. Sc. (Biotechnology), Department of Life Sciences, University of Calicut	Physiological and biochemical response of cassava during submergence tolerance and genetic diversity analysis using molecular markers	Dr. Senthilkumar,K.M.
28	Ms. Aneesa, N.	M. Sc. (Biotechnology), Department of Life Sciences, University of Calicut	Biochemical and physiological responses of sweet potato towards growth retardants and genetic diversity analysis using SSRs	Dr. Senthilkumar,K.M.
29	Mr. Noel Longhinos	M. Sc. (Biotechnology), School of Biotechnology, Amrita Vishwa Vidyapeetham, Kollam	Genome-wide microsatellite marker identification and genetic diversity analysis in cassava (*Manihot esculenta* Crantz)	Dr. Senthilkumar K.M.

30	Ms. Kavya Anil	M.Sc. (Biotechnology), Cochin University of Science and Technology, Kochi	Tissue culture and molecular biology techniques in tuber crops	Dr. Shirly Raichal Anil
31	Ms. Akshaya S Vijayan	M. Sc. (Biochemistry), National College, Thiruvananthapuram, University of Kerala	Biochemical changes associated with soil and plants under NUE cassava genotypes	Dr. Susan John, K.
32	Ms. S. Athira	M.Sc. (Microbiology), P.G.M College of Arts and Science, MG University, Kottayam	Developing liquid formulation of *Trichoderma asperellum* and its role in plant growth promotion	Dr. S.S. Veena
33	Ms. Bhagya Chandran	M.Sc. (Microbiology), Marthoma College, Thiruvalla, MG University, Kottayam	Establishment of pathogenicity and variability studies with *Colletotrichum* and *Fusarium* associated with leaf and pseudostem rot in elephant foot yam	Dr. S.S. Veena
34	Ms. Chithra Vinod	M.Sc. (Microbiology), MES M K Mackar Pillay College for Advanced Studies, MG University, Kottayam	Identification and characterization of *Trichoderma* isolates for temperature, fungicide tolerance and anti-fungal activity	Dr. S.S. Veena
35	Ms. Fathima Irshad	M.Sc. (Microbiology), MES M K Mackar Pillay College for Advanced Studies, MG University, Kottayam	Exploration of bacterial isolates for NPK activity, degradation of plastics and wastes	Dr. S.S. Veena
36	Ms. Ganga Gireesh	M.Sc. (Microbiology), PGM College of Arts and Science, Kottayam, Kerala	Exploring antifungal activity of actinomycetes against fungal pathogens of aroids	Dr. S.S. Veena
37	Mr. Amal Raj R.B.	M.Sc. (Biotechnology), School of Biotechnology, Amrita Vishwa Vidyapeetham, Kollam	Molecular characterisation of sweet potato germplasm using SSR markers	Dr. Visalakshi Chandra
38	Mr. Nidhin R.V.	M.Sc. (Biotechnology), School of Biotechnology, Amrita Vishwa Vidyapeetham, Kollam	Genetic characterization of parents and progenies of cassava using SSR markers	Dr. Visalakshi Chandra
39	Ms. Sharmin	M.Sc. (Biotechnology), A.J. College of Science and Technology, Thonnakal, University of Kerala	Genetic diversity studies in cassava genotypes using microsatellite markers	Dr. Visalakshi Chandra
40	Ms. Aparna H.	M.Sc. (Biochemistry), Dept. of Life Sciences, University of Calicut	Characterisation of clonal progenies of sweet potato for quality and biochemical traits	Dr. Visalakshi Chandra

Training programmes

The farmers, officials, and students from different parts of the country had undergone training at the Institute. Training were imparted on advanced tuber crops technologies including value addition to increase their income and livelihood.

On-campus training

Sl. No	Particulars of training	Date	Details of participants
1	Advances in plant biotechnology and molecular biology for crop improvement	2-22 January 2024	14 from ICAR Institutes/Universities/ Colleges
2	R for biological data analysis	8-12 January 2024	Academicians/ students
3	Pest problems in cassava in Malayalam (online)	17 January 2024	60 from SAU, State Department of Agriculture and farmers
4	Improved technologies of tropical tuber crops	30 January 2024	45 farmers from Trichy
5		30 January 2024	40 farmers from Ramanathapuram
6		30 January to 01 February 2024	28 farmers
7	Smart farming driven by artificial intelligence	05-09 February 2024	7 from ICAR institutes, KAU and Industry
8	Improved technologies of tuber crops (RAWE)	8 -13 February 2024	13 students, College of Agriculture, Vellayani
9	Improved production technologies and value addition	14 February 2024	25 farmers, Pune, Maharashtra
10	Diagnostics of plant diseases through novel approaches	19-23 February 2024	6 from SAU and ICAR
11	Agro techniques and value addition in tropical tuber crops	27-29 February 2024	20 farmers
12		28-29 February 2024	16 farmers
13		29 February – 01 March 2024	20 farmers
14	Protected cultivation for clean seed production of tropical tuber crops	05 March 2024	60 farmers
15	Harnessing NextGen technology for tuber crops cultivation	05 March 2024	25 SCSP farmers
16	Nateel vasthu sambharanavum rogakeedangalum - kizhangu vizhakalil (Malayalam) (Online)	27 March 2024	70 SAU, State Department of Agriculture and farmers
17	Improved technologies of tropical tuber crops	07-09 May 2024	26 farmers from Tamil Nadu
18		29 May 2024	25 teachers from different government schools of Thiruvananthapuram
19	Improved technologies of tuber crops (Internship training)	19 – 29 June 2024	10 B.Sc., (Ag.) students of Vellore Institute of Technology, Tamil Nadu
20	Hitech approaches for clean seed production in tropical tuber crops	25 June 2024	Interns & Technicians
21	Quality planting material production in tropical tuber crops	09 July 2024	50 farmers
22	Soil, plant, and water analysis for efficient nutrient management	22–26 July 2024	26 from soil testing lab, Private labs, AICRP centres, ICAR and KVK
23	Competency building of agripreneurs for creating and managing tuber crops based businesses with special reference to taro	29-30 July 2024	33 women from Women Self-Help Group (SHG) Joida Taluk, Karnataka,
24	Industry-focused production techniques of tuber crops	29–30 July 2024	20 from Industry
25	Advances in integrated plant health management	05-09 August 2024	21 from SAU, Industry and ICAR
26	Protected cultivation for clean seed production of tropical tuber crops	07 August 2024	28 farmers
27	Tuber crops-based farming system	13 -15 September	30 tribal farmers of Odisha
28	Improved technologies of tuber crops (RHWE)	18 September to 15 October 2024	3 B.Sc. (Hons.) Agricultural students of Karunya Institute of Technology and Sciences, Tamil Nadu
29	Advances in quality planting material production of tropical tuber crops	23–27 September 2024	14 academicians, department staff, students

30	Improved technologies of tuber crops (RHWE)	01 October to 03 November 2024	7 B.Sc. (Hons.) Agricultural students, ITM University, Gwalior, Madhya Pradesh
31	Improved production technologies on tuber crops for enhancing farm income	16 October 2024	20 farmers from Ambasamudram, Tamil Nadu
32	Tuberous vegetables based nutri gardens by organic and urban farming	18–22 November 2024	15 from universities and entrepreneurs
33	Innovation in detection and management of pests	22 November 2024	20 farmers
34	Value added products for entrepreneurship development in tuber crops	29 November 2024	41 farmers from Cittumala, Chathannur, Kollam
35		04 December 2024	47 stakeholders from Vellayani, Trivandrum

On-campus training programmes by Techno Incubation Centre

Sl. No	Particulars of training	Date	Details of participants
1	Value added products for entrepreneurship development in tuber crops	10 January 2024	19 farmers, Krishi Bhavan, Vaikom
2	Value addition and entrepreneurship development in tubers and millets	30 January – 02 February 2024	30 farmers
3	Value addition and entrepreneurship development in tuber crops	26 February – 01 March 2024	35 farmers
4	Value added products for entrepreneurship development in tuber crops	12 April 2024	20 farmers Krishi Bhavan, Vaikom
5		12 April 2024	45 farmers, Krishi Bhavan, Parassala
6		18 April 2024	25 farmers
7		02 May 2024	13 farmers, Krishi Bhavan, Malappuram
8		06-07 May 2024	30 farmers, Krishi Bhavan, Kollam
9		09 May 2024	27 farmers Tiruchirapalli
10		14 May 2024	26 farmers, Krishibhavan, Kollam
11		29 May 2024	22 farmers
12		01 to 31July 24	18 B.Tech (Agril. Engg.) students, College of Agricultural Engineering Technology, OUAT, Bhubaneswar, Odisha
13		12 July 2024	32 farmers from Krishi bhavan, Chathannur, Kollam
14		17 July 2024	22 students College of Agriculture, Vellayani
15		18 July 2024	33 farmers from krishi bhavan, Kondotty, Malappuram
16		06 August 2024	28 stakeholders from Forest Dept., Thenmala
17		08 August 2024	27 farmers from ATMA, Irinjalakuda, Thrissur
18		19 September – 27 November 2024	22 B.Tech (Agril. Engg.) students College of Agricultural Engineering Technology, OUAT, Bhubaneswar
19		17 December 2024	34 stakeholders

Off-campus training/meetings

Sl. No.	Title of programme	Date(s)	Place	No. of beneficiaries farmers/ other stakeholders
1	Value addition and processing equipments in tuber crops	10 January 2024	RTTC, Vellayani, Thiruvananthapuram, Kerala	40
2	Production and value addition in tuber crops	19 January 2024	KVK, Rastaguntubai, Manyam district, A.P.	75
3	Sweet potato cultivation in rice fallows	29 January 2024	Beruda, Jajpur district	50
4	Tuber crops cultivation and integrated nutrient management	31 January 2024	Goodamalai, Salem district, Tamil Nadu	50
5	Tuber crops day	31 January 2024	Koradapongala, Gajapati district, Odisha	1000
6	Tuber crops cultivation and integrated nutrient management	01 February 2024	Chembanarcoil block, Mayiladuthurai district, Tamil Nadu	40
7	Role of soil physical properties for sustaining productivity of tuber crops	09 February 2024	College of Agriculture, Vellayani, Kerala	10
8	Production and value addition in tuber crops	12 February 2024	Saragchhida village, Mayurbhanj district, Odisha	80
9	Production and value addition in tuber crops	13 February 2024	Baskitala village, Mayurbhanj district, Odisha	70
10	Seed village in cassava & drone demonstrations for tuber crops	19 February 2024	Eraniel, Kanyakumari, Tamil Nadu	15
11	Site-specific nutrient management in Chinese potato & drone demonstrations for tuber crops	20 February 2024	Tenkasi, Tamil Nadu	50
12	Site-specific nutrient management in Chinese potato & drone demonstrations for tuber crops	21 February 2024	Tenkasi, Tamil Nadu	55
13	Site-specific nutrient management in Chinese potato & drone demonstrations for tuber crops	22 February 2024	Pallakal, Pothukudi, Tirunelveli, Tamil Nadu	55
14	Tuber crops and rainbow diet	04 March 2024	Muthi village, Aizawl, Mizoram	50
15	Production and value addition in tuber crops	04 March 2024	G. Kankabadi village, Rayagada district, Odisha	70
16	Production and value addition in tuber crops	05 March 2024	Hatamuniguda village, Rayagada district, Odisha	70
17	Tuber crops and rainbow diet	06 March 2024	Nausel village, Aizawl, Mizoram	50
18	Soil health management in coconut based cropping systems involving tuber crops	12 March 2024	Tirupur, Tamil Nadu	65
19	Value addition and entrepreneurship development in tubers and millets	20 – 22 March 2024	Raikia, Kandhamal district, Odisha	60
20	Arrowroot starch extractor	17 April 2024	Hatapeta, Lamtaput, Koraput, Odisha	54
21	Arrowroot starch extractor	18 April 2024	Kadraguma, Rayadgada, Odisha	63
22	Tuber crops based farming system	19 April 2024	Khajuripada, Rayadgada, Odisha	600
23	i) Quality planting material production in tropical tuber crops - Role of DSM and seed villages ii) Value addition and entrepreneurship development in tuber crops iii) Tuber crops seed village programme and distribution of inputs	19 June 2024	Kalanjoor, Pathanamthitta, Kerala	100
24	Improved tuber crops technologies for SC farmers	03 September 2024	Karimannoor, Thodupuzha, Idukki, Kerala	150

25	Training on quality planting materials of tuber crops under SCSP project	04 September 2024	Ollukkara, Thrissur, Kerala	100
26	Tuber crop development program and distribution of products for SC farmers	05 October 2024	Ollukkara Block Panchayat, Thrissur	200
27	Sweet potato cultivation and prospects	21 June 2024	Madappally, Changanassery, Kottayam, Kerala	55
28	Quality planting material production in tropical tuber crops and role of DSM and seed villages Value addition and entrepreneurship development in tuber crops	11 July 2024	Ollukkara, Thrissur, Kerala	80
29	Hitech approaches for clean seed production in tropical tuber crops	19 July 2024	TNAU, Coimbatore, Tamil Nadu	50
30	Production and value addition in tuber crops	25 July 2024	Nathma village, Rayagada, Odisha	50
31		26 July 2024	Korapadi village, Rayagada, Odisha	50
32			Saragchhidavill & Mayurbhanj, Odisha	50
33	Landraces and varieties of tuber crops and their conservation	31 July 2024	Thuvayoor and VFPCK Thalir Farmer's Market, Erathu	35
34	Production and value addition in tuber crops	02 August 2024	Baskitala village, Mayurbhanj district, Odisha	50
35	Prospects of arrowroot cultivation and quality planting material production of tuber crops	05 August 2024	Manjali, Aluva, Kerala	100
36	Arecanut-based cropping system	06 August 2024	ICAR-KVK, Erode, Kerala	556
37	Value addition and entrepreneurship development in tuber crops	12 August 2024	Attappadi, Palakkad, Kerala	300
38	Value added products from tuber crops	13 August 2024	Attappadi, Palakkad, Kerala	50
39	Crop diversification with tuber crops	16 August 2024	Dolapada, Khajuripada, Kandhamal, Odisha	50
40	Crop diversification with tuber crops	17 August 2024	Khariguda, Mohana, Gajapati, Odisha	52
41	Prospects of arrowroot cultivation	17 August 2024	Nellad, Muvattupuzha, Kerala	75
42	Cassava stem and root rot	29 August 2024	Machipilavu, Adimali, Kerala	64
43	Value addition and entrepreneurship development in tuber crops	03 September 2024	Karimannoor , Thodupuzha, Idukki , Kerala	100
44	Crop diversification with tuber crops	12 September 2024	Haldibasanta, Tangi, Cuttack, Odisha	60
45	Tuber crops-based farming system	30 September 2024	Sukhilambha, Mohana, Gajapati, Odisha	50
46	Crop diversification with cassava and sweet potato	16 October 2024	Cholagara village, Purulia, West Bengal	50
47	Improved technologies of tuber crops for enhancing farm income	16 October 2024	Mundanthurai, Ambasamudram, Tamil Nadu	90
48	Improved production technologies of tuber crops for enhancing farm income	16 October 2024	Mundanthurai, Tirunelveli, Tamil Nadu	80
49	Role of soil, water, and nutrients in crop production of cassava	17 October 2024	Kanyakumari, Tamil Nadu	30
50	Crop diversification with cassava and sweet potato	17 October 2024	Gholhura Purulia, West Bengal	50
51	Recent crop production technologies in cassava	06 November 2024	Goodamalai, Salem , Tamil Nadu	55
52	Value addition and entrepreneurship development in tuber crops	06 November 2024	Moolapudur, Salem, Tamil Nadu	35
53	Value added products from tuber crops	07 November 2024	Myladuthurai, Tamil Nadu	40
54	Recent crop production technologies in cassava	07 November 2024	Tiruchirappalli, Tamil Nadu	40

55	Improved varieties, technologies and value addition in tuber crops	25 November 2024	Lower Damalgre, South West Garo Hills, Meghalaya	106
56	Improved varieties, technologies and value addition in tuber crops	28 November 2024	Lumdiengngan, Ri Bhoi, Meghalaya	85
57	Value addition and entrepreneurship development in tuber crops	28 November 2024	RTTC, Vellayani, Kerala	40
58	Tuber crops for health	29 November 2024	Attappadi, Palakkad, Kerala	100
59	Value addition and entrepreneurship development in tuber crops	23 December 2024	Cherthalai, Polima, Alleppey, Kerala	250
60	Good agricultural practices for cassava	23 December 2024	Vamanapuram, Kerala	17

Apart from this under the SCSP project, three candidates completed one year Skill Development Programmes on quality planting material production of tuber crops, mass production/multiplication of bio control agents (*Trichoderma*), and *in vitro* conservation of tuber crops.

Trainings attended by ICAR-CTCRI scientific staff

Sl. No	Name of the training	Particulars of the training	Period
1	Dr. S.N. Rahana	Hands-on-training on Advances in plant biotechnology and molecular biology for crop improvement' organized by ICAR-CTCRI	02-22 January 2024
2	Dr. T.P. Sujatha	One-day 2nd refresher training programme for testing and calibrating assessors by NABL, Bengaluru	09 February 2024
3	Dr. K.M. Senthilkumar	NAAS-4th pedagogy development program enhancing pedagogical competencies for agricultural education	29 January 2024- 02 February 2024
4	Dr. T. Krishnakumar	Modern food packaging technologies: regulatory aspects and global trends	January to April 2024 (12 week)
5	Dr. P. Prakash	MOOC training on artificial intelligence in agriculture organized by ICAR-NAARM, Hyderabad.	01-31 March 2024
6	Dr. T. Krishnakumar	Food safety and standards (Packaging and labeling) Regulations, conducted by Kerala Startup Mission, Kerala	19 June 2024
7	Dr. J. Suresh Kumar	Developing winning research proposals by ICAR-NAARM, Hyderabad	15-19 July 2024
8	Dr. K. Hanume Gowda	Multivariate Analysis Using R, at ICAR-NAARM, Hyderabad.	August 26 to 30, 2024,
9	All scientists	Awareness programme on diversity, equity, inclusion and belonging, ICAR-CTCRI, Thiruvananthapuram	27 September 2024
10	Dr. B.G. Sangeetha	Genome editing technologies in crops by ICAR- Indian Institute of Rice Research (IIRR)	14 – 23 October 2024
11	Dr. T.P. Sujatha	IP Awareness/ Training program under National intellectual property awareness mission organised by Office of the Controller General of Patents, Designs and Trademarks, Department of Promotion of Industry and Internal Trade, Government of India	18 October 2024
12	Dr. N. Krishna Radhika	Next generation sequencing (NGS) data analysis at ICAR-NAARM, Hyderabad	21-26 October 2024
13	Dr. N. Krishna Radhika	Genome editing — basic principles and practices organized by ICAR-IARI, New Delhi	02-06 December 2024
14	Dr. S.N. Rahana	International Winter School on "Navigating agricultural transformations for upliftment of rural excellence" (NATURE:2024) jointly by Agri Meet Foundation Bharat and Southern Federal University Russia, CIMMYT Mexico, ICRISAT Hyderabad, Visva-Bharati University West Bengal, ICAR-NDRI Karnal, MGUVV Durg, ICAR-ATARI Jabalpur and SKLTSHU Telangana	02-31 December 2024

15	Dr. Sheela Immanuel Dr. D. Jaganathan Dr. P. Prakash Dr. R. Muthuraj Dr. V. Ramesh Dr. K. Sunil Kumar Dr. K. Susan John Dr. Saravanan Raju Dr. Suresh Kumar Dr. A. Asha Devi Dr. S.N. Rehana Dr. S.S. Veena Dr. M.L. Jeeva Dr. B.G. Sangeetha Dr. N. Krishna Radhika Dr. Shirly Raichal Anil Dr. K.M. Senthil Kumar Dr. P. Murugesan	Personality development training for scientists of ICAR-CTCRI Institute of Management in Government Thiruvananthapuram	18-20 December 2024

Scientists and staff from the Institute completed many IGOT trainings through onine conducted by Karmayogi Mission, Government of India

Resource person in training programmes

The scientists handled over 250 classes in both online and offline modes, catering to farmers, officials, students, and various stakeholders nationwide. These sessions covered a wide range of topics, including improved crop varieties, agricultural techniques, nutrient management, quality planting material production, pest and disease control strategies, value addition, smart farming practices, drone applications, statistical tools, and entrepreneurship. The training programs were organized both within the institute's campus and at outside locations to ensure broader outreach and effective knowledge dissemination.

Awards and Recognitions

Awards

1. Dr. T. Makeshkumar, conferred with S.N. Dasgupta memorial award by Indian Phytopathological Society for his contribution on plant viruses infecting tropical tuber crops and their management in the 76th Annual meeting of the Indian Phytopathological Society on *Plant Health for Food Security: Threats and Promises* held during 1-3 February 2024 at ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh

2. Dr. P. Murugesan was awarded the Fellow of Chai Award-2024 by Confederation Horticulture Association of India New Delhi on 28 May 2024 for the outstanding contributions to horticultural crops research and development

3. Dr. H. Kesava Kumar bagged the Best Oral Paper Award for the research paper 'Identification of entomopathogenic nematode and its endosymbiont from Thiruvananthapuram, Kerala' in *the International Seminar on New Horizons in Plant Sciences (NHPS 2024)* held during 28-30 May 2024 at University of Kerala, Karyavattom, Thiruvananthapuram, Kerala (Authors: Kumar, H.K., Senthilkumar, K.M., Asheefa, J., Shilpa., Jeeva, M.L. and Makeshkumar, T)

4. Dr. B. G. Sangeetha bagged the Best Oral Paper Award for the research paper '*Ipomoea mauritiana* Jacq. – A source of resistant gene and insecticidal proteins against sweet potato weevil' in *International seminar- New Horizons in Plant Sciences (NHPS 2024)* conducted at Department of Botany, University of Kerala, Karyavattom, Trivandrum, Kerala during 28-30 May 2024. (Authors: Sangeetha, B. G., Athira. J., Jayan, K.., Makeshkumar, T., Santhoshkumar, T., Ajesh, G., Harish, E. R. and Rajeshwari, L.S.)

5. Dr. Hanume Gowda, K. received Best Research Paper Award for Scientist in recognition of the research paper 'Yield evaluation and identification of drought tolerant lines based on stress tolerant indices, ranking method and multivariate analysis in sweet potato (*Ipomoea batatas* Lam)' published in *Scientia Horticulturae*, 326: 112781 during ICAR-CTCRI Foundation Day Celebration on 09 July 2024 (Authors: Gowda, H.K., Chauhan, V.B.S., Nedunchezhiyan, M., Pati, K., Arutselvan, R. and Hegde, V.)

6. Dr. R. Arutselvan bagged the Best Scientist Award (Resource Mobilization: Externally Aided Project) 2024 for the externally aided project 'Establishment of mass production unit of bioagents for ecofriendly disease management in vegetable crops of Odisha' funded by RKVY, Odisha with a budget of Rs. 320.91 lakhs on 09 July 2024 during the 61thFoundation Day Celebration of ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala

7. Dr. D. Jaganathan was awarded Certificate of Excellence from Arecanut Growers Association, Gobi, Erode, Tamil Nadu for his contributions for the development of arecanut and tuber crops in Tamil Nadu, on 06 August 2024

8. Dr. K. Sunil Kumar received the Scientist of the Year Award-2024 hosted by TNAU and Pomological Society of India at the *International Conference on Precision Horticulture-2024* held during 22-24 August 2024 at HC & RI, Periakulam, Tamil Nadu

9. Dr. Susan John was conferred with the Fertilizer Association of India (FAI) Award for 'Excellence in Plant Nutrition Research 2024' for the best work done in the field of plant nutrition during the inaugural function of the FAI Annual Seminar on 4 December 2024 at New Delhi

10. Shri. B. Satheesan, Technical Assistant was awarded the Best Employee Award 2024 (among Technical staff category) during 61st foundation day of ICAR-CTCRI, Thiruvananthapuram on 09 July 2024

11. Shri. S. Sasikumar, Private Secretary was awarded the Best Employee Award 2024 (Administrative staff category) during 61st foundation day of ICAR-CTCRI, Thiruvananthapuram on 09 July 2024

12. Shri. S. Radhakrishnan Nair was awarded the Best Employee Award 2024 (Skilled supporting staff category) during 61st foundation day of ICAR-CTCRI, Thiruvananthapuram on 09 July 2024

13. Ms. P.R. Amrutha bagged MJ Narasimhan Academic Merit Award Commendation Certificate award for the research paper 'Management of greater yam (*Dioscorea alata* L.) anthracnose caused by *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. employing endophytes from medicinal plants (Authors: Amrutha PR and Jeeva, M.L) in the 76th Annual meeting of the Indian Phytopathological Society on Plant Health for Food Security: Threats and Promises' held during 1-3 February 2024 at ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh

14. Mr. U. Adarsh Krishnan received the Best Paper Award for the oral Presentation for the paper entitled 'Evaluation and validation of SNP related to cassava mosaic disease resistance in cassava using tetra-primer ARMS PCR technique' (Authors: Adarsh Krishnan, U., Asha, K.I. and Makeshkumar, T) in the *International*

Seminar on New Horizons in Plant Science (NHPS-2024) held during 28-30 May 2024 at the Department of Botany, University of Kerala, Thiruvananthapuram, Kerala

15. Mr. S. Behera, received Best Research Paper Award for students research paper "*In vitro* plant regeneration, genetic fidelity, biochemical analysis and anticancer activity of anthocyanin-rich purple flesh sweet potato var. Bhu Krishna" published in *South African Journal of Botany*, 166: 332-343 during ICAR-CTCRI foundation day celebration on 09 July 2024 (Authors: Behera, S Chauhan, V.B.S., Monalisa, K., Meher, R.K., Kar, S.K., Pati, K., Bansode, V.V., Nedunchezhiyan, M., Verma, A.K., Naik, P.K., and Naik, S.K)

16. Ms. P. Nileena, bagged the Best Oral Presentation Award for the research paper "Morphological characterisation of organisms associated with leaf and pseudostem rot disease in elephant foot yam" in *International conference on Biotechnology- the way forward (ICBWF-2024)* held during 20-22 November 2024 at University of Kerala, Karyavattom, Thiruvananthapuram, Kerala (Authors: Nileena, P., Veena, S.S., Karthikeyan, S. and Jeeva, M.L.)

17. Ms. Amrutha P.R. received Best poster award for the research paper 'Unveiling the genomic potential of endophytic *Bacillus subtilis* from *Aloe vera*: A gateway to sustainable Agriculture' in *ISMPP Zonal Meet (South Zone) & National Seminar on Advances in Plant Pathology: Challenges and Prospects* on 14 December 2024 at ICAR- Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala (Authors: Amrutha, P.R., Jeeva, M.L., Shilpa, S.U, Tom Cyriac)

18. Ms. Pavithra, S.A bagged Best Poster Award (Runner up) for the research paper 'Microbial profiling of elephant foot yam's phylloplane: insights into disease dynamics and plant health' (Authors: Pavithra, S.A., Veena, S.S., Aundy Kumar, Divya, S., Krishnaveni, K., Beegamnazrin, Harish, E.R., Karthikeyan, S., Shilpa, S.U., Tom Cyriac, Nileena, P., Makeshkumar, T. and Jeeva, M.L) in *ISMPP Zonal Meet (South Zone) & National Seminar on Advances in Plant Pathology: Challenges and Prospects* on 14 December 2024 at ICAR- Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala

19. Shilpa, S.U. bagged best poster award for the research paper "Endophyte Diversity and bio control: Contributions of wild and cultivated taro against *Phytophthora colocasiae*" (Authors: Shilpa, S.U., Jeeva, M.L., Veena, S.S. Amrutha, P.R. Tom Cyriac) in *ISMPP Zonal Meet (South Zone) & National Seminar on Advances in Plant Pathology: Challenges and Prospects* on 14 December 2024 at ICAR- Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala

20. AINPOF Thiruvananthapuram Centre was rated as Outstanding by QRT of ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh for the period 2018-2023

21. ICAR-CTCRI was awarded best exhibition stall in the exhibition organized as the part of the International Seminar on "Sustainable Urban Agricultural Practices and Community-Resilient Cities" held at Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram, 22 to 23 March 2024

22. ICAR-CTCRI bagged best exhibition stall award (2nd Prize) in connection with Chertala Fest – Karappuram Kazhchakal exhibition at Chertala, Alappuzha district, 20-29 December 2024

Recognitions

Crop Improvement

Dr. P. Murugesan

1. Adjudicator, Ph.D. thesis of Ms. Aswathi A.P., University of Calicut

2. Co-Chairman, Advisory committee of M. Thangamuniyandi, Ph.D. in Vegetable Science at HC&RI (TNAU), Periyakulam, Theni, Tamil Nadu for the research titled 'Genetic evaluation and feasibility of Chinese potato (*Plectranthus rotundifolius*) genotypes under matured coconut gardens'

3. Co-Chairman, Advisory committee of U. Atchaya, Ph.D. in Vegetable Science at HC&RI (TNAU), Coimbatore for the research topic on 'Hybrid vigour exploitation in pumpkin (*Cucurbita moschata* Duch ex. Poir) enriched beta carotene, high flesh thickness, small fruits using molecular markers'.

4. Co-Chairman, Advisory committee of Ms. S. Gomathi, PG Scholar, AC &RI, Madurai, TNAU on the research topic 'Elucidating allelopathic and bio pesticide effect of yam bean seeds'

5. External Examiner for the qualifying viva for 8 Ph.D. scholars of Vegetable Science of Horticultural College and Research Institute, TNAU, Coimbatore

6. External Expert, Selection Committee for the promotion of a teaching staff from Professor to Senior Professor under CAS held at The Gandhigram Rural Institute (Deemed to be University), Gandhigram. Tamil Nadu

7. Chairman and delivered a lead talk on 'Climate change mitigation and adaptation efforts through plant genetic resources of neglected and underutilised tuber crops' in the International Conference on Precision Horticulture (ICPH-2024) held at Horticultural College and Research Institute (TNAU), Periyakulam, Theni, Tamil Nadu during 22-24 August 2024

8. Resource person and presented a guest lecture on the topic,' PGR of Queensland arrowroot and its utilization' on 21 October 2024

9. Recognized as PG Faculty and Research Guide of ICAR-IARI (ICAR-IIHR, Bangaluru hub)

10. Panel member and co-chaired one of the technical sessions in the National Workshop on 'Reviving of agrobiodiversity in rainfed areas through traditional varieties for climate resilience agriculture' 2024 jointly organized by WASSAN and National Rainfed Area Authority (NRAA), Government of India held at NASC, Pusa, New Delhi on 24 December 2024

Dr. K. I. Asha

1. Resource person and delivered a lecture on the topic 'Importance of tuber crops and common tuber crops in Kerala and its varieties' In: The Farmers Training Programme on Scientific Cultivation of Tuber Crops and its Value Addition' organized by the Regional Agricultural Technology Training Centre (RATTC), Thiruvananthapuram on 17 January 2024
2. Reviewer, Asia-Pacific Journal of Science and Technology for the article, 'Development of ISSR-derived SCAR marker for rapid and accurate authentication of arrowroot (*Maranta arundinacea* L.)

Dr. A. Asha Devi

1. Member, Board of Studies in Botany (Pass), University of Kerala
2. Course coordinator, 21-day training programme on Advances in Biotechnology from 02-22 January 2024
3. Recognized as Ph.D. research guide in Botany under the Faculty of Science, University of Kerala on 20 July 2024
4. Member, expert committee for the selection of awardees for the Prof A. Abraham Endowment Oration and Endowment award programme on 14 Aug 2024
5. Editor, Journal of Root Crops
6. External expert, 36th Kerala Science Congress paper evaluation committee for Agriculture and Food Sciences
7. Reviewer, Heliyon and The Indian Journal of Agricultural Sciences
8. Adjudicator of two M.Sc. (Ag) theses of Department of Genetics and Plant Breeding, KAU, Vellayani
9. Resource person for handling classes for farmers at the training on 'Scientific cultivation of tuber crops & spices' organized by RATTC, Kazhakkuttom during 05-07 Dec 2024

Dr. Shirly Raichal Anil

1. Reviewer, Biodiversitas, Journal of Biological Diversity, Discover Plants Springer
2. Resource person for ICAR-Farmer First programme conducted by ICAR-CPCRI Kayamkumlam and Muthukulam Gram Panchayat, Arattupuzha for 40 farmers on 'Sweet potato cultivation' on 05 July 2024
3. Co-ordinated review meeting by CIP Officials and field visit on 8-9 August 2024

Dr. N. Krishna Radhika

1. Recognized as research guide for Ph.D. in Biotechnology from the University of Kerala.

Dr. Kalidas Pati

1. Reviewer of the journals, Frontiers in Plant Science, Heliyon and Annals of Applied Biology

Dr. C. Visalakshi Chandra

1. Guest Editor, Special issue on Deciphering plant stress signaling Networks: Implications for resilience and microbiome interactions
2. Reviewer, South African Journal of Botany, BMC Biology, BMC Genomics and Heliyon

Dr. K.M. Senthilkumar

1. Member, selection committee for requirement of SRF at ICAR-IIOPR, RC, Palode on 03 July 2024
2. Reviewer, The Indian Journal of Agricultural Sciences, BMC Genomics, Frontiers in Nutrition, Genetic Resources and Crop Evolution, Molecular Biology Reports, Journal of Plant Biochemistry and Biotechnology
3. Life member, Indian Society for Genetics and Plant Breeding

Dr. T.P. Sujatha

1. Assistant Editor, Applied Biochemistry and Biotechnology, Section: Biological processes and Genomics, Springer
2. Reviewer, BMC Genomics
3. Recognised as ICAR-IARI (IIHR- Bengaluru hub) research guide for M.Sc. Molecular Biology and Biotechnology
4. Life member, Vijnana Bharathi

Dr. S.N. Rahana

1. Evaluator, Oral and Poster presentation of the technical session in the International Seminar on *Sustainable Urban Agricultural Practices and Community Resilient Cities* organized by the Kerala Agricultural University at College of Agriculture, Vellayani, Thiruvananthapuram, Keralaon 23 March 2024
2. Evaluator, Oral and poster presentation of the technical session in the *International Seminar on Spices* organised by the Kerala Agricultural University at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala on 7 June 2024

Crop Production

Dr. G. Byju

1. Inaugurated one day training programme under AICRP TC SCSP at Jaipur on 29 January 2024
2. Inaugurated five days training programme under DBT-KIIT at Regional Station on 30 January 2024
3. Inaugurated & delivered keynote address in Karyashala workshop on 'Plant Bio-Prospecting, Analytical Techniques, Sustainable Practices and Opportunities' organized by KSCSTE in association with SERB at KSCSTE - Malabar Botanical Garden and Institute of Plant Science, Kozhikode on 20 March 2024
4. Chief guest at valedictory function of 'International Seminar on Urban Agricultural Systems and Community Resilient Cities' on 23 March 2024, College of Agriculture, Vellayani, Thiruvananthapuram

5. Member, Institute Management Committee meeting of ICAR-NAARM, Hyderabad
6. Inaugurated the seminar on 'Arecanut cultivation, post-harvest technology and marketing'organized by ICAR-KVK, Erodu, Tamil Nadu
7. Inaugurated the Refresher Course for Faculties (DBT Skill Vigyan State Partnership Programme) at KSCSTE-Jawaharlal Nehru Tropical Botanical Garden and Research Institute, Palode, Thiruvananthapuram, Kerala on 22 August 2024
8. Delivered the 34th Dr. S.P. Raychaudhuri Memorial Lecture on 'Role of plant nutrition in food security: achievements, aspirations and action plan' at College of Agriculture, Vellanikkara, Thrissur organised by The Indian Society of Soil Science, Thrissur chapter on 25 September 2024
9. Inaugurated 'L-Spectra', the science and arts exhibition of students at Loyola School, Thiruvananthapuram on 28 September 2024
10. Inaugurated 'Janakeeyam-2024' seminar and unveiled the portrait of Dr. E.K. Janaki Ammal at Sree Narayana College of Technology, Kollam, Kerala on 11 November 2024
11. Delivered the World Soil Day lecture on 'Role of plant nutrition in food security: achievements, aspirations and action plan' at ICAR-Sugarcane Breeding Institute (SBI), Coimbatore on 05 December 2024

Dr. G. Suja

1. Honoured as one of the Women Achievers of 2023, for bagging the Indian Society of Agronomy Gold Medal & Fellow Indian Society for Root Crops during International Womens' day at ICAR-CTCRI
2. Editor of Journal of Root Crops
3. Nominated as Councillor, Kerala Chapter, Indian Society of Agronomy
4. Co-chairman of the technical session on Agrotechniques and recommended three varieties for release as member, Variety Identification Committee in the 24th AGM of AICRP on Tuber Crops held at NAU, Navsari on 25-26 June 2024
5. Local organizing secretary, coordinated the Fifth QRT Meeting of ICAR-IIFSR, (including AICRP on IFS & AINPOF) & field visits.
6. Received technology certificate as Associate Developer for the technology titled IOFS models for Chhattisgarh, Gujarat, Kerala, Meghalaya, Rajasthan, Sikkim and Tamil Nadu.
7. Nominated as Member Secretary, QRT VIII, ICAR-CTCRI & AICRP TC.
8. Member, Jury Committee, M.S. Swaminathan Award for Agricultural Research (Best Researcher State Award), nominated by Director of Extension, Kerala Agricultural University.
9. Resource person for an online course on Natural Farming: Principles & Practices and recorded a lecture on the topic 'Landscape based integrated natural farming system' at the Massive Open Online Course (MOOC) Lab, MANAGE, Hyderabad, on 17 August 2024
10. Evaluator of research articles for *Journal of Spices & Aromatic Crops* 2020, 29 (1&2) for Dr. J.S. Pruthi Award & submitted the evaluation report
11. Reviewer of research papers to International Journal of Vegetable Science, Journal of Plant Breeding and Crop Science, Journal of the Indian Society of Soil Science, Journal of Environmental Biology, Journal of Spices & Aromatic Crops, Indian Farming, Indian Horticulture
12. External Examiner to one dual Ph.D. programme of Western Sydney University & Kerala Agricultural University and 3 M.Sc. Agronomy students, Kerala Agricultural University

Dr. K. Susan John

1. Evaluator of 8 extended abstracts, 36 & 37th Kerala Science Congress
2. Examiner for 13 Ph.D and one MSc. (Ag) students, Soil Science & Agricultural Chemistry, Tamil Nadu Agricultural University & Kerala Agricultural University
3. Technical expert, Central Soil Analytical Laboratory, Department of Soil Survey and Soil Conservation, Government of Kerala
4. Member, School Management Committee, Bharatiya Vidyabhavan School, Manvila, Thiruvananthapuram
5. Consultant, Polysulphate project, Indian Cardamom Research Institute, Idukki
6. Expert, Scientific Advisory Committee, KVK, Kollam
7. Session Chairman, International Seminar 'Sustainable Urban Agricultural Systems and Community Resilient Cities' held at CoA, Vellayani on 22-23 March 2024
8. Expert, Review of KVK, Kollam
9. Chairman, Committee, Selection of JRF under the DST-SERB funded project
10. Reviewer, VEGETOS, Agricultural Research, Indian Society of Soil Science and Journal of Root Crops

Dr. K. Sunil kumar

1. Session Co-chair on Spices: New Vistas in Crop Production and Protection – sub theme -Sustainable Agricultural Practices in *International seminar on Spices* organised by KAU from 5 - 7 June 2024 at CoA, Vellayani
2. Evaluator for two Ph.D. and three M.Sc. (Ag.) theses at Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram

Dr. S. Sunitha

1. External examiner for 2 Ph.D. and 7 M.Sc.(Ag.) students of KAU

2. DG's nominee for the CAS held at IISR, Calicut on 12 January 2024
3. Member, state level unit cost committee meeting of NABARD for 2024-25, at NABARD Regional office, Thiruvananthapuram on June 28 2024
4. Guide for two M.Sc. Chemistry students and one Biochemistry student from Kerala University
5. Nominated as visiting scientist by the Director, ATARI to KVK, Kumarakom, Kottayam district for appraising the activities of KVK

Dr. K. Laxminarayana

1. Member to scrutinise the variety release proposals, Technical Support Group meeting at Directorate of Horticulture, Govt. of Odisha on 26 February 2024
2. Guest of Honour in the Kisan Gosthi organized by ICAR-NRRI, Cuttack at Sambalpur, Odisha on 13 March 2024
3. Member to scrutinise the variety release proposals as a member for variety release committee. Technical Support Group meeting at Directorate of Horticulture, Govt. of Odisha under National Horticulture Mission on 14 March 2024
4. Chief Guest in the 'World Water Day' on the theme 'Water for peace' organized by ICAR-Indian Institute of Water Management, Bhubaneswar on 22 March 2024

Dr. R. Muthuraj

1. Evaluator for two M.Sc. (Ag.) theses at Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram

Dr. V. Ramesh

1. Evaluator for one M.Sc. (Ag.) thesis each at Department of SS&AC, AC&RI (TNAU), Madurai, Tamil Nadu and Department of SS & AC, College of Agriculture, Vellayani

Dr. Saravanan Raju

1. External examiner for 3 Ph.D. and 2 M.Sc.(Ag.) students of KAU
2. Evaluator for three Ph.D. and one M.Sc. (Ag.) theses at Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram
3. Editor, Journal of Horticultural Sciences
4. Evaluator of presentations International Seminar On Spices, KAU- 2024 (ISSK 2024) Spices: New Vistas in Crop Production and Protection -Sub theme: Innovative production systems by KAU from 5-7, June 2024 at CoA, Vellayani

Dr. J. Sureshkumar

1. Evaluator of research papers for the 37th Kerala Science Congress for the theme, Agriculture and Food Sciences

Crop Protection

Dr. T. Makeshkumar

1. External Examiner for the open defense of a Ph.D. student at Bharathiar University, Tamil Nadu
2. External examiner for conducting qualifying viva of eleven M.Sc. (Ag.) & two Ph.D. students of Department of Plant Pathology, College of Agriculture, KAU, Vellayani during 17-19 July 2024
3. Guest of honour in two day National conference on "Plant Active Bioenergy and Sustainable Bioproducts" organized by Department of Botany, Bishop Heber College, Trichy during 02-03 August 2024
4. DBT nominee of IBSC, ICAR-NRCB, Tiruchirapalli
5. Chairman for the committee to visit Oil Palm India Ltd (OPIL) nursery near Kulathupuzha on 26 July 2024 to study the suitability of oil palm seedlings available with OPIL to transport to other states
6. External member for IBSC , College of Agriculture, KAU, Vellayani on 04 November 2024
7. Chaired a session and delivered a lead talk in International Conference on Emerging viruses: Pandemi& Biosecurity Perspectives (VIROCON 2024) held during 11-13 November 2024 at DRDE, Gwalior, Madhya Pradesh

Dr. M.L. Jeeva

1. Invitee by Kilimanoor Krishibhavan to analyse the problem in cassava which showed wilt symptoms on 16 January 2024, Kilimanoor, Thiruvananthapuram
2. Invitee by Pangode Krishibhavan to analyse the problem in cassava which showed wilt symptoms on 16 January 2024 Pangode, Thiruvananthapuram
3. Invitee by Varapetty Krishibhavan, Kothamangalam to analyse the problem in cassava which showed root rot symptoms on 30 August 2024
4. Invited speaker in S & T interventions for the development of Bioresources of the southern region (Kerala) with special focus on the involvement of women scientists and technologists on October 1 2024 at RGCB Akkulam campus, Thiruvananthapuram and organised by the National Academy of Sciences, India (NASI) and RGCB, Thiruvananthapuram
5. External examiner for 1 Ph.D. and 5 M.Sc. students, Kerala Agricultural University
6. Nominated as visiting scientist by the Director, ATARI to KVK, Kumarakom, Kottayam district for appraising the activities of KVK

Dr. S.S. Veena

1. DG nominee as subject expert in CAS of Scientist (Plant pathology), ICAR-Indian Institute of Spices Research, Kozhikode
2. Member, selection/screening cum evaluation committee, Kerala Agricultural University, Thrissur, Kerala
3. External examiner, three Ph.D. and two M.Sc (Ag)

students, Indian Agricultural Research Institute, Kerala Agricultural University and Mahatma Gandhi University, Kottayam

4. Reviewer, Scientia Horticulturae, International Journal of Recycling of Organic Waste in Agriculture, Journal of Plant Pathology, Journal of Horticultural Sciences, Journal of Root Crops and Plant Science Today
5. Evaluator, M.K. Patel Memorial Young Scientist Award, S.N. Dasgupta Memorial Award, K.C. Mehta and Manoranjan Mitra Award and Fellow of Indian Phytopathological Society (FPSI), New Delhi
6. Evaluator, Dr. J.S. Pruthi Award for the best research paper published in the journal, Journal of Spices and Aromatic Crops by Indian Society for Spices, ICAR-Indian Institute of Spices Research, Kozhikode.
7. Jury Member, Viksit Bharath Young leaders dialogue-state championship, Nehru Yuva Kendra Sangathan, Thiruvananthapuram
8. Member, BLAKC, Office of ADA, Attingal, Thiruvananthapuram

Dr. E.R. Harish

1. Faculty/Research Guide in ICAR-IARI (IARI-IIHR Bengaluru Hub)
2. Mentor, Young Innovators Program of Kerala Development and Innovation Strategic Council (K-DISC).
3. Evaluator, Session II of International Seminar on Spices, KAU-2024 (ISSK2024), College of Agriculture, Vellayani, Thiruvananthapuram on 5 June 2024
4. External examiner for three M.Sc. students, Kerala Agricultural University
5. Reviewer, Springer Nature, International Journal of Tropical Insect Science, Journal of Biological Control, Current Agriculture Research Journal and Journal of Root Crops
6. Evaluator, Research project proposals, KSCSTE, Kerala
7. Executive committee member, Association for Advancement of Entomology

Dr. H. Kesava Kumar

1. Councillor, South Zone (2024), Nematological Society of India, New Delhi
2. Reviewer, Microscopy Research and Technique
3. Evaluator, Research proposals in Rashtriya Krishi Vikas Yojana (RKVY) scheme under Govt. of Rajasthan
4. Evaluator, Research papers for 37th Kerala Science Congress for the theme, Agriculture and Food Sciences
5. Expert member of the VI Scientific Advisory Committee meeting of ICAR-RVS Krishi Vigyan Kendra, Tirunelveli on 13 March 2024
6. Mentor for Young Innovators Program of Kerala Development and Innovation Strategic Council (K-DISC)
7. Question paper setter, end term examination 2023-2024 of B.Sc. (Agriculture) course on Nematode Management for Students of College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Imphal, Umiam
8. Jury Member, Viksit Bharath Young leader's dialogue-State Championship, at Kerala Institute of Tourism & Travel Studies, Govt. Guest House Compound, Nehru Yuva Kendra Sangathan, Thycaud, Thiruvananthapuram on 27 December 2024
9. External examiner, one M.Sc. (Nematology) student, Kerala Agricultural University
10. External expert, qualifying viva voce, 2 M.Sc. (Nematology) students, Kerala Agricultural University

Dr. B. G. Sangeetha

1. Evaluator in session I of spices: Frontiers in crop improvement, Sub theme 2: Biotechnological and biochemical interventions of International Seminar on Spices, KAU-2024 (ISSK2024) at College of Agriculture, Vellayani, Thiruvananthapuram on 5 May 2024
2. External examiner for setting of question paper and evaluation of answer sheets for written qualifying examination of master's degree programme in Molecular Biology and Biotechnology GKVK, University of Agriculture Sciences, Bengaluru
3. External examiner for oral qualifying examination for 17 PG students of M.Sc. (Agri) in Molecular Biology and Biotechnology GKVK, University of Agriculture Sciences, Bengaluru
4. Member, Advisory committee, Ph.D. student, Kerala Agricultural University and IARI-IIHR, Bengaluru Hub
5. Research Guide for Biotechnology in ICAR-IARI (IIHR Bengaluru Hub), University of Kerala, Thiruvananthapuram

Dr. R. Arutselvan

1. Reviewer, Journal of Horticultural Sciences.
2. Research guide, M.Sc. (Ag.), Odisha University of Agriculture & Technology, Bhubaneswar.
3. Institutional attachment training Coordinator, 4th year B.Sc. (Hons) Agriculture, Institute of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar

Crop Utilisation

Dr. A.N. Jyothi

1. Member, Technical Committee, Kerala State Pesticide Testing Laboratory, Department of Agriculture, Government of Kerala
2. Member, Advisory Committee of one student of PG Diploma course in Food Industry Management & Quality Control, Kerala Agricultural University, Thrissur, Kerala
3. Member, Advisory committee of one Ph.D. programme

at Department of Communication Science, College of Agriculture, Vellanikkara, Thrissur, Kerala

4. Member, Advisory Committee of one Ph.D. programme at Department of Food Process Engineering, School of Bioengineering, SRMIST, Kattankulathur, Tamil Nadu

Dr. M.S. Sajeev

1. Member, Working Group on Post harvest Engineering and Technology for Horticulture, SMD (Agricultural Engineering), ICAR, New Delhi
2. Member, Core Committee, Agri Entrepreneurs, FPOs and Agri Starups, Comprehensive Development Mission Programme of Agriculture, Govt. of Kerala
3. Member, Sub Mission on Agrl. Mechanisation-Committee for Empanelling of Manufacturers, Agrl Development and Farmers Welfare Department, Govt. of Kerala
4. Member in the assessment committee of Technical personal, IISR Calicut, 22 May 2024
5. Member, Board of Studies (BoS), Biotechnology & Biochemical Engineering Department, Sree Buddha College of Engineering, Pattoor
6. Member, Interview board of scientist selection, KSCSTE, Trivandrum, 22 October 2024
7. Reviewer for Journal of Tropical Agriculture, Heliyon, Journal of Food Science & Technology
8. External examiner for KAU, Vellanikara and UAS, Raichur
9. External expert for evaluation of projects under KRISP project at ICAR-CPCRI, Kasaragod, Kerala.
10. External expert for selection of project fellow at CSIR-NIIST, Thiruvananthapuram

Dr. T. Krishnakumar

1. Technical member in the Sectional Committee of FAD 16 – Food grains, Allied products and other agricultural produce, Bureau of Indian Standards (BIS), Govt. of India
2. Final theory question paper setter for B.Tech (Agricultural Engineering) and B.Tech (Food Process Engineering) course, Tamil Nadu Agricultural University (TNAU), Coimbatore
3. Advisory committee member for a M.Tech (Processing and Food Engineering) thesis at TNAU, Coimbatore
4. External examiner for M.Tech (Agricultural Engineering) thesis, Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur
5. Exernal examiner for Master of Technology (Food Technology) for NITFTEM-T, Thanjavur
6. Reviewer for LWT - Food Science and Technology, Journal of Food Science & Technology, Journal of Food Processing & Preservation, Journal of Agricultural engineering
7. Technical member for establishing FSSAI lab for SAGOSERVE, Salem, Tamil Nadu

Dr. Pradeepika Chintha

1. Reviewer, Scientia Horticulturae and CYTA-Journal of Food
2. Co-chair in the session on 'Post-harvest management' during the International Seminar on Spices KAU-2024 held by the Regional Agricultural Research Station (Southern Zone), Vellayani, Kerala Agricultural University from 05 to 07 June, 2024

Extension and Social Sciences

Dr. J. Sreekumar

1. Chairman, Progress assessment committee of five, third year Ph.D. students of IASRI for upgradation of fellowship
2. External examiner for three M.Sc. (Ag. Statistics) students, College of Agriculture, Vellayani, Thiruvananthapuram
3. Expert, Agricultural Bio Informatics in the Assessment Committee for Career Advancement Scheme of ARS scientists of ICAR-IISR, Kozhikode
4. Conducted the course 'Computational methods for data analysis' for 8 students of B.Tech. Biotechnology, KAU, November 2023 to March 2024
5. Resource person for the Online workshop on R for Bioinformatics organized by ICAR-IISR, Kozhikode and delivered a lecture on Basic Statics using R on 5 November 2024
6. Acted as the External Expert, Bioinformatics, in the CAS of ARS Scientists of ICAR-IISR Kozhikode

Dr. Sheela Immanuel

1. Handled two courses on AEM 101: Introduction to Agricultural Extension and AEM 104 : Gender mainstreaming for agriculture development, for the 16th batch PGDAEM students 2 July 2024 and 05 July 2024 respectively
2. Examiner for the PGDAEM course, MANAGE, Hyderabad
3. Nominated as visiting scientist to KVK, Mitraniketan, Thiruvananthapuram, Kerala for appraising the activities of KVK
4. External examiner for conducting qualifying viva voce of one Ph.D Students, College of Agriculture, Vellayani, 8 November 2024
5. Reviewer , Indian Journal of Fisheries, Journal of Marine Biological Association of India, Fishery Technology, Plant Science today, Cogent Food and Agriculture
6. Question paper setter for KUFOS, Kochi
7. Evaluator for the KAU work plan on strategic necessity of establishing centre for agricultural innovations and technology transfer, Vellayani

Dr. V.S. Santhosh Mithra

1. Lead talk on 'Digital Sensing of Environment' and co-chaired the session on Urban Biodiversity and Ecosystem Services, International Seminar on Sustainable Urban Agricultural Practices and Community-Resilient Cities, College of Agriculture, Vellayani, 22-23 March 2024
2. Lead lecture on 'Use of ICT and sensor for enhancing water productivity in rainfed ecosystem' in the workshop on 'Rainwater Management Options for Enhancing Agricultural Productivity' held in hybrid mode, ICAR-IIWM, Bhubaneswar. 28 June 2024

Dr. S. Sivakumar

1. Initiatives of ICAR to support Incubation & Agri-startups'' at the "Saturday Webinar Series" organized by MANAGE, Hyderabad, 6 January 2024
2. Invited talk on Applied Multi variate Data Analysis" at the capacity building programme (CBP) sponsored by Indian Council of Social Science Research (ICSSR) at Rajendra Prasad Central Agricultural University, 13 January 2024
3. Co-Chairperson in the session 'Climate Resilient Agriculture' at the *International Conference on 'Food & Nutritional Security through Agriculture Ecosystem'* organised by MANAGE in collaboration with our 'Knowledge Partners' IRRI, CIP, ICRISAT and Harvest Plus, MANAGE, Hyderabad, 1-2 February 2024
4. Invited talk Webinar Series organized by MANAGE, Hyderabad, 21 February 2024
5. Invited talk on Impact of IP on Agriculture: ICAR - CTCRI Experiences at *the International Conference and Round Table* organized by the Inter University Centre for IPR Studies, CUSAT, Kochi, 2 March 2024
6. Lead lecture on extension Approaches for Agri Startup Ecosystem at the ICAR-RC-NEH, Umiam and National Institute of Agricultural Extension Management (MANAGE), Hyderabad collaborative National Training Program on 13 March, 2024
7. Panellist in the Expert Panel Session as a part of the National Seminar on the *Impact of IP on Agricultural Innovation and Commercialisation* organised by Inter University Centre for IPR Studies, and delivered a talk on 'Initiatives of ICAR-CTCRI to Support Incubation and Startups', CUSAT, Kochi, 23 March 2024
8. Two invited talks at the National Young Professional Development programme on New Competencies, Career Opportunities and Research Priorities in Agricultural Extension at Shiksha O Anusandhan deemed to be University, Bhubaneswar, Orissa, 22-26 July 2024
9. Invited talk in the Agricultural Extension Evening 4 Learning webinar organised by MANAGE, Hyderabad, 27 August 2024
10. Invited talk at the National Young Professionals Development Program on New Competencies, Career Opportunities and Research Priorities in Agricultural Extension, at Kerala Agricultural University, Thrissur, 30 September - 05 October 2024
11. Panellist in the 'Trends and Challenges in processing varieties and value chain development' and 'Future proofing production in the face of Climate Change' at the 'Stakeholder Consultation on Priorities for Potato and Sweet potato Science and Innovation in India" organised by CIP, Lima, Peru, New Delhi, 16-17 October 2024
12. Panellist in the session 'Leveraging Incubators for Startup Excellence' at the *National Conference on Building Sustainable Agricultural Start-ups*, ICAR-NAARM, Rajendranagar, Hyderabad, 12- 13 November, 2024
13. Panellist in the Plenary Session on "Harnessing informal seed systems for sustainable seed business: Challenges and opportunities in India" at the "*National Seed Congress*", IRRI, Varanasi, 28-30 November 2024
14. Invited talk on 'Emerging research traditions, approaches and tools in extension: from accretion to excavation' and 'Human decision modelling in extension research' at the National Young Professionals Development
15. Expert and participated in the KSCSTE – Third Expert Committee Meeting- Entrepreneurship Development By SC-ST Women In STEM (ED/SC-ST- WISTEM) 2022 held at Dept of Environmental Science, University of Kerala, 10 December 2024
16. Invited talk on "Career options in Agribusiness" at the RAWE 2025 Orientation and Interaction programme for B.Sc. (Ag) students at the College of Agriculture, KAU, Vellayani, 31 December 2024
17. External Examiner for evaluating Ph.D. thesis, TERI School of Advanced Studies, New Delhi
18. External Examiner for the adjudication of thesis of three Ph.D. students of College of Agriculture, KAU, Vellayani, Thiruvananthapuram

Dr. D. Jaganathan

1. Co-chairman and evaluator of the Technical Session on 'Socio economic impacts of Urban Agriculture', *International Seminar on Sustainable Urban Agricultural Practices and Community-Resilient Cities*, Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram, 22-23 March 2024
2. External examiner for the viva-voce of two Ph.D. students, College of Agriculture, Vellayani, Thiruvananthapuram
3. Adjudicator and evaluated the theses of two Ph.D students, College of Agriculture, Vellayani, Thiruvananthapuram
4. Convenor, Brainstorming on Chinese potato for empowering stakeholders: Challenges and strategies, HRS, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari, Andhra Pradesh, 13 February 2024
5. External examiner for the qualifying examination of one M.Sc. student and final viva voce of one Ph.D. student, College of Agriculture, Vellayani, Thiruvananthapuram

6. Nominated as visiting scientist to KVK, Idukki, Kerala for appraising the activities of KVK
7. Question paper setter, Institute of Agriculture Research & Technology (IART), NMV University, Aruppukottai, Virudhunagar, Tamil Nadu
8. Lead talk on 'Decentralized seed production of tropical tuber crops: Prospects, challenges and way forward' in 31st Swadeshi Science Congress held during 07-09 November 2024 at ICAR-Central Institute of Fisheries Technology, Kochi, Kerala
9. Visiting Scientist to KVK, Idukki, Kerala for providing technological and methodological support for strengthening activities of KVK
10. Editor, the Journal of Traditional and Folk Practices JNTBGRI, KSCSTE, Government of Kerala

Dr. P. Prakash

1. Evaluator in the technical session on Urban Biodiversity and Ecosystem Services, International Seminar on 'Sustainable Urban Agricultural Practices and Community-Resilient Cities', Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram, 22-23 March 2024
2. Invited lecture for final year B.Sc. (Hons.) Agriculture students, RAWE-EDP & Project Management Module, College of Agriculture, Vellayani, Kerala, 18-20 March 2024
3. Received a grant an amount of Rs. 580 USD for participation and presentation of research work in the 32nd International Conference of Agricultural Economists ,02-07 August, New Delhi
4. Reviewer, Journal of Spices and Aromatic Crops

Linkages and Collaborations

International collaborations

1. International Centre for Tropical Agriculture (CIAT), Cali, Columbia
2. International Potato Centre (CIP), Lima, Peru

Organizations having MoU with ICAR-CTCRI

1. College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram, Kerala
2. Indian Institute of Technology, Palakkad, Kerala
3. Coconut Development Board, Ministry of Agriculture & Farmers' Welfare, Government of India
4. Mahatma Gandhi University, Kottayam, Kerala
5. Digital University of Kerala (DUK), Thiruvananthapuram, Kerala
6. a-IDEA, Techno Business Incubator (TBI), ICAR-NAARM, Hyderabad
7. National Institute of Food Technology, Entrepreneurship and Management, Thanjavur, (NIFTEM-T), Tamil Nadu
8. Jawaharlal Nehru Krishi Vigyan Kendra, Jabalpur, Madhya Pradesh
9. Odisha University of Agriculture & Technology, Bhubaneswar, Odisha
10. Dr. YSR Horticultural University, Andhra Pradesh
11. Tamil Nadu Veterinary and Animal Sciences University, (TANUVAS), Chennai, Tamil Nadu
12. M/s KCM Agri Clinic, Tirunelveli, Tamil Nadu
13. M/s Linga chemicals Pvt. Ltd., Madurai, Tamil Nadu
14. M/s MicroNutrich Pvt. Ltd., Tiruvallur, Tamil Nadu
15. M/s SAGOSERVE, Salem, Tamil Nadu
16. M/s Xobu Foods and Beverages Private Limited, Rajahmundry, East Godavari, Andhra Pradesh
17. M/s Spudnik Foods, Bengaluru, Karnataka

Linkages through collaborative research and extension activities

1. ICAR-Central Institute of Agricultural Engineering, Regional Centre, Coimbatore, Tamil Nadu
2. ICAR-Central Institute of Fisheries Technology, Kochi, Kerala
3. ICAR-Central Institute of Women in Agriculture, Bhubaneswar, Odisha
4. ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala
5. ICAR-Central Institute for Research on Cotton Technology, Mumbai, Maharashtra
6. ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh
7. ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka
8. ICAR-Indian Institute of Spices Research, Kozhikode, Kerala
9. ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana
10. ICAR-National Bureau of Plant Genetic Resources, New Delhi
11. ICAR- National Research Centre for Banana, Tiruchirapalli, Tamil Nadu
12. ICAR-National Rice Research Institute, Cuttack, Odisha
13. ICAR Research Complex for NEH Region, Barapani, Meghalaya
14. ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu
15. Agricultural Technology Application Research Institute, Bengaluru, Karnataka
16. Kerala Agricultural University, Vellanikkara, Kerala
17. Central Institute of Petrochemicals Engineering & Technology (IPT), Kochi, Kerala

18. CSIR-NIIST, Thiruvananthapuram
19. College of PG Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya
20. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu
21. Department of Agriculture, Government of Kerala
22. Department of Horticulture and Department of Agriculture, Government of Odisha
23. Department of Horticulture, Government of Tamil Nadu
24. Kerala Agricultural University, Thrissur, Kerala
25. Medical College, Thiruvananthapuram , Govt. of Kerala
26. National Institute of Technology, Trichy, Tamil Nadu
27. Rubber Research Institute of India, Kottayam

Linkages through project funding

1. Coconut Development Board
2. Department of Agriculture and Farmer's Welfare, Government of Kerala
3. Department of Science and Technology, Government of India
4. Department of Biotechnology, Government of India
5. Government of Odisha
6. Government of Kerala
7. ICAR, National Agricultural Innovation Fund (NAIF), Government of India
8. Kerala State Council for Science, Technology and Environment (KSCSTE), Government of Kerala
9. Kerala State Horticulture Mission, Government of Kerala
10. Kerala State Planning Board
11. National Bank for Agriculture and Rural Development (NABARD), Government of India
12. Protection of Plant Varieties & Farmers' Rights Authority (PPV&FRA)
13. Rashtriya Krishi Vikas Yojana (RKVY), Government of India
14. Small Farmers Agri-business Consortium (SFAC), Government of Kerala
15. Centre for Development of Advanced Computing (C-DAC), Thiruvananthapuram

Others

1. Horticulture Department, West Garo Hills and Meghalaya Basin Development Agency
2. National Institute of Agricultural Extension Management (MANAGE), Hyderabad
3. Indian Centre for Research on Innovation and Science Policy (CRISP), Hyderabad.
4. Indian Institute of Technology, Roorkee and Central Agricultural University (CAU), Imphal.
5. Kerala State Industrial Development Corporation (KSIDC)
6. Kerala Start-up Mission, Department of Agriculture, Government of Kerala
7. Krishi Vigyan Kendra, Tura, Meghalaya.
8. Krishi Vigyan Kendra, Namsai, Arunachal Pradesh
9. Krishi Vigyan Kendras, Adimali, Kumarakom, Thiruvananthapuram, Sadanandapuram (Kerala)
10. Krishi Vigyan Kendra, Jajpur, (Odisha)
11. Krishi Vigyan Kendra, Thenkasi and Karur (Tamil Nadu)
12. Kudumbasree Mission, Govt. of Kerala
13. Madurai Agribusiness Incubation Forum of NABARD, Madurai
14. North Eastern Hill University, Tura Campus, Meghalaya
15. Sagoserve, Salem, Tamil Nadu
16. Department of Agriculture in Koraput, Kandhamal and Ranchi districts
17. WASSAN & RRA Network
18. Aati Pual Mushroom (opc) Pvt. Ltd

Publications

Research Papers

1. Amritha, M.S., Dhanya, O.G., Nair, A.G., Vidya, P., Senthilkumar, K.M. and Mohan, C. 2024. Genetic diversity studies between *Ipomoea* wild species and cultivated sweet potato (*Ipomoea batatas* (L.) Lam.) using SSR markers. *S. Afr. J. Bot.*, **169**: 452-463. (NAAS score: 9.11).
2. Aneetta Baby, Veena, S.S. and Karthikeyan, S. 2022. Study on compatibility of *Trichoderma asperellum* and fungicides for the development of environment friendly and cost-effective disease management strategies. *J. Root Crops,* **48**(1&2): 35-40.
3. Arutselvan, R. and Makeshkumar, T. 2024. Single-tube colorimetric loop-mediated isothermal amplification (LAMP) assay for high-sensitivity detection in cassava from southern India. *Microb. Pathog.,* **192**:106718. (NAAS score: 9.8).
4. Asha, K.I., Asha Devi, A. and Shirly Raichal Anil. 2023. Advancing agriculture with tuber crops: ICAR-CTCRI's role and achievements. *Abrahamia: Int. J. Plant Sci.*, **9**(1): 5-14.
5. Athira, K., Pradeepika, C., Krishnakumar, T., Sajeev, M.S. and Hanume Gowda, K. 2024. Pearl millet incorporated sweet potato choco-filled cookies. *J. Root Crops,* **50**(1): 16-22.
6. Behera, S., Chauhan, V.B.S., Monalisa, K., Meher, R.K., Kar, S.K., Pati, K., Bansode, V.V., Nedunchezhiyan, M., Verma, A.K., Naik, P.K. and Naik, S. K. 2024. *In vitro* plant regeneration, genetic fidelity, biochemical analysis and anticancer activity of anthocyanin-rich purple flesh sweet potato var. Bhu Krishna. *S. Afr. J. Bot.*, **166**: 332-343. (NAAS score: 9.11).
7. Chithra, K., Shashikanth, E., Gowda, K.H., Ramanagouda, S.H., Devaraju, M., Jagadeesh, S.L., Sarvamangala, C., and Shivaji, K.D. 2024. Multivariate analysis for nutritional composition, phytochemical contents, yield and yield contributing characters in underutilized cucurbit sponge gourd (*Luffa cylindrica* (L.) Roem.). *Genet. Resour. Crop Evol.*https://doi.org/10.1007/s10722-024-02159-0.
8. Chithra Vinod, Veena, S.S., Sreekumar, J., Karthikeyan, S. and Jeeva, M.L. 2024. Assessment of variability in temperature tolerance and antagonistic activity among *Trichoderma* isolates for biological control applications. *J. Root Crops,* **50**(1): 45-52.
9. Divya Joseph, Jyothi, A.N. and Sreekumar, J. 2024. Optimization of synthesis of cassava starch phosphates by response surface methodology and characterization of the modified starches, *Starch/Starke*. **76**: 2200241. DOI:10.1002/star.202200241. (NAAS score: 8.69).
10. Divya, K., Makeshkumar, T. and Radhika, N.K. 2024. CRISPR/Cas9: An advanced platform for root and tuber crops improvement. *Front. Genome Ed.,* **5**: 1242510. DOI: 10.3389/fgeed.2023.1242510. (Impact Factor: 4.9).
11. Dixit, J., Nedunchezhiyan, M., Pati, K., Chauhan, V.B.S., Gowda, K.H., Pradeepika, C., Sajeev, M.S. and Byju, G. 2024. Nan-khatai: A cassava flour-based cookie. *J. Root Crops*, **50**(1): 3-7.
12. Gowda, K.H., Chauhan, V.B.S., Nedunchezhiyan, M., Pati, K., Arutselvan, R., and Hegde, V. 2024. Yield evaluation and identification of drought tolerant lines based on stress tolerant indices, ranking method and multivariate analysis in sweet potato (*Ipomoea batatas* Lam). *Sci. Hortic.*, 326: 112781. https://doi.org/10.1016/j.scienta.2023.112781.
13. Gowda, K.H., Reddy, K.M., Maheshwari, U., Prabu, P., Hegde, V. and Arutselvan, R. 2024. Screening, identification of root-knot nematode resistance sources using multivariate analysis and validation

of molecular markers linked to Me genes in chilli (*Capsicum annuum* L.). *Genet. Resour. Crop Evol*. https://doi.org/10.1007/s10722-024-02124-x.

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21. Kishore, A., Patil, R.J., Singh, A. and Pati, K. 2024. Jicama (*Pachyrhizus* spp.) a nonconventional starch: A review on isolation, composition, structure, properties, modifications and its application. *Int. J. Biol. Macromol*., **258**: 129095. (NAAS score: 14.20).

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Research paper presentations in Seminar/Conference/ Symposia/Workshop

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Coffee Table Book

1. ICAR-CTCRI 2024. *The 3 A's of Division of Crop Improvement. Achievements, Aspirations and Action Plan*, Sahoo, M.R., Sheela, M.N., Asha Devi, A., Krishna Radhika, N., Visalakshi Chandra, C., Murugesan, P., Asha, K.I., Mohan, C., Shirly Raichal Anil, Bharathi, L.K., Senthilkumar, K.M., Sujatha, T.P. and Rahana, S.N. (Eds.), ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 28 p.

2. ICAR-CTCRI. 2024. *The 3 A's of Division of Crop Production: Achievements, Aspirations and Action Plan*, Suja, G., Susan John, K., Sunitha, S., Sunilkumar, K., Ramesh. V., Muthuraj. R., Saravanan Raju and Suresh Kumar, J (Eds.), ICAR-Central

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3. ICAR-CTCRI. 2024. *The 3A's of Division of Crop Protection*: *Achievements, Aspirations and Action Plan*, Makeshkumar, T., Jeeva, M.L., Veena, S.S., Sangeetha, B.G., Harish, E.R. and Kumar, H.K (Eds), ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 24 p.
4. ICAR-CTCRI. 2024. *The 3A's of the Section of Crop Utilization-Achievements, Aspirations and Action Plan*, Jyothi, A.N., Sajeev, M.S., Pradeepika, C. and Krishnakumar, T (Eds.), ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 24p.
5. ICAR-CTCRI. 2024. *The 3 A's of Section of Extension and Social Sciences: Achievements, Aspirations and Action Plan*, Sreekumar, J., Sheela Immanuel, Santhosh Mithra, V.S., Sethuraman Sivakumar P., Jaganathan, D. and Prakash, P. (Eds.), ICAR-Central Tuber Crops Research Institute, Kerala, India, 27 p.
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7. ICAR-CTCRI. 2024. ICAR-CTCRI *in Media 2023*, *Coffee Table Book*, Harish, E.R., Sreekumar, J., Shameer, P.S., Deepa, B.S., Sreekumar, V.S. and Rejin, D.T. (Eds.) ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 52 p.

Institute Publications

1. ICAR-AICRP TC. 2024. *Annual Report 2023*, *ICAR-All India Coordinated Research Project on Tuber Crops*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 115 p.
2. ICAR-AICRP TC. 2024. *Technical Report. XIV Annual Group Meeting*, 25-27 June 2024, ICAR-All India Coordinated Research Project on Tuber Crops, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 201 p.
3. ICAR-CTCRI. 2024. *ICAR-CTCRI Newsletter January-March 2024 (Quarterly)*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 41(1): 23 p.
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7. ICAR-CTCRI. 2023. *Quarterly Review Meeting of Scientists: Progress Report (October- December 2023)*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 224 p.
8. ICAR-CTCRI. 2024. *50th Annual IRC Meeting: Action Taken Report & Salient Achievements (2023-2024)*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 229 p.
9. ICAR-CTCRI. 2024. *50th Annual IRC Meeting: Output Summary (2023-2024)*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 179 p.
10. ICAR-CTCRI. 2024. *50th Annual IRC Meeting: Proceedings and Project Milestones (2024-2025)*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 131 p.
11. ICAR-CTCRI. 2024. *Action Taken and Progress Report of Third Meeting of IX Research Advisory Committee*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 110 p.
12. ICAR-CTCRI. 2024. *Annual Report 2023.* ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 176 p.
13. ICAR-CTCRI. 2024. *Background Document*, *QRT VIII*, ICAR-Central Tuber Crops Research Institute & All India Coordinated Project on Tuber Crops, Thiruvananthapuram, Kerala, 290 p.
14. ICAR-CTCRI. 2024. *Proceedings of Third Meeting of IX Research Advisory Committee*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 23 p.
15. ICAR-CTCRI. 2024. *Quarterly Review Meeting of*

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18. ICAR-CTCRI 2024. *Quinquennial Review Team Meeting, 2024-2019 AICRP on Tuber Crops, Bhubaneswar Centre Background Document, AICRPTC*, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 28 p.

Radio Talks

1. Byju, G. and Jaganathan, D. 2024. *Coconut and tuber crops based agrifood systems for resilience and sustainable income*(Tamil),in Oorpurathile, All India Radio, Coimbatore, Nadu, 2 September 2024.
2. Byju, G., Jaganathan, D. and Muthuraj, R. 2024. *Improved varieties and technologies of cassava for higher income*. News,All India Radio, Chennai, Tamil Nadu,7 August 2024.
3. Jaganathan, D. and Muthuraj, R. 2024. *Stakeholders interface on cassava farming in Tamil Nadu*,News, All India Radio, Chennai, Tamil Nadu, 19 September 2024.
4. Jyothi A.N**.** 2024.*Precausions while feeding cattle with tapicoa*(Malayalam), in Njattuvela programme, All India Radio, Thiruvananthapuram, 6 Febraury 2024.
5. Rahana, S.N. 2024. *Keralathilenaapana krishiyude sadyathakal,* in Vayallum Veedum Programme, Farm Information Bureau, 8 August 2024.
6. Sajeev, M.S. 2024. *The working principles and advantageous of Chinese potato grader*, Akasavani Nalla Vartha, 6 April 2024.
7. Santhosh Mithra, V.S. 2024. Interviewed on *Applications of drones in Agriculture*, in Farm and Home Programme, All India Radio, 10 June 2024.
8. Shirly Raichal Anil. 2024. *Jaiva sampushteekaricha madhurakizhanginangal,* Radio Talk, Farm Information Bureau, 8 April 2024.
9. Suja, G. 2024. *Chinese potato and arrowroot: Opportunities and production techniques*, in the Farm & Home Section, All India Radio, Thiruvananthapuram, 1 April 2024.
10. Suja. G. 2024. *Scientific cultivation of elephant foot yam*, Vayalvani, Akashavani, Kochi, 26 December 2024.
11. Susan John, K. 2024. *Discussion on balanced nutrient management for tuber crops*, in All India Radio, Thiruvananthapuram, 7 October 2024.
12. Susan John, K. 2024. *New cassava varieties namely Sree Annam and Sree Manna,* in Njattuvela of Farm Information Beureau, Government of Kerala, 12 December 2024.
13. Veena, S.S. 2024. *Precautions to be taken for selecting planting materials to minimise pest and diseases*, in Njattuvela programme, All India Radio, Thiruvananthapuram, 25 March 2024.

Video/TV Programmes

1. Asha K.I. 2024. *An episode on collection of landraces of tuber crops*, in "Haritha Gatha" an online agri-based video series by Mannar Krishi Bhavan, August 2024.
2. Byju, G., Jaganathan, D. and Muthuraj, R. 2024. *Improved varieties and technologies of cassava for higher income*, DD Podhigai News in Doordarshan, Chennai, Tamil Nadu, 8 August 2024.
3. Byju, G., Jaganathan, D. and Muthuraj, R**.** 2024. *Improved varieties and technologies of cassava for higher income*. DD Podhigai News on 08 August 2024 in Doordarshan, Chennai, Tamil Nadu.
4. Jaganathan, D. and Muthuraj, R. 2024. *Stakeholders interface on cassava farming in Tamil Nadu*, DD Podhigai News Doordarshan, Chennai, Tamil Nadu, 19 September 2024.
5. Jaganathan, D. and Prakash, P. 2024. *CTCRI Scientists offered farmers a number of solutions for reducing the cost of elephant foot yam seed* in Andhra Jyothi, 9 December 2024.
6. Jaganathan, D. and Prakash, P. 2024. *High quality seed is important for higher returns in cassava,* in Andhra Jyothi, 11 December 2024.
7. Jyothi, A.N. 2024. *Precausions to be taken while feeding cattle with tapicoa peels* (*Pasukkalkku maracheenitholi kodukkathinu munpu ivayokke*

sradhikkam), Talk in Krishi Jagaran Video channel (Malayalam), 04 January 2024.

8. Krishna Radhika, N. 2024. *Gene editing in cassava*, Speech telecasted in Krishi Darshan programme aired in connection with NCTTC programme in Doordarshan (Malayalam), 2 January 2024.

9. Mohan, C. and Muthuraj, R. 2024. *Rainbow diet campaign program: Tuber crops workshop and exhibition*, in DD News, Mizoram, 8 March 2024.

10. Santhosh Mithra, V.S. was interviewed on *Smart Farming* by Tharaka Jayasinghe, Visiting lecturer (Development Extension), Faculty of Agriculture, University of Rajarata, Sri Lanka for the youTube channel https://www.youtube.com/channel/UCI3tPvMp654lP0vbuBnghKQ.

11. Suja, G. 2024. Expert in the Live Phone in programme on *Planting time of tuber crops,* in Krishi Darshan, Doordarshan Kendra, Thiruvananthapuram, 12 April 2024.

Participation of Staff Members in Conferences, Meetings, Workshops, Symposia in India

Sl.No.	Name of the programme	Particulars of the programme	Name of the participants
1	International webinar on Functional Phenomics for Improved Climate Resilience in Tropical Agriculture	ICAR-CTCRI, Thiruvananthapuram 04 January 2024	All scientists
2	Farmers first programme of ICAR-CPCRI in the popularisation of sweet potato	Alapuzha 05 January 2024	Dr. K. Susan John
3	18th AGM of All India Network Programme on Organic Farming	UAS, Dharwad 07-10 January 2024	Dr. G. Suja
4	Quarterly Review meeting of scientists	ICAR-CTCRI, Thiruvananthapuram 8 & 9, January 2024	All scientists
5	State credit seminar, NABARD	Hotel Hycinth, Tiruvananthapuram 12 January 2024	Dr. Sheela Immanuel
6	Institute Management Committee meeting	ICAR-CTCRI, Thiruvananthapuram 12 January 2024	Dr. G. Byju Dr. G. Suja Dr. T. Makeshkumar Dr. Manas Ranjan Sahoo Dr. A.N. Jyothi Dr. J. Sreekumar Dr. D. Jaganathan
7	Webinar on Important Pests of Cassava and their Management	ICAR-CTCRI, Thiruvananthapuram 17 January 2024	All scientists
8	SRIJAN: Orientation programme for ICAR-ZTMCs/ITMU	New Delhi 17 to 19 January 2024	Dr. P.S. Sivakumar
9	Meeting with His Excellency Shri. Arif Mohammed Khan, Governor of Kerala	Raj Bhavan, Thiruvananthapuram 20 January 2024	Dr. G. Byju Dr. D. Jaganathan
10	Research Advisory Committee Meeting	ICAR-CTCRI, Thiruvananthapuram 22-23 January 2024	All scientists
11	SAC meeting KVK, Mitraniketan	KVK, Thiruvananthapuram 24 January 2024	Dr. Sheela Immanuel
12	Technical committee meeting of the Department of Soil Conservation and Soil survey, Govt. of Kerala	24 January 2024	Dr. K. Susan John
13	Institutional Bio-safety Committee meeting	ICAR-CTCRI, Thiruvananthapuram 25 January 2024	Dr. G. Byju Dr. T. Makeshkumar Dr. Manas Ranjan Sahoo Dr. M.L. Jeeva Dr. N. Krishna Radhika Dr. K.M. Senthilkumar Dr. T.P. Sujatha
14	Review meeting of the project on Assessment of the effect of polysulphate (dehydrite poly halite) on yield and quality parameters of small cardamom (*Elettaria cardamomom Maton*) under Kerala region	(Online) Indian Cardamom Research Institute 25 January 2024	Dr. K. Susan John
15	Technology certification meeting	ICAR-CTCRI, Thiruvananthapuram 31 January 2024	Dr. K.I. Asha

16	National conference on Plant Health for Food Security: Threats and Promises	ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh 01-03 February 2024	Dr. T. Makeshkumar
17	Scientific advisory committee meeting	KVK, Kollam 9 February 2024	Dr. K. Susan John
18	Review meeting on budget chaired by Dr. S.K. Singh, DDG (HS)	(Online) ICAR-New Delhi 12 February 2024	Dr. G. Suja
19	Brainstorming session on Elephant Foot Yam for Empowering Stakeholders: Challenges and Strategies	Horticultural Research Station, Dr.YSR Horticultural University, West Godavari 13 February 2024	Dr. G. Byju Dr. M. Nedunchezhiyan Dr. D. Jaganathan
20	Meeting with Dr. Abhay Karandikar, Secretary, DST, Govt. of India (SCTIMST)	Thiruvananthapuram 14 February 2024	Dr. G. Suja
21	Plant health intervention at the plant–insect-pathogen interface DST Funded online lecture series	ICAR-IIHR, Bengaluru 26 February 2024	Dr. T. Makeshkumar Dr. S. S. Veena Dr. E.R. Harish Dr. H. Kesava Kumar
22	Technical Support Group meeting	Directorate of Horticulture, Govt. of Odisha 26 February 2024	Dr. K. Laxminarayana
23	National science day	ICAR-CTCRI, Thiruvananthapuram 28 February 2024	All scientists
24	'Mukhamukham' programme	Department of Agriculture and Farmers' Welfare, Alapuzha, Kerala 02 March 2024	Dr. K. Susan John
25	General council meeting of Coconut Development Council	Thiruvananthapuram, 02 March 2024	Dr. K. Susan John
26	Executive committee meeting of Indian Phytopathological Society	(Online) Indian Phytopathological Society, New Delhi 03 March 2024	Dr. S.S. Veena
27	15th Scientific advisory committee meeting of KVK, Kumarakom	Kottayam 04 March 2024	Dr. G. Suja
28	Review meeting of ICAR-CRP on Vaccines and Diagnostics	ICAR-IVRI Regional Centre 04-05 March 2024	Dr. T. Makeshkumar
29	International Women's Day	ICAR-CTCRI, Thiruvananthapuram 08 March 2024	All staff
30	SAC meeting of ICAR-KVK	Tirupathisaram 12 March 2024	Dr. V. Ramesh
31	Kisan Mela	KVK, Puri 13 March 2024	Dr. M. Nedunchezhiyan
32	Crop simulation modelling workshop	TNAU, Coimbatore 13 March 2024	Dr. G. Byju
33	Technical support group meeting	Directorate of Horticulture, Govt. of Odisha 14 March 2024	Dr. K. Laxminarayana
34	Annual review meeting of AICRP on Post-Harvest Engineering & Technology	ICAR-CIPHET, Ludhiana 13-15 March 2024	Dr. M.S. Sajeev Dr. T. Krishnakumar
35	Sangam-2024	ICAR-NRRI, Cuttack 15 March 2024	Dr. M. Nedunchezhiyan
36	FYUGP-syllabus workshop	University of Kerala 19-23 March 2024	Dr. A. Asha Devi
37	World water day	ICAR-Indian Institute of Water Management, Bhubaneswar 22 March 2024	Dr. K. Laxminarayana

38	International seminar on Sustainable Urban Agricultural Practices and Community-resilient Cities	College of Agriculture, Vellayani Thiruvananthapuram 22-23 March 2024	Dr. D. Jaganathan Dr. P. Prakash Dr. V. S. Santhosh Mithra
39	Joint monitoring committee meeting to review the work under the contract research project with M/s SAGOSERVE	SAGOSERVE, Salem 25 March 2024	Dr. A.N. Jyothi Dr. J. Sreekumar Dr. T. Krishnakumar
40	Webinar on Planting Material Storage, Pests and Diseases in Tuber Crops	ICAR-CTCRI (Online),Thiruvananthapuram 27 March 2024	Dr. T. Makeshkumar Dr. M.L. Jeeva Dr. S.S. Veena Dr. E.R. Harish Dr. H. Kesava Kumar Dr. B.G. Sangeetha
41	37th Foundation day celebration	ICAR-CIFA, Bhubaneswar 01 April 2024	Dr. K. Laxminarayana
42	Meeting on comprehensive guidelines for the foreign visits of the scientists/officials of ICAR	(Online) ICAR, New Delhi 03 April 2024	All Scientists
43	Quarterly Review meeting of scientists	ICAR-CTCRI, Thiruvananthapuram 4 & 5 April 2024	All scientists
44	NASF project review meeting	NRC Banana, Tiruchirapalli 4-5 April 2024	Dr. M. S.Sajeev
45	NASF expert committee meeting	(Online) NASF, New Delhi 10 April 2024	Dr. M. S.Sajeev
46	Executive committee meeting of Indian Society of Agronomy	(Online) 10 April 2024	Dr. G. Suja
47	Meeting on Eco regional programme chaired by DG, ICAR	(Online) ICAR, New Delhi 12 April 2024	All Scientists
48	Institute Biosafety Committee Meeting as DBT Nominee	ICAR-NRCB 12 April 2024	Dr. T. Makeshkumar
49	Meeting on Vikshit Bharat chaired by DG, ICAR	(Online) ICAR, New Delhi 16 April 2024	All Scientists
50	Annual meeting of board of studies in Botany (UG)	University college, Thiruvananthapuram 20 April 2024	Dr. A. Asha Devi
51	Lecture on IP management and commercialization: Experience of TiMED Incubator (SCTIMST)	ICAR-CTCRI, Thiruvananthapuram 30 April 2024	All scientists
52	Meeting on Vikshit Bharat with respect to various commodities like fruits, vegetables, tuber crops, spices, flower & medicinal plants and plantation crops chaired by DG, ICAR	ICAR, New Delhi (Online) 01 May 2024	All Scientists
53	Pre-kharif review meeting of AINPOF	(Online) 02 May 2024	Dr. G. Suja Dr. S. Sunitha Dr. S.S. Veena
54	Workshop on IPR, Patent Filing & Drafting	CSIR-NIIST, Thiruvananthapuram 02 May 2024	Dr. J. Suresh Kumar
55	Review meeting on genome editing by DDG (HS)	(Online) 07 May 2024	Dr. G. Byju Dr. T. Makeshkumar Dr. A.N. Jyothi Dr. N. Krishana Radhika Dr. K.M. Senthilkumar Dr. T.P. Sujatha

56	Meeting of Agricultural Education, Agricultural Extension, Agricultural Engineering and Crop Science Divisions of ICAR on the Ecoregional Working Group chaired by the DG, ICAR	(Online) 10 May 2024	All Scientists
57	37th Foundation day celebrations of ICAR-IIWM	ICAR-IIWM, Bhubaneswar 12 May 2024	Dr. K. Laxminarayana
58	Screening committee meeting for release of horticultural crop varieties	Directorate of Horticulture, Bhubaneswar 14 May 2024	Dr. K. Laxminarayana Dr. Kalidas Pati
59	Online meeting of Virtual biodiversity cadre (VBDC)	Kerala State Biodiversity Board, Thiruvananthapuram 16 May 2024	Dr. K.I. Asha Dr. A. Asha Devi
60	Meeting on Conservation of PPVFRA registered varieties of perennial horticultural crop in field gene bank	(Online) PPV & FRA 21 May 2024	Dr. K.I. Asha
61	One day consultative workshop on Bioinvasion-presentation of the policy document	Kerala State Biodiversity Board Thiruvananthapuram 22 May 2024	Dr. K.I. Asha Dr. A. Asha Devi
62	Meeting with FSSAI officials	FDA Bhawan, New Delhi 24 May 2024	Dr. T. Krishnakumar
63	Inauguration of distribution of shares certificates of kudumbamithra women FPC by Shri. V. Muralidharan, Union minister of state for external affairs and parliamentary affairs and delivered a keynote speech	Thiruvananthapuram 25 May 2024	Dr. G. Byju
64	International seminar on New Horizons in Plant Sciences NHPS-2024	University of Kerala, Thiruvananthapuram 28-29 May 2024	Dr. K.I. Asha Dr. A. Asha Devi Dr. K.M. Senthilkumar Dr. S.S. Veena Dr. E.R. Harish Dr. H. Kesava Kumar Dr. B.G. Sangeetha
65	Presentation on commodities of the Fisheries Science division of ICAR chaired by DG, ICAR	(online) ICAR, New Delhi 30 May 2024	All Scientists
66	International workshop on Plant Reproductive Biology	Department of Botany, University of Kerala, Thiruvananthapuram 30 May 2024	Dr. A. Asha Devi Dr. K.M. Senthilkumar Dr. H. Kesava Kumar
67	Interaction meeting of Dr. Girish Chandel, Vice Chancellor, IGKV Raipur, Chhattisgarh with scientists	ICAR-CTCRI, Thiruvananthapuram 31 May 2024	All Scientists
68	H.H. Sree Visakham Thirunal Endowment Lecture: 2024	ICAR-CTCRI, Thiruvananthapuram 03 June 2024	All staff
69	World environment day celebrations	ICAR-CTCRI, Thiruvananthapuram 05 June 2024	All staff
70	International seminar on spices, KAU- 2024 (ISSK2024)	College of Agriculture, Thiruvananthapuram 05-06 June 2024	Dr. E.R. Harish
71	Webinar on Introducing proteomics at the speed and throughput of genomics, Genotypic Technology & Standard Bio tools	(Online) 06 June 2024	Dr. T.P. Sujatha
72	Quinquennial review team meeting of AICRP on Integrated farming systems and All India network programme on organic farming	ICAR-CTCRI, Thiruvananthapuram 07-08 June 2024	Dr. G. Suja Dr. S.S. Veena

73	The 50th Institute Research Council Meeting	ICAR-CTCRI, Thiruvananthapuram 10-13 June 2024	All Scientists
74	National seminar on Climate Smart Agriculture for Sustainable Soil and Plant Health in Plantation Crops	ICAR-CPCRI Regional Station, Kayamkulam 13-14 June 2024	Dr. G. Byju Dr. E.R. Harish Dr. H. Kesava Kumar Dr. L.S. Rajeswari Dr. V. S. Santhosh Mithra
75	Webinar on Bio-control agents (Tamil)	Farm Graduates Forum, Tirunelveli 16 June 2024	Dr. H. Kesava Kumar
76	Screening committee meeting for release of horticultural crop varieties	Directorate of Horticulture, Bhubaneswar 20 June 2024	Dr. Kalidas Pati
77	8th Dr. Y.R. Sarma memorial lecture	ICAR-IISR (Online), Kozhikode 20 June 2024	Dr. S.S. Veena
78	International yoga day celebration	ICAR-CTCRI, Thiruvananthapuram 21 June 2024	All staff
79	24th Annual group meeting of ICAR-AICRP on Tuber Crops	NAU, Navsari, Gujarat 25-27 June 2024	Dr. G. Byju Dr. G. Suja Dr. T. Makeshkumar Dr. Manas Ranjan Sahoo Dr. J. Sreekumar Dr. A. N. Jyothi Dr. K. Laxminarayana Dr. K. Susan John Dr. K.I. Asha Dr. M. Nedunchezhiyan Dr. H. Kesava Kumar Dr. Kalidas Pati
80	OWOT (EED) on Agrivoltaics: Technology gap and needs assessment as special invitee	CSIR-NIIST, Thiruvananthapuram 26 June 2024	Dr. J. Suresh Kumar
81	23rd Foundation day of ICAR-National Institute on foot and mouth disease (NIFMD)	Arugal, Bhubaneswar 05 July 2024	Dr. K. Laxminarayana
82	Quarterly Review meeting of scientists	ICAR-CTCRI, Thiruvananthapuram 22 & 23 July 2024	All scientists
83	1st International workshop-cum-webinar on CRISPR genome editing	(Online) Glostem, New Delhi 22-26 July 2024	Dr. K.M. Senthilkumar Dr. T.P. Sujatha Dr. S.N. Rahana
85	Empanel Committee meeting, Sub Mission on Agrl. mechanisation- Agrl development and farmers welfare department, Govt. of Kerala SMAM	(Online) Govt. of Kerala, SMAM 26 July 2024	Dr. M.S. Sajeev
85	World microbiome day	(Online) ICAR-CPCRI, Kasaragod 27 June 2024	Dr. S.S. Veena
86	State level unit cost meeting of NABARD	NABARD Regional Office, Thiruvananthapuram 28 June 2024	Dr. S. Sunitha
87	Brainstorming workshop on Rainwater Management options for Enhancing Agricultural Productivity	ICAR-IIWM, Bhubaneswar. 28 June 2024	Dr. V.S. Santhosh Mithra
88	Collaborative research meeting on tuber crops between ICAR-CTCRI and WASSAN Hyderabad	ICAR-CTCRI, Thiruvananthapuram 05 July 2024	Dr. T. Makeshkumar
89	61st Foundation day celebrations of ICAR-CTCRI, Thiruvananthapuram	ICAR-CTCRI, Thiruvananthapuram 09 July 2024	All staff
90	AAB-Plant webinar: I Seminar on genome editing	(Online) 09 July 2024	Dr. T.P. Sujatha

91	National fish farmers' Day	ICAR-CIFA, Bhubaneswar 13 July 2024	Dr. K. Laxminarayana
92	6th Prof. N. Panda memorial lecture on Digital innovation: Transforming agri-food system	OUAT, Bhubaneswar 13 July 2024	Dr. K. Laxminarayana
93	ICAR Foundation day and technology day	NASC, New Delhi 15-16 July 2024	Dr. G. Byju Dr. A.N. Jyothi Dr. J. Sreekumar
94	2nd State Level technical committee meeting on Pilot project on Forgotten Foods Collection, Conservation for Meeting Food & Nutrition Climate and Livelihood related Challenges among Farming Communities of Malkangiri and Nuapada District of Odisha	Bhubaneswar, Odisha 16 July 2024	Dr. K. Laxminarayana
95	Review meeting of the KSBB project titled "Collection and Database creation of important named landraces of tuber crops from Southern districts of Kerala".	KSBB, Thiruvananthapuram 18 July 2024	Dr. K.I. Asha Dr. A. Asha Devi
96	31st Meeting of the Central Sub- Committee on Crop Standards, Notification and Release of varieties for Horticultural Crops	(Online) 19 July 2024	Dr. Asha K.I.
97	First quarterly review meeting	ICAR-CTCRI, Thiruvananthapuram 22-23 July 2024	All scientists
98	Webinar on Next Generation Sequencing-Optimizing Sample Preparation Techniques	MP Biomedicals Microsoft teams 25 July 2024	Dr. T.P. Sujatha
99	Brainstorming workshop on Harnessing Crop Wild Relatives for Tuber Crops Improvement	ICAR-CTCRI, Thiruvananthapuram 29 July 2024	All scientists
100	Stakeholders interface meeting on natural farming	ICAR-CTCRI, Thiruvananthapuram 31 July 2024	All scientists
101	First meeting of the Working group of post-harvest engineering and technology in horticulture	ICAR, NASC complex, New Delhi 31 July 2024	Dr. M.S. Sajeev
102	32nd International conference of agricultural economists on the theme transformation towards sustainable agri-food systems	NASC, New Delhi 02-07 August 2024	Dr. P. Prakash
103	Workshop on Gender and Social Analysis of Seed Systems and Promoting Women's Entrepreneurship	Krushi Bhawan, Bhubaneswar 07 August 2024	Dr. K. Laxminarayana
104	CTCRI - CIP Scientists interaction meeting	ICAR-CTCRI, Thiruvananthapuram 08 August 2024	Dr. Shirly Raichal Anil Dr. C. Visalakshi Chandra
105	Intellectual Property Rights (IPR) awareness seminar on Lab to Market: Leveraging IP as part of National IPR awareness Mission (NIPAM 2.0)	ICAR-National Research Centre for Grapes (Online) 09 August 2024	Dr. T.P. Sujatha
106	International Conference on Emerging Technologies in Agriculture and Allied Sciences (ETAAS-2024)	(Online) Society for Agriculture, Allied Sciences & Technology (SAAST) Odisha, 10-11 August 2024	Dr. R. Arutselvan
107	Livelihood workshop on tuber crops	Sholayur, Palakkad, Kerala 12-13 August 2024	Dr. H. Kesava Kumar

108	Workshop on Identification of state policy dialogues/studies under the project on Biodiversity, sustainable land forest management and climate change medication or for various conservation and agro ecological practices under UNFAO-Green -Agriculture Project	Krushi Bhavan, Bhubaneswar 13 August 2024	Dr. K. Laxminarayana
109	20th Institute Management Committee	ICAR-CTCRI, Thiruvananthapuram 14 August 2024	Dr. G. Byju Dr. G. Suja Dr. T. Makeshkumar Dr. P. Murugesan Dr. M.S. Sajeev Dr. Sheela Immanuel Dr. K. Laxminarayana Dr. S. Sunitha Dr. V.S. Santhosh Mithra Dr. D. Jaganathan Shri. S. Bhadrakumar Shri. M. Kuriakose Shri. S. Sreekumar
110	Meeting of the Board of studies, Department of Food Technology	(Online) Sree Budha college of engineering, Pattoor, Alappuzha	Dr. M.S. Sajeev
111	IP awareness week	IP&TM Unit, ICAR 16, 20 and 21 August 2024	All scientists
112	First half yearly meeting of the Town Official Language Implementation Committee (Office-I)	Office of the Post Master General, Thiruvananthapuram 20 August 2024	Dr. A. Asha Devi Shri. S. Bhadrakumar
113	International conference on precision Horticulture - 2024	Horticultural College and Research Institute (TNAU), Periyakulam, Tamil Nadu, India 22-24 August 2024	Dr. P. Murugesan Dr. K. Sunilkumar
114	27th Meeting of ICAR Regional Committee-II	ICAR-National Rice Research Institute, Cuttack 23 August 2024	Dr. K. Laxminarayana
115	63th Foundation day	OUAT, Bhubaneswar 24 August 2024	Dr. K. Laxminarayana
116	Seminar on Advances in Artificial Intelligence and Sensor Based Smart Precision Farming	ICAR-CPCRI, Kasaragod 28 August 2024	Dr. S.S.Veena Dr. H. Kesava Kumar Dr. K. Sunilkumar
117	Odisha Balabhadra Jaibika Chasa Mission	Krushi Bhavan, Bhubaneswar 28 August 2024	Dr. K. Laxminarayana
118	Stakeholder's consultation meet on Transforming Agricultural Research – Enhancing Role of Private Sector	ICAR-CTCRI 03 September 2024	All scientists
119	Meeting chaired by DDG to review the utilization of budget & target & achievements of 100 days programme	(Online) 09 September 2024	Dr. G. Suja
120	International webinar on Synthetic biology: Technological developments and policy discussions and risk assessment and risk management: looking ahead to CP-MOP	(Online) CP-MOP by KIPABiC, Korea 13-27 September 2024	Dr. K.M. Senthilkumar
121	IPR meeting with DDG: IP awareness panel discussion	(Online) ICAR-CTCRI, Thiruvnanthapuram 13 September 2024	All Scientists

122	Inaugural function of the International conference on building small holder climate resilience for achieving sustainable food system	OUAT, Bhubaneswar 17 September 2024	Dr. K. Laxminarayana
123	Preliminary meeting of QRT	New Delhi 19 September 2024	Dr. G. Byju Dr. G. Suja
124	Interactive meeting with Dr. Kuldeep K. Lal, Director, ICAR-CIBA	ICAR-CTCRI, Thiruvananthapuram 25 September 2024	Dr. G. Suja Dr. K. Susan John Dr. S. Sunitha Dr. V. Ramesh Dr. R. Muthuraj Dr. J. Suresh Kumar
125	Executive committee meeting of Indian Society of Agronomy as Councilor, Kerala	(Online) 25 September 2024	Dr. G. Suja
126	Awareness programme on diversity, equity, inclusion and belonging	ICAR-CTCRI, Thiruvananthapuram 27 September 2024	All scientists
127	S&T Interventions for the development of bioresources of the region (Kerala) with special focus on the involvement of women scientists and technologists	National Academy of Sciences, India (NASI) and RGCB, Thiruvananthapuram 01 October 2024	Dr. M.L. Jeeva
128	Agri udaan food and agribusiness accelerator programme, a roadshow/Start up hunt.	ICAR-NAARM, Hyderabad and ICAR-CTCRI 01 October 2024	All scientists
129	First meeting of Quinquennial Review Team (QRT VIII)	ICAR-CTCRI, Thiruvananthapuram 08-09 October 2024	All scientists
130	Stakeholder consultation on Priorities for Potato and Sweet Potato Science and Innovation in India	ITC Maurya Hotel, New Delhi 16-17 October 2024	Dr. G. Byju Dr. P.S. Sivakumar
131	Inaugural function and technological exhibition of CSIR-NIIST, Golden Jubilee 95th Celebration	CSIR-NIIST, Thiruvananthapuram 17 October 2024	Dr. P. Murugesan
132	Understanding IP: encouraging creativity and innovation	(Online) ICAR-Central Arid Zone Research Institute, Jodhpur 18 October 2024	Dr. T.P. Sujatha
133	Quarterly Review meeting of scientists	ICAR-CTCRI, Thiruvananthapuram 18 & 22 October 2024	All scientists
134	Stakeholders meeting for the project on Rainbow Diet Kampaign for Odisha: Development and Scaling of Customised Rainbow diet Food Matrices for Combating Malnutrition Among Children in Keonjhar District	Office of the CDO, Keonjhar, Odisha 22 October 2024	Dr. P.S. Sivakumar
135	Webinar on Karmayogi mission	(Online) Organized by CBU of DARE/ ICAR-NAARM 22 October 2024	All scientists
136	Karmayogi Saptah National Learning Week	(Online) iGOT Karmayogi 19-27 October 2024	All scientists
137	10th International conference on Recent Advances in Agriculture, Engineering, Applied & Life sciences for Environmental sustainability (RAAEALSES-2024)	Uttaranchal University, Dehradun 23-25 October 2024	Dr. C. Visalakshi Chandra
138	Webinar on Recent Threats of Invasive Insect Pests to Indian Agriculture: Challenges & way forward	ICAR-IISR, Kozhikode 25 October 2024	Dr. S.S. Veena Dr. H. Kesava Kumar Dr. T.P. Sujatha
139	Vigilance awareness week 2024 on culture of integrity for nation's prosperity	ICAR-CTCRI, Thiruvananthapuram 28 October - 03 November 2024	All Staff

140	Workshop on R for bioinformatics	(Online) ICAR-IISR, Kozhikode 05 November 2024	Dr. J. Sreekumar
141	32nd Foundation Day of CHES	ICAR-IIHR, Bhubaneswar 06 November 2024	Dr. K. Laxminarayana
142	Second meeting of Quinquennial Review Team (QRT VIII)	MPUAT, Udaipur 07-08 November 2024	Dr. G. Byju Dr. G. Suja Dr. J. Sreekumar
143	31st Swadeshi Science Congress on Towards Net Zero Emission: Approaches and Strategies	ICAR-CIFT, Kochi 07-09 November 2024	Dr. D. Jaganathan Dr. K.M. Senthilkumar
144	19th AGM of AINPOF	08 November 2024	Dr. G. Suja
145	International symposium on Shree anna & forgotten foods 2024	Lok Seva Bhawan, Bhubaneswar 10-11 November 2024	Dr. K. Laxminarayana
146	20th Foundation Day meeting of PPV & FRA, New Delhi	(Online) PPV & FRA, New Delhi 11 November 2024	Dr. C. Visalakshi Chandra
147	International conference on Emerging Viruses: Pandemic & Biosecurity Perspectives (VIROCON 2024)	DRDE, Gwalior 11-13 November 2024	Dr. T. Makeshkumar
148	29th State Seed Sub-Committee for Varietal Release, Kerala	Samaithi, Thiruvananthapuram 12 November 2025	Dr. K.I. Asha Dr. K. Susan John
149	ICAR Regional Committee Meeting No. IV	ICAR - IISR, Lucknow 14 November 2024	Dr. T. Makeshkumar
150	Global Soils Conference 2024. Caring Soils Beyond food Security: Climate Change mitigation & ecosystem services	NASC Complex, Pusa, New Delhi 19-22 November 2024	Dr. K. Laxminarayana
151	Annual workshop of AICRP on Post-harvest engineering & technology (PHET) at AAU, Jorhat	20-22 November 2024	Dr. M.S. Sajeev Dr. T. Krishnakumar
152	Webinar on Epigenetics: A paradigm shift with long-read sequencing from bi-sulphite to long-read sequencing: Change in the gold standard	Genotypic Technology, Bengaluru 20 November 2024	Dr. T.P Sujatha
153	International conference on Biotechnology-the way forward (ICBWF-2024)	Department of Biotechnology, Karyavattom, Thiruvananthapuram 20-22 November 2024	Dr. S.S. Veena
154	Hands on Workshop on Artificial Intelligence (AI)	Digital Media Foundation 24 November 2024	Dr. S.N. Rahana
155	Third Meeting of Quinquennial Review Team (QRT VIII)	AAU, Jorhat 25-26 November 2024	Dr. G. Byju Dr. G. Suja Dr. J. Sreekumar
156	BLAKC meeting to finalise Farm PIan-2024-25	Office of the Asst. Director of Agriculture, Attingal, Thiruvananthapuram 27 November 2024	Dr. S.S. Veena
157	ISWS Biennial conference on Climate Smart Weed Management for Global Food Security	BHU, Varanasi 28-29 November 2024	Dr. J. Suresh Kumar
158	Workshop on Agricultural digitalization: Digital Platforms for Agricultural Advisories	CAB International, New Delhi and Kerala Agricultural University at KAU, Vellanikkara 29-30November 2024	Dr. V.S. Santhosh Mithra
159	Rooting for Tubers: Workshop cum exhibition	Spudnik Pvt. Ltd. and ABI-ICAR-CTCRI, Bengaluru 01 December 2024	Dr. C. Visalakshi Chandra
160	Meeting with Shri. Gabriel D. Wangsu, Minister of Agriculture, Government of Arunachal Pradesh	ICAR-CTCRI, Thiruvananthapuram 02 December 2024	All scientists

161	International winter school on Navigating Agricultural Transformations for Upliftment of rural excellence (NATURE:2024)'	(Hybrid mode) Agri Meet Foundation Bharat, Telangana 02 to 31 December 2024	Dr. S.N. Rahana
162	National brainstorming workshop on Formalization of Seed System of Tropical Tuber crops	ICAR-CTCRI, Thiruvananthapuram 03 December 2024	All scientists
163	Annual Seminar of Fertilizer Association of India	New Delhi 4-6 December 2024	Dr. K. Susan John
164	World Soil Day celebration	ICAR-CTCRI, Thiruvananthapuram 05 December 2024	All staff members
165	International Workshop-cum-Webinar on CRISPR Construct Design for Efficient Genome Editing in Plants	(Online) Glostem, New Delhi 04-06 December 2024	Dr. K.M. Senthilkumar
166	Annual meeting of the Board of studies in botany (UG), University of Kerala	University College, Thiruvananthapuram 06 December 2024	Dr. A. Asha Devi
167	International virtual workshop on 'Molecular Phylogenetics: From Theory to Practice'	Quaxon Bio & IT solutions, India 6-8 December 2024	Dr. T.P. Sujatha
168	NASF advisory committee and second review meeting of the project on Development of Smart Foods, Bio-composites, Green Packaging and Bio-energy from Agro-residues	ICAR-CTCRI, Thiruvananthapuram 09 December 2024	Dr. M.S. Sajeev Dr. A.N. Jyothi Dr. T. Krishnakumar Dr. C. Pradeepika Dr. S.S. Veena
169	Annual Review meeting of the project on Soil health management in coconut based cropping systems involving tuber crops for enhanced yield and income' funded by Coconut Development Board, Kochi	(Online) 10 December 2024	Dr. D. Jaganathan
170	Second half yearly meeting of TOLIC for the year 2024-25 and award distribution ceremony	The Office of the Post Master General, Thiruvananthapuram 12 December 2024	Dr. A. Asha Devi Sh. S. Bhadrakumar
171	Tuber Crops Day	ICAR-CTCRI, Thiruvananthapuram 13 December 2024	All staff members
172	Meeting of selection, screening cum evaluation committee	Kerala Agricultural University, Thrissur 13 December 2024	Dr. S.S. Veena
173	ISMPP Zonal Meet (South Zone) & national seminar on advances in plant pathology: challenges and prospects	ISMPP, ICAR-CTCRI and KAU, Thrissur at ICAR-CTCRI Thiruvananthapuram 14 December 2024	Dr. M.L. Jeeva Dr. S.S. Veena
174	Lecture by Dr. Himanshu Pathak, Secretary DARE & DG ICAR on Best practices for project formulations	ICAR, New Delhi 16 December 2024	All Scientists
175	Fourth Meeting of Quinquennial Review Team (QRT VIII)	ICAR-CTCRI, Regional Station, Bhubaneswar 16-18 December 2024	Dr. G. Byju Dr. G. Suja Dr. J. Sreekumar Dr. H. Kesava Kumar All scientists of Regional Station
176	Industry meet cum workshop on biofortified sweet potato	ICAR-CTCRI, Regional Station, Bhubaneswar 17 December 2024	Dr. G. Byju Dr. G. Suja Dr. J. Sreekumar Dr. P.S. Sivakumar Dr. H. Kesava Kumar All scientists of Regional Station
177	Review meeting of ICAR-CIAT collaborative project	NASC, New Delhi 17 December 2024	Dr. S. Sunitha Dr. Visalakshi Chandra

178	International virtual workshop on NGS & transcriptomics data analysis V-8.0	(Online) Quaxon Bio & IT solutions, India 17-21 December 2024	Dr. T.P. Sujatha
179	13th Scientific advisory committee meeting of KVK-Khordha	ICAR-CIFA 20 December 2024	Dr. K. Laxminarayana
180	Assessment committee meeting for CAS considering promotion of ARS scientists	ICAR-Indian Institute of Spices Research, Kozhikode 20 December 2024	Dr. S.S. Veena
181	3rd meeting of IX Research Advisory Committee meeting	ICAR-CTCRI, Thiruvananthapuram 22-23 January 2024	All Scientists
182	Cherthala Polima Karappuram Kazchakal	St. Michael's College, Cherthala 23 December 2024	Dr. G. Byju Dr. S. Sunitha Dr. S.S. Veena Dr. M.S. Sajeev
183	National workshop on Reviving of Agrobiodiversity in Rainfed areas Through Traditional Varieties for Climate Resilience Agriculture	WASSAN and National Rainfed Area Authority (NRAA), Government of India at NASC, Pusa, New Delhi 24 December 2024	Dr. P. Murugesan
184	Viksit Bharath young leaders dialogue- state championship	Thiruvananthapuram 27 December 2024	Dr. S.S. Veena Dr. H. Kesava Kumar
185	Institute Biosafety Committee meeting	ICAR-CTCRI, Thiruvananthapuram 31 December 2024	Dr. T. Makeshkumar Dr. M.L. Jeeva Dr. J. Sreekumar Dr. N. Krishna Radhika Dr. K.M. Senthil Kumar Dr. T.P. Sujatha
186	Mid-term review meeting of ICAR-Bioveristy International and CIAT alliance collaborative project	NAAS complex, New Delhi	Dr. C. Visalakshi Chandra Dr. S. Sunitha

Visit Abroad

Dr. T. Makeshkumar, Principal Scientist & Head, Division of Crop Protection visited DSMZ - German Collection of Microorganisms and Cell Cultures GmbH (German: Leibniz-Institut DSMZ-Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH), Braunschweig, Germany during 03-18 May 2024 to attend European Virus Archive- global EVAg workshop on Advanced virus diagnostics: from serology to high throughput sequencing during 13-17 May 2024.

Distinguished Visitors

Headquarters, Thiruvananthapuram, Kerala

1. Shri. Arif Mohammed Khan, Hon'ble Governor of Kerala
2. Shri. P. Prasad, Hon'ble Minister of Agriculture and Farmers Welfare, Govt. of Kerala
3. Shri. Gabriel D. Wangsu, Hon'ble Minister of Agriculture, Horticulture, Animal Husbandry & Veterinary, Fisheries, Legal Metrology & Consumer affairs, and Food & Civil Supply, Government of Arunachal Pradesh
4. Prince Adithya Varma, Travancore Royal Family
5. Smt. R. Nishanthini, IPS, Deputy Inspector General of Police, Thiruvananthapuram Range
6. Dr. N.P. Singh, Member, CACP, DA & FW, Government of India
7. Padma Shri Prof. Arvind Kumar, Former VC, RLBCAU, Jhansi
8. Dr. S.S. Chahal, Emeritus President and former Vice Chancellor of MPAUT, Udaipur
9. Dr. P. Rajendran, Chairman, Kerala Farmers Welfare Fund Board & Former Vice Chancellor, Kerala Agricultural University
10. Dr. S.D. Shikhamany, Former Vice Chancellor, Dr. YSR Horticultural University, Andhra Pradesh
11. Dr. A.K. Singh, Former VC, BAU, Sabour
12. Dr. Trilochan Mohapatra, Chairman, PPV&FR Authority, New Delhi and Former Secretary, DARE and DG, ICAR, New Delhi
13. Dr. N.K. Krishna Kumar, Former DDG (Horticultural Science), ICAR
14. Dr. S.K. Sharma, ADG (HRM), ICAR, New Delhi
15. Dr. Praveen Malik, Chief Executive Officer, Agrinnovate India Limited (AgIn), DARE, Ministry of Agriculture & Farmers Welfare, Govt. of India
16. Dr. T.K. Behera, Director, ICAR-IIHR, Bengaluru
17. Dr. R. Dinesh, Director, ICAR-IISR, Kozhikode
18. Dr. V.S. Korikanthimath, Former Director, ICAR-CCARI, Goa
19. Dr. Kuldeep K. Lal, Director, ICAR-CIBA Chennai
20. Dr. Manish Das, Director, ICAR- DMAPR, Anand, Gujarat
21. Shri. Murukan Kattakada, Director, Malayalam Mission, Department of Culture, Govt. of Kerala

22. Dr. K.U.K. Nampoothiri, Former Director, ICAR-CPCRI
23. Dr. S.K. Pandey, Former Director, ICAR-CPRI, Shimla
24. Dr. E. Sreekumar, Director, Institute of Advanced Virology, Thiruvananthapuram
25. Dr. Ch. Sreenivasa Rao, Director, ICAR-NAARM, Hyderabad
26. Dr. Sunil Kumar, Director, ICAR-IIFSR, Modipuram
27. Dr. S.N. Sushil, Director, ICAR-NBAIR, Bengaluru
28. Dr. P.M. Govinda krishnan, Former Project Coordinator, AICRP (Potato), ICAR-CPCRI, Shimla
29. Dr. N. Ravisankar, PC(IFS) & NPI, AINP-OF, ICAR-IIFSR, Modipuram
30. Dr. J. Rajangam, Dean, HC & RI, Periyakulam, TNAU
31. Dr. Roy Stephen, Dean, College of Agriculture, Vellayani, Thiruvananthapuram
32. Dr. Sanjaya Kumar Dash, Dean, College of Agricultural Engineering & Technology, OUAT, Bhubaneswar
33. Sri. Baiju N. Kurup, CGM of NABARD, Kerala Regional Office
34. Shri. Praveen K.S., Chief Executive Officer, Kerala Life Sciences Industries Park, Thiruvananthapuram
35. Dr. P. Rajasekharan, Chairman, State Agricultural Prices Board, Kerala
36. Dr. S. Senthil Vinayagam, CEO, a-Idea, ICAR-NAARM, Hyderabad
37. Dr. Jacob John, Director of Extension, Kerala Agricultural University, Thiruvananthapuram
38. Dr. H. Philip, Former Director of Extension, TNAU, Coimbatore
39. Dr. Jagan Mohan, DSW & Head, Food Science & Nutrition, NIFTEM, Thanjavur
40. Dr. Raghavendra Singh, Head (CSRM), ICAR-IIFSR, Modipuram
41. Dr. Saralakumari, Head, Soil Science, GKVK, Karnataka
42. Dr. Rakesh Pandey, Prof. Emeritus, AcSIR & CSIR, CIMAP, Lucknow
43. Dr. Sudhakar Rao D. V., Principal Scientist, ICAR- IIHR, Bengaluru
44. Dr. Manoj Kumar, Principal Scientist (PIM Section), ICAR HQ
45. Dr. K. Umamaheswaran, Former Professor, Kerala Agricultural University, Thiruvananthapuram
46. Dr. M.M. Sahamli, Prof & Head, Dept. of Hindi, Govt. Women's College, Thiruvananthapuram

Regional Station, Bhubaneswar, Odisha

1. Dr. S.D. Shikhamany, Former Vice Chancellor, Dr. YSR Horticultural University, Andhra Pradesh
2. Dr. N.K. Krishna Kumar, Former DDG (Horticultural Science), ICAR
3. Dr. Sudhakar Pandey, Assistant Director General (FVSMP), ICAR, New Delhi
4. Dr. Rakesh Pandey, Prof. Emeritus, AcSIR& CSIR, CIMAP, Lucknow
5. Dr. S.K. Pandey, Former Director, ICAR-CPRI, Shimla
6. Dr. V.S. Korikanthimath, Former Director, ICAR-CCARI, Goa
7. Dr. Sudhanshu K.K. Mishra, Chief General Manager, NABARD, Odisha
8. Dr. Jagan Mohan, DSW & Head, Food Science & Nutrition, NIFTEM, Thanjavur, T.N
9. Dr. K.K. Rout, Former Dean, College of Agriculture, OUAT and Dean, School of Agriculture, DRIEMS, University, Cuttack, Odisha
10. Dr. P.M. Govindakrishnan, Ex-Project Coordinator, AICRP (Potato), ICAR-CPCRI, Shimla

Personnel

Scientific Staff

Head Quarters, Thiruvananthapuram	
Dr. G. Byju	**Director**
Division of Crop Improvement	
Dr. Manas Ranjan Sahoo	**Principal Scientist (Horticulture) & Head**
Dr. M.N. Sheela (Rtd. 31.05.2024)	Principal Scientist (Genetics and Plant Breeding)
Dr. P. Murugesan	Principal Scientist (Vegetable Science)
Dr. K.I. Asha	Principal Scientist (Economic Botany and PGR)
Dr. C. Mohan	Principal Scientist (Genetics and Plant Breeding)
Dr. A. Asha Devi	Principal Scientist (Genetics and Plant Breeding)
Dr. Shirly Raichal Anil	Principal Scientist (Genetics and Plant Breeding)
Dr. L.K. Bharathi	Principal Scientist (Vegetable Science)
Dr. N. Krishna Radhika	Senior Scientist (Agricultural Biotechnology)
Dr. C. Visalakshi Chandra	Senior Scientist (Genetics and Plant Breeding)
Dr. K.M. Senthilkumar	Senior Scientist (Agricultural Biotechnology)
Dr. T.P. Sujatha	Scientist (Agricultural Biotechnology)
Dr. S.N. Rahana	Scientist (Genetics and Plant Breeding)
Division of Crop Production	
Dr. G. Suja	**Principal Scientist (Agronomy) & Head**
Dr. K. Susan John	Principal Scientist (Soil Science)
Dr. S. Sunitha	Principal Scientist (Agronomy)
Dr. K. Sunil Kumar	Principal Scientist (Vegetable Science)
Dr. V. Ramesh	Principal Scientist (Soil Science)
Dr. R. Muthuraj	Principal Scientist (Seed Science and Technology)
Dr. Saravanan Raju	Principal Scientist (Plant Physiology)
Dr. J. Suresh Kumar	Scientist (Vegetable Science)
Division of Crop Protection	
Dr. T. Makeshkumar	**Principal Scientist (Plant Pathology) & Head**
Dr. M.L. Jeeva	Principal Scientist (Plant Pathology)
Dr. S.S. Veena	Principal Scientist (Plant Pathology)
Dr. E.R. Harish	Senior Scientist (Agricultural Entomology)
Dr. H. Kesava Kumar	Senior Scientist (Nematology)
Dr. B.G. Sangeetha	Senior Scientist (Agricultural Biotechnology)
Section of Crop Utilization	
Dr. A.N. Jyothi	**Principal Scientist (Agricultural Chemicals) & Scientist in Charge**
Dr. M.S. Sajeev	Principal Scientist (Agricultural Structures & Process Engineering)
Dr. Pradeepika Chintha	Scientist (Vegetable Science)
Dr. T. Krishnakumar	Scientist (Agricultural Structures & Process Engineering)
Section of Extension and Social Sciences	

Dr. J. Sreekumar	**Principal Scientist (Agricultural Statistics) & Scientist In Charge**
Dr. Sheela Immanuel	Principal Scientist (Agricultural Extension)
Dr. V.S. Santhosh Mithra	Principal Scientist (Computer Application in Agriculture)
Dr. P. Sethuraman Sivakumar	Principal Scientist (Agricultural Extension)
Dr. D. Jaganathan	Senior Scientist (Agricultural Extension)
Dr. P. Prakash	Scientist (Agricultural Economics)

Technical Staff

Smt. N. Sujatha Kumari	Chief Technical Officer
Dr. L.S. Rajeswari	Chief Technical Officer
Shri. A. Madhu	Chief Technical Officer
Shri. M. Kuriakose	Chief Technical Officer
Shri. V.R. Sasankan	Assistant Chief Technical Officer
Shri. B. Renjith Kishor	Assistant Chief Technical Officer
Shri. V.S. Sreekumar	Assistant Chief Technical Officer
Shri. V. Ganesh (Rtd. 31.01.2024)	Technical Officer
Shri. A.S. Manikuttan Nair	Technical Officer
Shri. G. Suresh	Technical Officer
Dr. S. Shanavas (Deputation w.e.f. 18.03.2024)	Technical Officer
Dr. B.S. Prakash Krishnan	Technical Officer
Shri. G. Shajikumar	Technical Officer
Smt. B.S. Deepa	Technical Officer
Shri. L. Luke Armstrong	Senior Technical Assistant
Dr. S. Karthikeyan	Senior Technical Assistant
Shri. K. Sunil	Senior Technical Assistant
Dr. P.S. Shameer	Technical Assistant
Shri. B. Satheesan	Technical Assistant
Shri. D.T. Rejin	Senior Technician
Shri. T.M. Shinil	Senior Technician
Shri. T. Manikantan Nair	Senior Technician
Shri. Hareesh B.T. (w.e.f. 24.04.2024)	Senior Technician
Shri. K. Chandran	Technician
Smt. S.S. Sneha	Technician
Smt. R. Nijamol	Technician
Shri. SreenathVijay	Technician
Smt. Rini Alocious	Technician
Ms. Pooja Krishnan (w.e.f. 24.04.2024)	Technician
Ms. Sreelakshmi L (w.e.f. 14.06.2024)	Technician

Administrative Staff

Shri. S. Bhadra Kumar	Senior Administrative Officer
Smt. Jessymol Antony	Senior Finance and Accounts Officer (i/c)
Shri. T. Vijayakumara Kurup (Rtd. 31.05.2024)	Assistant Administrative Officer
Shri. S. Sreekumar (w.e.f. 28.06.2024) (Rtd. 31.10.2024)	Assistant Administrative Officer
Shri. J. Unni (w.e.f. 25.11.2024)	Assistant Administrative Officer
Shri. S. Sasikumar	Private Secretary

Smt. L. Saritha	Personal Assistant
Smt. S. Sunitha	Personal Assistant
Shri. O.C. Ayyappan (Rtd. 30.04.2024)	Assistant
Shri. R.S. Adarsh	Assistant
Shri. Ashish V. (w.e.f. 06.08.2024)	Assistant
Shri. S. Sreeni Nair (w.e.f. 04.10.2024)	Assistant
Shri. C. Chandru	U. D. C.
Shri. N. Jayachandran	U. D. C.
Smt. C.G. Chandra Bindu	U. D. C.
Smt. Rohini K. Nair	L. D. C.
Shri. D. Arun Raj	L. D. C.
Shri. Stiphin George	L. D. C.
Ms. S. Anjitha	L. D. C.

Skilled Support Staff

Shri. K. Saratchandra Kumar (Rtd. 31.05.2024)	Skilled Support Staff
Shri. S. Radhakrishnan Nair	Skilled Support Staff (Canteen Staff)
Shri. G. Madhu	Skilled Support Staff
Shri. K. Sivadas	Skilled Support Staff
Shri. L. Samynathan	Skilled Support Staff
Shri. S. Sreekumaran	Skilled Support Staff
Ms. C.P. Gayathri	Skilled Support Staff
Shri. S. Abhishek	Skilled Support Staff
Smt. S.L. Jyothi	Skilled Support Staff
Smt. P. Vidhya	Skilled Support Staff
Shri. S. Sudhish	Skilled Support Staff
Shri. P. Aswin Raj	Skilled Support Staff
Smt. V.S. Remya	Skilled Support Staff
Smt. R. Anuja	Skilled Support Staff
Shri. N. Shiju	Skilled Support Staff

Regional Station, Bhubaneswar

Scientific Staff

Dr. K. Laxminarayana (w.e.f. 11.04.2022)	**Principal Scientist (Soil Science) & Scientist In charge**
Dr. M. Nedunchezhiyan	Principal Scientist (Agronomy)
Dr. KalidasPati	Senior Scientist (Vegetable Science)
Dr. Vijay Bahadur Singh Chauhan	Scientist (Vegetable Science)
Shri. K. Hanume Gowda	Scientist (Vegetable Science)
Dr. R. Arutselvan	Scientist (Plant Pathology)

Technical Staff

Shri. BibhutiBhusan Das	Senior Technical Officer
Shri. Pramod Kumar Mati	Technical Officer
Shri. Sushanta Kumar Jata	Technical Officer
Shri. Keshab Paikaray	Senior Technician

Administrative Staff

Shri. A. Lakshmana Rao	Assistant Administrative Officer

Skilled Support Staff

Shri. Babuli Sethi (Rtd. 29.02.2024)	Skilled Support Staff
Shri. Prakash Kumar Nayak	Skilled Support Staff

Other Information

International Webinar on Functional Phenomics for Improved Climate Resilience in Tropical Agriculture

An International webinar on 'Functional Phenomics for Improved Climate Resilience in Tropical Agriculture' was held on 04 January 2024. Dr. G. Byju, Director, ICAR-CTCRI, inaugurated the webinar and in his inaugural speech he emphasized the importance of high throughput phenomics and AI platform for mapping important traits and genetic improvement of cassava. Dr. Michael Gomez Selvaraj, Leader, Phenomics Platform, Bioversity International CIAT, Cali, Colombia presented the ongoing phenomics-based research program at CIAT and potential area of collaboration with ICAR-CTCRI. it was decided to initiate a joint collaborative programme between ICAR-CTCRI and Bioversity International CIAT on post-harvest physiological deterioration (PPD) and drought tolerance in cassava. More than 350 participants from India and other countries participated in the webinar.

Institute Management Committee meeting

The XIX Institute Management Committee Meeting of ICAR-CTCRI, Thiruvananthapuram was held on 12 January 2024 under the Chairmanship of Dr. G. Byju, Director, ICAR-CTCRI.

The following officials attended the meeting:

1. Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram
2. Dr. Manoj Kumar, Principal Scientist (PIM Section), ICAR HQ
3. Dr. D.V. Sudhakar Rao, Principal Scientist, ICAR-IIHR, Bengaluru
4. Dr. Manish Das, Director, ICAR-DMAPR, Anand, Gujarat
5. Shri. S.Bhadra Kumar, Senior Administrative Officer, ICAR-CTCRI, Thiruvananthapuram
6. Dr. G. Suja, Head, Division of Crop Production, ICAR-CTCRI
7. Dr. T. Makeshkumar, Head, Division of Crop Protection & SIC (PME), ICAR-CTCRI
8. Dr. Manas R. Sahoo, Head, Division of Crop Improvement, ICAR-CTCRI
9. Dr. A.N. Jyothi, SIC, Section of Crop Utilization, ICAR-CTCRI
10. Dr. J. Sreekumar, SIC, Section of Extension. & Social Sciences, ICAR-CTCRI
11. Dr. K. Laxminarayana, SIC, ICAR- CTCRI Regional Station, Bhubaneswar, Odisha
12. Dr. M.S. Sajeev, SIC, E&M Cell, ICAR-CTCRI
13. Dr. V.S. Santhosh Mithra, SIC, Library, ICAR-CTCRI
14. Dr. R. Saravanan Raju, SIC, Farm, ICAR-CTCRI
15. Dr. D. Jaganathan, Member, PME, ICAR-CTCRI
16. Smt. Jessymol Antony, Senior Finance & Accounts Officer i/c, ICAR-CTCRI
17. Shri. T. Vijayakumara Kurup, Assistant Administrative Officer, ICAR-CTCRI
18. Shri.A. Lakshmana Rao, Assistant Administrative Officer, ICAR-CTCRI

Shri. S. Bhadra Kumar, Member Secretary, IMC & SAO, ICAR-CTCRI, Thiruvananthapuram, welcomed the members of IMC. Dr. G. Byju made the introductory remarks which was followed by a presentation by Dr. D. Jaganathan, Member, PME on the mandate, research activities and achievements of the Institute.

The action taken report was approved by the house. The establishment and personnel section report was presented by SAO and the progressive expenditure of 2023-24 upto 10 January 2024 was presented by SFAO (i/c).

Webinar on Maracheeniyile pradhana keedangalum niyanthrana maargangalum (Malayalam)

The webinar on 'Major pests in cassava and their control measures' in Malayalam was organised on 17 January 2024 at ICAR-CTCRI. Dr. G. Byju, Director presided over the webinar & Head, Division of Crop Protection briefed about the topic. Dr. E.R. Harish, Senior Scientist (Agrl. Entomology) gave an overview about the important pests of cassava and their management strategies. Fifty participants comprising farmers and KVK officials participated.

Interface Meeting with Governor of Kerala

An interface meeting with His Excellency Shri. Arif Mohammed Khan, Governor of Kerala was held on 20 January 2024 to discuss about the R&D activities of ICAR-CTCRI at Raj Bhavan, Thiruvananthapuram, Kerala. Dr. G. Byju, Director, ICAR-CTCRI briefed about the achievements and activities and future plan of the Institute to strengthen tuber crops sector in the country.

Third meeting of IX Research Advisory Committee

The Third meeting of IX Research Advisory Committee was held at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala during 22-23 January 2024 under the chairmanship of Dr. N.K. Krishna Kumar, Ex-DDG (Hort. Sci.), ICAR.

The following members attended the meeting:

1. Dr. N.K. Krishna Kumar, Ex-DDG (Horticultural Science), ICAR
2. Dr. S.K. Pandey, Ex-Director, ICAR-CPCRI, Shimla
3. Dr. P.M. Govindakrishnan, Ex-Project Coordinator, AICRP (Potato), ICAR-CPRI, Shimla
4. Dr. K. Umamaheswaran, Ex-Professor, Kerala Agricultural University, Thiruvananthapuram
5. Dr. Sanjaya Kumar Dash, Dean, College of Agricultural Engineering & Technology, OUAT, Bhubaneswar
6. Dr. H. Philip, Ex-Director (Extension), TNAU, Coimbatore
7. Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram
8. Dr. P. Murugesan, Principal Scientist & Member Secretary, ICAR-CTCRI, Thiruvananthapuram

All the HoDs, Sections-in-Charges and Scientists of HQ participated in the meeting. Dr. K. Laxminarayana, Scientist in-Charge and Dr. M. Nedunchezhiyan, Principal Scientist, Regional Station of ICAR-CTCRI, Bhubaneswar also attended. In the inaugural session, 3 tuber crops-based products and 4 technical publications of ICAR-CTCRI were released by Dr. N.K. Krishna Kumar, Chairman. An exhibition was also arranged showcasing tuber crops varieties, technologies and products. The committee appreciated the Institute's achievements on quality planting material production, commercialization of technologies, academic activities, initiation of genome editing programme and other cutting edge research programmes. Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram presented the overall achievements of the Institute. The mega project leaders presented the salient achievements/progress of research. The meeting was co-ordinated by Dr. P. Murugesan, Principal Scientist & Member Secretary. Dr. N.K. Krishna Kumar, Chairman and Dr. P.M. Govinda Krishnan, Member visited the Regional Station, ICAR-CTCRI, Bhubaneswar on 02 February 2024 and reviewed the ongoing research programmes.

Institute Biosafety Committee Meeting (IBSC)

The first meeting of the Institute Biosafety Committee (IBSC) was held at ICAR-CTCRI, Thiruvananthapuram on 25 January 2024 and the second meeting was held on 31 December 2024 to review the rDNA-based research projects. Dr. G. Byju, Director, ICAR-CTCRI and Chairman, IBSC; Dr. S. Manjula, Scientist F, RGCB, Thiruvananthapuram and DBT Nominee; Dr. T. Bindu, Medical Officer, Government of Kerala, Thiruvananthapuram and Biosafety Officer; Dr. E.V. Soniya, Scientist G, RGCB, Thiruvananthapuram, Dr. T. Makeshkumar, Head, Division of Crop Protection and Scientist-in-Charge, PME Cell; Dr. Manas Ranjan Sahoo, Head, Division of Crop Improvement; Dr. J. Sreekumar, Principal Scientist and SIC, ESS; Dr. M.L. Jeeva, Principal Scientist and Dr. K.M. Senthilkumar,

Senior Scientist attended the meeting and the external members reviewed the progress of rDNA-based research projects of ICAR-CTCRI. The committee members appreciated the scientists for strict adherence of the biosafety guidelines at the research laboratories of the Institute

Rooting for Tubers Festival

The Institute has collaborated with Bengaluru-based Spudnik Farms along with Rohini Nilekani Philanthropies and Rainmatter Foundation, in the 'Rooting for Tubers Festival' organized at the Bangalore International Centre on 4 February, 2024. Dr. G. Byju in his inaugural address highlighted the importance of tuber crops in climate change situations. Ms. Sumeet Kaur, Founder of Spudnik Farms also spoke in this occasion. A panel discussion was also held. The panellists included Dr. G. Byju, Director, ICAR-CTCRI; Chef K.Thirugnanasambantham; Principal at WGSHA, Manipal; Ms. Tanya Kak; Rohini Nilekani Philanthropies; Ms. Marisha Thakur, Rainmatter Foundation; Dr. Jayanand Derekar, Sanjivani Seva Trust; Dr. K. Ramachandra Naik, Director (Research), University of Horticultural Sciences, Bagalkot; Dr. P. Sethuraman Sivakumar, Principal Scientist, ICAR-CTCRI and Dr. B. Shanmugasundaram, Professor, Kerala Agricultural University. Over 300 participants from different sectors participated.

Brainstorming on Elephant Foot Yam for Empowering Stakeholders: Challenges and Strategies

A one-day brainstorming meeting on elephant foot yam cultivation was organized on 13 February 2024 at HRS, Dr. YSR Horticultural University, Andhra Pradesh, by AICRP on Tuber Crops and ICAR-CTCRI. The event was inaugurated by Dr. T. Janakiram, Vice Chancellor, Dr. YSRHU. The event aimed to address challenges, develop high-yielding, pest-resistant varieties, and enhance market intelligence. Dr. Naram Naidu, Director of Research, and Dr. E. Karunasree, Director of Extension, Dr. YSRHU, were Guests of Honour. Dr. G. Byju, Director, ICAR-CTCRI, presided over the meeting, emphasizing the crop's economic and nutritional importance. Dr. Ramanandam, Zonal Research Head, HRS, Kovvur, welcomed the participants, and Dr. P. Mamatha, Principal Scientist, HRS, Kovvur, delivered the vote of thanks. Dr. M. Nedunchezhiyan and Dr. D. Jaganathan served as resource persons. The brainstorming meeting provided an invaluable platform for stakeholders to exchange ideas, discuss challenges, and explore innovative solutions for enhancing elephant foot yam cultivation in India.

National Science Day Celebrations

The National Science Day was celebrated on 28 February 2024 with an open house event for students and farmers. Dr. K.M. Sreekumar, Professor & HoD, College of Agriculture, Padannakkad delivered a guest lecture on 'Pesticides-the most misunderstood molecules'. Around 330 participants including scientists, students, farmers and staff of ICAR-CTCRI participated.

International Women's Day

The International Women's Day was celebrated at ICAR-Central Tuber Crops Research Institute with various programmes on 07 March 2024. Dr. G. Byju, Director, ICAR-CTCRI presided the meeting. Smt. R. Nishanthini, IPS, Deputy Inspector General of Police, Thiruvananthapuram Range was the chief guest and delivered a speech on the focal theme 'Invest in Women: Accelerate Progress'. She stressed the need for investing in mental well-being, self-love and pride in women empowerment. Cultural programme and various competitions for women added colour to the celebration.

Webinar on Nadilvasthukkalude sambharanavum kizhanguvilakalile keedangalum rogangalum (Malayalam)

A webinar on planting material storage and pests and diseases in tuber crops in Malayalam was organised at ICAR-CTCRI on 27 March 2024. Dr. G. Byju, Director presided over the webinar & Head, Division of Crop Protection briefed about the topic. Dr. S.S. Veena, Principal Scientist (Plant Pathology) gave an overview about the planting material storage and pests and diseases in tuber crops. A total of 60 participants comprising of farmers and KVK officials participated in the program.

H.H. Sree Visakham Thirunal Endowment Lecture

The Indian Society for Root Crops (ISRC) along with ICAR-CTCRI, Sreekariyam, Thiruvananthapuram, organized the 'H.H. SreeVisakhamThirunal Endowment Lecture' on 03 June 2024. Dr. G. Byju, Director, ICAR-CTCRI presided the function. Prince Adithya

Varma, the guest of honour, discussed the historical introduction of tapioca from Brazil in the 18th century and its successful establishment in Kerala. The chief guest, Dr. K.V. Shaji, Chairman, NABARD, Mumbai delivered the endowment lecture on 'Harnessing Digital Technologies for Sustainable Agriculture and Rural Development.' He elaborated on the concerted efforts for greater income realization in rural economy by increasing core-productivity, robust value chain, climate resilience and rural entrepreneurship drive. The lecture was attended by the staff of ICAR-CTCRI, invitees from selected institutions and schools.

World Environment Day 2024

The World Environment Day 2024 was celebrated at ICAR-CTCRI on 05 June by planting saplings of fruit plants in the campus by the Director and staff. Dr. Praveen Malik, CEO, Agrinnovate India limited, Department of Agricultural Research and Education (DARE) was the chief guest and he delivered a talk on 'Land restoration, Desertification and Drought resilience'.

50th Annual Institute Research Council Meeting

The Golden Jubilee Annual Institute Research Council meeting was held during 10-13 June 2024.The IRC meeting was inaugurated on 10 June 2024 by Dr. G. Byju, Director and Chairman, IRC. Eight Institute publications including 'Output Summary 2023-2024' were released by the Director. The Chairman made a presentation on 'Progress report of ICAR-CTCRI for the year 2023-2024'. During the inaugural speech, Director congratulated all the scientists and other staff members for their dedication and commitment towards research through which ICAR-CTCRI addresses the challenges faced by farmers and other stakeholders. The projects are being undertaken by 42 scientists of Crop Improvement, Crop Production, Crop Protection, Crop Utilization and Extension & Social Sciences Divisions/Sections. All the 44 projects under 8 Institute mega projects and 3 developmental projects viz., SCSP, TSP and NEH were presented by the project leaders. Significant achievements and outputs of all the projects were thoroughly discussed and finalized the technical programme for the year 2024-2025. One new project proposal under ongoing Institute Mega project 2 was presented and approved.Twenty five externally aided projects of the Institute were also discussed.

International Yoga Day

The 10th International Yoga Day was celebrated at ICAR-CTCRI on 21 June 2024 on the theme 'Yoga for Self and Society'. Dr. G. Byju, Director inaugurated the programme. Mr. Baskaran Nair and Mr. Arunkumar, yoga instructors from Art of Living Thiruvananthapuram Centre conducted the yoga session. The participants were trained in yoga stretching, yoga positions, pranayama and meditation.

61st Foundation Day of ICAR-CTCRI

The 61st Foundation Day of the Institute was celebrated on 09 July 2024 at ICAR-CTCRI campus in Thiruvananthapuram. Shri. Arif Mohammed Khan, Hon'ble Governor of Kerala, inaugurated the programme. In his inaugural address, he congratulated ICAR- CTCRI for 'the silent revolution' in tune with nation's goal of achieving food and nutritional security. He was eloquent in stating that through the institutes current research on bio-fortification, this poor man's crop can become part of everyman's healthy diet. He released new technologies and publications, honoured progressive tuber crop farmers, meritorious staff and students of ICAR-CTCRI. Dr. G. Byju, Director, ICAR-CTCRI, in his presidential address detailed about the research activities of the Institute. He also stated that the multipurpose, climate resilient, future crops are popularised across the nation are included in'rainbow diet campaign' for the nutritional security of the country. The Institute is a designated national repository for tuber crops in the country, and focusing specially in product diversification, livelihood security, women friendly technologies and biofortification. Prof. Chandrabhas Narayana, Director, Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram offered a special address and highlighted the innovations made in tuber crops sector by the Institute. He emphasised the need for making the tuber crop based foods in children's diet plan. Dr. G. Suja, Head, Division of Crop Production, ICAR-CTCRI delivered the welcome address. During the occasion, an exhibition stall showcasing the technologies of ICAR-CTCRI was also arranged.

Brainstorming Workshop on Harnessing Crop Wild Relatives for Tuber Crops Improvement

The Brainstorming Workshop on "Harnessing Crop Wild Relatives for Tuber Crops Improvement" was held on 29 July 2024. The Chief Guest for the program

was Dr. Trilochan Mohapatra, Chairperson, PPV&FRA and Dr. T.K. Behera, Director, ICAR-IIHR, the Guest of Honour. Dr. G. Byju, Director, ICAR-CTCRI, presided. Felicitation remarks were delivered by Dr. K.U.K. Nampoothiri, former Director, ICAR-CPCRI, and Dr. J. Rajangam, Dean, HC&RI, Periyakulam (TNAU), Tamil Nadu. In the inaugural session, Dr. Trilochan Mohapatra highlighted the urgent need for both *ex-situ* and *in-situ* conservation and the use of modern genomic tools. The technical session included expert talks from Dr. K. Joseph John, Dr. K. Pradheep (ICAR-NBPGR), Dr. V. Arunachalam (ICAR-CCARI), and Dr. Manas Ranjan Sahoo (ICAR-CTCRI), covering exploration, conservation, and breeding strategies for Crop Wild Relatives (CWRs) in tuber crops. Two panel discussions I. Plant genetic resources management and II. Conventional and non-conventional breeding strategies for improvement of crop wild relatives were conducted. Farmers also shared their experiences and learnt about tuber crop conservation, and they were honoured. The plenary session summarized on emphasizing long-term conservation, breeding advancements, and donor wild species for various breeding objectives. A exhibition was also organized, showcasing the genetic diversity of tuber crops and their wild relatives, providing participants with insights into valuable germplasm resources. About 150 participants, including scientists, researchers, department officials, students, and farmers, attended the.

Launching of Sweet Potato Agri-Food System Project in Attappadi

The ICAR-CTCRI launched sweet potato agri-food system project in Attappadi: Christened 'Punarjeevanam' and jointly launched with State Kudumbashree Mission, Government of Kerala on 12 August 2024. Shri. M.B. Rajesh, Minister for local self-governments, rural development and excise, Government of Kerala inaugurated the programme online. Dr. G. Byju, Director, ICAR-CTCRI delivered a keynote address. Scientists of ICAR-CTCRI handled classes during the three days livelihood improvement training programme.

Institute Management Committee Meeting

The 20th Institute Management Committee Meeting of ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram was held on 14 August 2024 in hybrid mode. The meeting was chaired by Dr. G. Byju, Director, ICAR-CTCRI who gave the introductory remarks followed by a presentation by Dr. D. Jaganathan, briefing the history, mandate, staff strength, activities, achievements and action plan of the Institute. This was followed by a presentation of minutes of the previous meeting. The action taken on each item was also reviewed. The Senior Administrative Officer presented the report of Establishment and Personnel Section. The Senior Finance & Accounts Officer presented the Progressive Expenditure of 2023-2024. Proposals for the consideration and approval of the IMC were discussed.

Foundation Stone Laying Ceremony of Bio-agents Mass Production Unit under RKVY at Regional Station ICAR-CTCRI, Bhubaneswar

Dr. Sudhakar Pandey, Assistant Director General (FVS&MP) laid the foundation stone for a Bioagents Mass Production Unit under the RKVY funded project titled 'Establishment of Mass Production Unit of Bioagents for Ecofriendly Disease Management in Vegetable Crops of Odisha' on 13 September 2024. Dr. G. Byju, Director, ICAR-CTCRI graced the occasion. Dr. Sudhanshu K.K. Mishra, Chief General Manager, NABARD, Bhubaneswar and Dr. M.K. Mishra, Professor and Head, Department of Plant Pathology, OUAT, Bhubaneswar were Guests of Honour in the programme.

Vigilance Awareness Week 2024

The Institute observed the Vigilance Awareness Week 2024 during 28 October to 03 November 2024 with the focal theme 'Culture of Integrity for Nation's Prosperity'. The programme was launched on 28 October 2024 with the Integrity Pledge taking ceremony. Various competitions viz., elocution, essay writing and poster competitions were held for the school students and the staff. The valedictory function of Vigilance Awareness Week was held on 04 November 2024 and Shri. Yogesh Gupta, DGP and Director, Vigilance and Anti-Corruption Bureau, Thiruvananthapuram was the chief guest. During his speech, he shared his vast experience and encouraged everyone to keep up the tradition of remaining corruption free. He mentioned about transparency in an institution and how important the various checks are in controlling corruption and the jurisdiction of various governmental enforcement agencies. Dr. G. Byju, Director, ICAR-CTCRI presided over the function and talked about maintaining an ethical culture in research and how important that is for

the advancement of a Nation.

Rooting for Tubers 2024

The ICAR-CTCRI ABI in collaboration with M/s Spudnik Farms, an incubate of ICAR-CTCRI, organised 'Rooting for tubers 2024' at Koramangala, Bengaluru on 01 December 2024. Dr. Kadirvel Govindasamy, Director, ATARI, Guwahati; Dr. Srinivasulu Rajendran, Co-Lead Work package 3 - CGIAR Seed Equal Initiative, faculty from NEHU, College of Horticulture & Forestry, CAU (I), Pasighat, Arunachal Pradesh; KAU, Wayanad; investors, startups, and farmers participated. Members of different tribal groups from Arunachal Pradesh, Tripura, Meghalaya, Odisha and Karnataka demonstrated their traditional tuber recipes. Over 500 people participated.

Quinquennial Review Team meeting

The Quinquennial Review Team (QRT) of ICAR-CTCRI reviewed the work of ICAR-CTCRI and AICRP TC for the period from 01 April 2019 to 31 March 2024. The experts of the team are Dr. S.D. Shikhamany, Former Vice Chancellor, Dr. YSR Horticultural University, Andhra Pradesh (Chairman); Dr. S.K. Pandey, Former Director, ICAR-CPRI, Shimla; Dr. V.S. Korikanthimath, Former Director, ICAR-CCARI, Goa; Dr. Rakesh Pandey, Prof. Emeritus, AcSIR& CSIR, CSIR-CIMAP, Lucknow, Uttar Pradesh; Prof. R. Jaganmohan, DSW & Head, Food Science & Nutrition, NIFTEM, Thanjavur, Tamil Nadu; Shri. Selvaraj Manivannan, Venus Starch Industries, Salem, Tamil Nadu, and Dr. G. Suja, Principal Scientist & Head, Division of Crop Production, ICAR-CTCRI (Member Secretary). During this quarter, the QRT conducted four visits: ICAR-CTCRI, Thiruvananthapuram (08-09 October); MPUAT, Udaipur (07 November); AAU, Jorhat (25-26 November) and ICAR-CTCRI Regional Station, Bhubaneswar (16-17 December). The team visited the experimental fields at ICAR-CTCRI, HQ at Thiruvananthapuram, its Regional Station at Bhubaneswar and selected centres of the coordinated research project, laboratories and other infrastructure, reviewed research programmes and their outcome and proposed the future lines of research, held interactive meetings with various stakeholders including farmers, processors and traders, officers of the State Department of Agriculture/Horticulture, the Head and Subject Matter Specialists of the Krishi Vigyan Kendra, faculty of MPUAT, Udaipur & AAU, Jorhat. An 'Industry Meet-cum-Workshop on 'Emerging Technologies and Business Prospects of Biofortified Sweet Potato in India' was organized at the RS ICAR-CTCRI on 17 December 2024. A technology pavilion showcasing diverse technologies of biofortified sweet potato with product demonstration was arranged and it was inaugurated by Dr. S.D. Shikhamany, Chairman, QRT. The team made a comprehensive assessment of the Institute's ongoing research programs and formulated a strategic roadmap for the next five years. The QRT also reviewed the institute's research outcomes against global research efforts, emphasizing its increasing responsibility to strengthen food and nutrition security and farm resilience, particularly for marginalized and climate-vulnerable communities.

Interface Meeting with Shri. Gabriel D. Wangsu, Minister of Agriculture, Arunachal Pradesh

Shri. Gabriel D. Wangsu, Minister of Agriculture, Horticulture, Animal Husbandry & Veterinary, Fisheries, Legal Metrology & Consumer affairs, and Food & Civil Supply, Government of Arunachal Pradesh visited ICAR-CTCRI, Thiruvananthapuram along with other officials on 02 December 2024 to explore advanced agricultural practices and potential collaborations to boost tuber crops production in Arunachal Pradesh. He visited the experimental farms and other facilities at ICAR-CTCRI and had a discussion with scientists and senior officials of the Institute.

National Brainstorming Workshop on Formalization of Seed System in Tropical Tuber Crops

The workshop was held on 03 December 2024 at ICAR-Central Tuber Crops Research Institute Thiruvananthapuram in hybrid mode. Dr. Sanjay Kumar Singh, Deputy Director General (Horticultural Science) inaugurated the brainstorming. Dr. Sudhakar Pandey, ADG (FVSMAP) was the guest of honour. Dr. K. Sunilkumar, Principal Scientist and organizing secretary welcomed the participants. Dr. Visalakshi Chandra C., Senior Scientist delievered vote of thanks. Dr. S.K. Chakrabarti (Former Director, ICAR-CTCRI), chaired the technical and plenary sessions, which was co chaired by Dr. G. Byju, Director and Dr. James George (former Director ICAR-CTCRI) In the technical session, 10 presentations were made. Based on that twenty one recommendations were (documented). A total of 197 partcipants attended.

World Soil Day

The Institute celebrated the World Soil Day 2024 at HQ and Regional Station, Bhubaneswar on 05 December 2024. At the HQ, Dr. P. Rajendran, Chairman, Kerala Farmers Welfare Fund Board & Former Vice Chancellor, Kerala Agricultural University delivered the lecture on this year's theme, 'Caring for soils: Measure, Monitor, Management, He emphasized that soil health will reflect on plant health which in turn on animal and human health. Students and staff from nearby schools also attended the celebration. World Soil Day pledge was administered by the Director, Dr. G. Byju. At the Regional Station, Dr. K.K. Rout, Former Dean, College of Agriculture, OUAT and Dean, School of Agriculture, DRIEMS University, Cuttack, Odisha was the chief guest and he delivered the theme lecture.

Tuber Crops Day

The Indian Society for Root Crops (ISRC) in collaboration with ICAR-CTCRI celebrated 'Tuber Crops Day, on 13 December 2024. Dr. G. Byju, Director, ICAR-CTCRI presided over the function. Shri. Murukan Kattakada, Malayalam poet and Director, Malayalam Mission, Department of Culture, Govt. of Kerala was the Chief guest. He emphasized the importance of agriculture and need for uplifting the downtrodden farmers. Dr. E. Sreekumar, Director, Institute of Advanced Virology, Thiruvananthapuram, the Guest of honour, highlighted the importance of tuber crop farmers and its benefits for the country. Various Institute publications, products and equipment were released and signed MoUs with C-DAC, Thiruvananthapuram and Haritha Lakshmi Krishikoottam, Kollam, Kerala. Around 150 farmers, scientists, staffs and students participated in the programme. A scientists-farmers interface was also arranged.

ISMPP Zonal Meet and National Seminar 2024

SMPP Zonal Meet and National Seminar 2024 was organized on 14 December 2024 at ICAR-CTCRI, Sreekaryam, Trivandrum. Eighty delegates from Kerala, Tamil Nadu, Karnataka and Andhra Pradesh registered for the event and 48 research papers as abstracts were exhibited as poster presentations during the event. The National Seminar was inaugurated by Dr. S.S. Chahal, the Emeritus President, ISMPP as well as the former Vice Chancellor, MPUAT, Udaipur, Rajasthan. Dr. G. Byju, the Director ICAR-CTCRI delivered the presidential address and Shri. Jacob John, Director of Extension, KAU delivered a talk.

Official Language Implementation Committee (OLIC)

The Official Language Implementation Committee (OLIC) conducted meetings in every quarter (20 February, 11 April, 16 August and 5 November 2024) under the chairmanship of Dr. G. Byju, Director, ICAR-CTCRI and Chairperson, OLIC. The meetings were conducted by Dr. A. Asha Devi, Principal Scientist and Liaison Officer.

- For the progressive use of official language, copies of the 22-point programs issued by ICAR-CTCRI were distributed among the administration department and employees working in Hindi.
- A decision was taken to start a Hindi e-magazine. A format was prepared for monthly review of Hindi work which was approved by the Chairman, OLIC for circulation among the staff.
- Key points of the revised Parliamentary Inspection Questionnaire were discussed.
- New roster of employees was prepared for working knowledge in Hindi. It was decided to prepare the list of staff that do not have working knowledge in Hindi and send them for training in the coming session.
- ICAR vide their letter No. OL 12(89)/2022-Hindi, dated 12 December 2024 has apreciated ICAR-CTCRI's work done under rule 3(3) and for total number of documents issued in bilingual format. Similarly, the correspondence of bilingual letters to all regions (A, B and C), the noting written on the files and the workshop conducted during the quarter were also appreciated.

The Hindi Fortnight 2024 was organized at the Headquarters from 14 to 28 September 2024.The valedictory function of the Hindi Fortnight Celebrations 2024 was conducted on 02 December 2024 along with prize distribution to the winners of various competitions. Cash awards were given to employees who did commendable work in Hindi under the Incentive Scheme Award 2024. This year's first prize was bagged by Smt. Remya V.S., Skilled Supporting Staff, for doing maximum work in Hindi. All quarterly performance reports were sent to the Council for their compliances.

Hindi Workshops

During the year, four one-day workshops were conducted by the Hindi Cell. The in-house Hindi workshop on "Official Language Policy and Rules" was organized for the Administrative and Accounts Sections on 23 February where 5 officers and 6 employees were trained. During the second quarter, a workshop on "Annual Programme 2024-25 and Glossary and Notes" was organized on 19 June 2024 where, Shri. A. Somadettan, Retired Assistant Director (OL), Income Tax Office, Thiruvananthapuram conducted the class. In this, 11 officers and 19 employees were trained. Two in-house Hindi workshops on the topics "Simple Hindi Grammar and Official Language Rules" and "Spoken Hindi" were organized on 02 August 2024 and 17 December 2024, respectively. Here, 07 officers and 13 employees as well as 07 officers and 10 employees were trained, respectively.

Library Activities

Implementation of Borrower's Cards: To improve access to library resources, 38 borrower's cards were issued to staff and research scholars.

Mobile App Integration for E-Resources: The library integrated mobile access for e-resources via J-Gate, allowing seamless browsing, searching, and downloading of scholarly articles. Features include remote access, a user-friendly interface, and personalization options.

Static IP Integration for ONOS: Under the One Nation One Subscription (ONOS) initiative, static IPs were integrated for ICAR-CTCRI headquarters and its Regional Station, ensuring secure and uninterrupted access to e-journals and databases.

Added 12 scientific books to the collection, issued 773 books through circulation services, facilitated 7,730 hits via CeRA services, including full-text and abstract views and provided reference services to 1,067 users, granting access to rare books, theses, symposium proceedings, and dictionaries and related literature.

Mera Gaon Mera Gaurav Programme

Under the MGMG programme eleven teams were formed and the total villages covered was 43. Each scientist has adopted one village. The programmes conducted in the villages include awareness campaigns, group meetings, trainings and demonstrations, mobile based advisories and literature support. The scientists frequently visited the villages and assessed their problems and provided suitable remedies to the existing problems.

A farmers training cum exhibition on 'Value added products from tuber crops' was organized at Ottoor Panchayath, Varkkala. Lecture on value addition in tuber crops and its importance was delivered and as a follow up, hands-on training was given to these farmers at the Techno Incubation Centre of ICAR-CTCRI. A tuber crops seed village program was organized in Venganoor panchayat and a training on 'Tuber crops seed village and decentralized seed multipliers program' was imparted. Farmers in Vellar, Thiruvananthapuram under Thiruvallam Krishi Bhavan were given the planting materials of cassava variety Sree Reksha. An awareness programme was conducted at Karakulam on the diseases of tuber crops and planting materials of improved varieties of cassava and sweet potato were distributed.

Swachhata Hi Seva- 2024

The ICAR-CTCRI organized various cleanliness initiatives in 2024 under *Swachhta Hi Seva*, *Swachh Bharat Diwas*, *Swachh Bharat Special Campaign 4.0*, and *Swachhta Pakhwada*. Monthly cleanliness drives were conducted. *Swachhta Hi Seva* (15 September – 02 October) was observed with the theme *"Swabhav Swachhta-Sanskaar Swachhata"*, including a Swachhta pledge, visits to old age homes, tourist villages and black spot cleaning, on 02 October. Swachhta pledge, a human chain, a road walk, and the inauguration of a transformed Cleanliness Target Unit (CTU) were done. During *Swachh Bharat Special Campaign 4.0* (02-31 Oct) daily reports on pendency identification and achievement status form was provided to ICAR which included the office scrap, quantity of scrap under disposal and revenue. *Swachhta Pakhwada* (16-31 December) involved disposing of old equipment, record room cleaning, celebrating *Kisan Diwas* (23 December) at Vamanapuram, conducting a motorcycle rally, and a mega cleanliness drive at Akkulam Tourist Village (27 December).

Exposure Visit Cum Training Programme

One day exposure visit cum training on 'Improved technologies of tuber crops' was organized for the benefit of 579 farmers, 2756 students and 245 officials during this period at the Institute

HRD Unit Activities

The HRD training unit is facilitating the staff to attend trainings across the country. Recently the staff members are encouraged to attend the IGoT trainings in their area of interest and the trainings assigned by the council on online mode under the Karmayogi mission. Most of the staff are regularly attending the IGoT training through online platform. Academic trainings were also organised by the Institute and last year six trainings were completed successfully. Scientists, administrative and accounts staff were given training in personality development at IMG, Thiruvananthapuram during this year.

Academic Cell Activities

Two meetings were conducted on 03 January and 25 July 2024 to review the progress and suggest the research activities of Ph.D. students by the Director and the members of the committee. Individual students presented the research progress during six months which will help them to complete their research programme on time.

Quarterly Review Meetings

Four quarterly review meetings of scientists were conducted on 08-09 January, 04-05 April, 22-23 July and 18 & 21 October, 2024 under the chairmanship of Dr. G. Byju, Director, to review the progress achieved during the quarter and to prioritize the targets.

Recreation Club

The club activities kick started with new year celebration on 01. January 2024. The occasion was marked by cake cutting by Dr. G. Byju, Director. Lucky dip and a cultural programme by staff/club members was organized. The Institute calendar was released by the Director on the New Year day. Onam 2024, was celebrated with *Athapookkalam* competition and Dr. G. Suja, Director (i/c) gave away the trophies to winners, followed by *Onasadya*.

The club has organised befitting farewell functions for 5 staff who superannuated, in appreciation of their valuable contribution to the Institute development as well as tuber crops research. The republic day and 77th Independence day function were organized by the club in which Director hoisted the national flag and addressed the staff.

Field Level Demonstrations/OFTs Conducted

Demonstrations (>200) of improved cassava, sweet potato, elephant foot yam, taro, and Chinese potato varieties, along with fertilizer best management practices, site specific nutrient management, application of micronutrient solutions and protection technologies including evaluation of biocapsule, bio agents and integrated management of cassava stem and root rot, were conducted in Kerala, Tamil Nadu, Andhra Pradesh, Odisha, Chhattisgarh, Jharkhand and the North Eastern states with the help of KVKs, Department of Agriculture/Horticulture. More than 10000 farmers were benefitted, which showcased the technical effectiveness and economic advantages of the improved practices. Farmers were trained in scientific crop management techniques. Pests and diseases, including mealybugs, spiraling whiteflies, and cassava mosaic disease and cassava stem and root rot in cassava; sweet potato weevils and foliage-feeding insects in sweet potato; and sucking pests and nematodes in Chinese potato, were effectively controlled using resistant varieties, integrated pest, disease, and nematode management strategies. A total of 170 drone demonstrations were conducted across Kerala and Tamil Nadu. The demonstrations were held in different villages of Thrissur, Palakkad, Kasargode, Wayanad (Kerala) and Tenkasi, Tirunelveli, and Kanyakumari (Tamil Nadu) in collaboration with the Department of Agriculture of the states . The demonstrations covered cassava, paddy, banana, taro, and Chinese potato fields, where nano urea and cassava special micronol nutrient solutions were sprayed. In total, 428 farmers and stakeholders participated, gaining awareness of the efficiency of drone-based nutrient application.

Participations in Exhibitions/ Field Days

ICAR-CTCRI participated in the following exhibitions for the benefit of farmers and other stakeholders. Large number of farmers, college and school students, industrialists and other general public acquired knowledge on improved technologies of tuber crops.

1. International fisheries and expo 2024 at KUFOS Campus, Panangad, Kochi, 12-14 January 2024
2. KAU-Corteva International Plant Science Symposium, College of Agriculture, Thiruvananthapuram, 18-19 January 2024
3. 36th Kerala Science Congress at Government

College, Kasaragod, Kerala, 08-11 February 2024

4. International Seminar on Sustainable Urban Agricultural Practices and Community-Resilient Cities at College of Agriculture, Thiruvananthapuram, 22-23 March 2024
5. Tuber crops cum product exhibitions in Muthi village and Nausel village, Aizawl, Mizoram, 04 and 06 March 2024
6. Exhibitions at KVK, Puri, Odisha on 13 March 2024 and ICAR-NRRI, Cuttack, 15 March 2024
7. Kisan Mela 'Food Forest and Mukkani Show' organized by the Isha Foundation in association with ICAR-IIHR, ICAR-NRCB, ICAR-CTCRI and NIFTEM at Pushkaram Agriculture College, Pudukkottai, 23 June 2024
8. Exhibition of tuber crops on ICAR foundation day and technology day at NASC, New Delhi,15-16 July 2024
9. Exhibition of tuber crops varieties and technologies at Attapadi, Palakkad, Kerala as part of the 'Punarjeevanam' during 12-14 August 2024
10. Exhibition in connection with state level seminar on Coconut and tuber crops based agrifood systems for resilience and sustainable income at Perumanallur, Tiruppur, Tamil Nadu, 29 August 2024
11. ICAR-CTCRI Agri-business Incubator set up a technology display stall at the Bioconnect 2.0 Kerala 2024, themed I2I (Innovation to Industry), organized by Kerala Life Sciences Industries Park (KLIP) with the support of the Kerala State Industrial Development Corporation (KSIDC) and the Industries Department, Govt. of Kerala during 27-28 September 2024.
12. Tuber Crops Development programme 2024-2025 at Ollukkara, Thrissur, Kerala, 05 October 2024
13. Chertala Fest – Karappuram Kazhchakal exhibition at Chertala, Alappuzha district, during 20-29 December 2024
14. The 3rd International Conference on 'Climate-Smart Nutri-Sensitive Integrated Farming System for Gender-equitable Sustainable Agriculture: Prospects and Challenges (ICNSFS) 2024 at ICAR-CIWA, Bhubaneswar, Odisha 06-08 November 2024

Media coverage

Newspapers and e-papers have consistently featured the Institute's activities, emphasizing research breakthroughs, farmer training initiatives, and crop enhancement programs. Leading national dailies in multiple languages, including English, Malayalam, Tamil, Telugu, Odia, Hindi, Marathi etc have covered key developments such as new tuber crop varieties, industry partnerships, and agricultural events. These reports highlight the institute's ongoing efforts to boost tuber crop productivity, promote value chains, and support sustainable farming practices across India.

वर्ष 2024 के दौरान इस सस्ंथान में आयोजित राजभाषा कार्यान्वयन से सबंन्धित कार्यक्रम

राजभाषा कार्यान्वयन समिति (ओएलआईसी) ने आईसीएआर-सीटीसीआरआई के निदेशक और ओएलआईसी के अध्यक्ष डॉ. जी. बैजु की अध्यक्षता में प्रत्येक तिमाही (20 फरवरी, 11 अप्रैल, 16 अगस्त और 5 नवंबर 2024) में बैठकें आयोजित कीं। बैठकों का संचालन डॉ. आशा देवी ए, प्रधान वैज्ञानिक और संपर्क अधिकारी द्वारा किया गया और मार्च 2024 तक डॉ. षानवास एस., तकनीकी अधिकारी और सदस्य सचिव (ओएलआईसी) और अप्रैल 2024 से श्री भद्रकुमार एस., वरिष्ठ प्रशासनिक अधिकारी और सदस्य सचिव (ओएलआईसी) द्वारा समर्थित किया गया। ओएलआईसी से संबंधित विभिन्न बिंदुओं पर चर्चा की गई और लिए गए निर्णयों को लागू किया गया।

राजभाषा के प्रगतिशील प्रयोग के लिए आईसीएआर-सीटीसीआरआई द्वारा जारी 22 सूत्री कार्यक्रमों की प्रतियां प्रशासनिक विभाग एवं हिंदी में काम करने वाले कर्मचारियों के बीच वितरित की गईं।

हिंदी ई-पत्रिका शुरू करने का निर्णय लिया गया।

हिंदी कार्य की मासिक समीक्षा के लिए एक प्रारूप तैयार किया गया, जिसे कर्मचारियों के बीच प्रसारित करने के लिए राजभाषा कार्यान्वयन समिति के अध्यक्ष द्वारा अनुमोदित किया गया।

संशोधित संसदीय निरीक्षण प्रश्नावली के मुख्य बिंदुओं पर चर्चा की गई।

हिंदी में कार्यसाधक ज्ञान रखने वाले कर्मचारियों की नई सूची तैयार की गई। हिंदी में कार्यसाधक ज्ञान न रखने वाले कर्मचारियों की सूची तैयार कर आगामी सत्र में प्रशिक्षण के लिए भेजने का निर्णय लिया गया।

आईसीएआर ने अपने पत्र संख्या ओएल 12(89)/2022-हिंदी, दिनांक 12 दिसंबर 2024 के माध्यम से द्विभाषी प्रारूप में जारी किए गए दस्तावेजों की कुल संख्या के लिए नियम 3(3) के तहत सीटीसीआरआई द्वारा किए गए कार्य की सराहना की है। इसी तरह, सभी क्षेत्रों (ए, बी और सी) को द्विभाषी पत्रों का पत्राचार, फाइलों पर लिखी गई टिप्पणियाँ और तिमाही के दौरान आयोजित कार्यशाला की भी सराहना की गई।

मुख्यालय में 14 से 28 सितम्बर 2024 तक हिन्दी पखवाड़ा 2024 का आयोजन किया गया। हिन्दी पखवाड़ा समारोह 2024 का समापन समारोह 02 दिसम्बर 2024 को आयोजित किया गया, जिसमें विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार वितरित किए गए। प्रोत्साहन योजना पुरस्कार 2024 के अन्तर्गत हिन्दी में सराहनीय कार्य करने वाले कर्मचारियों को नकद पुरस्कार प्रदान किए गए। इस वर्ष का प्रथम पुरस्कार श्रीमती रम्या वी.एस., कुशल सहायक कर्मचारी को हिन्दी में अधिकतम कार्य करने के लिए दिया गया। सभी तिमाही निष्पादन रिपोर्ट अनुपालन के लिए परिषद को भेजी गई।

हिंदी कार्यशालाएँ

इस वर्ष के दौरान हिंदी प्रकोष्ठ द्वारा चार एक दिवसीय कार्यशालाएं आयोजित की गईं। प्रशासनिक एवं लेखा अनुभाग के लिए "राजभाषा नीति एवं नियम" विषय पर आंतरिक हिंदी कार्यशाला 23 फरवरी को आयोजित की गई, जिसमें 5 अधिकारियों एवं 6 कर्मचारियों को प्रशिक्षण दिया गया। दूसरी तिमाही के दौरान "वार्षिक कार्यक्रम 2024-25 तथा शब्दावली एवं नोट्स" विषय पर कार्यशाला 19 जून 2024 को आयोजित की गई, जिसमें आयकर कार्यालय, तिरुवनंतपुरम के सेवानिवृत्त सहायक निदेशक (राजभाषा) श्री सोमदेत्तन ए. ने कक्षा का संचालन किया। इसमें 11 अधिकारियों एवं 19 कर्मचारियों को प्रशिक्षण दिया गया। "सरल हिंदी व्याकरण एवं राजभाषा नियम" तथा "बोली जाने वाली हिंदी" विषय पर दो आंतरिक हिंदी कार्यशालाएं क्रमशः 2 अगस्त 2024 तथा 17 दिसंबर 2024 को आयोजित की गईं। यहां क्रमशः 7 अधिकारियों एवं 13 कर्मचारियों तथा 7 अधिकारियों एवं 10 कर्मचारियों को प्रशिक्षण दिया गया।

सीटीसीआरआई, भुवनेश्वर, ओडिशा के क्षेत्रीय स्टेशन पर भी 14 से 28 सितंबर 2024 तक हिंदी पखवाड़ा 2024 का आयोजन किया गया।

Important Events

Sl. No.	Name of the event	Date
1.	National Training on Advances in Plant Biotechnology and Molecular Biology for Crop Improvement	2-22 January 2024
2.	International Webinar on Functional Phenomics for Improved Climate Resilience in Tropical Agriculture	04 January 2024
3.	19th and 20th Institute Management Committee meeting	12 January and 14 August 2024
4.	Webinar on Major pests in Cassava and their Control Measures in Malayalam	17 January 2024
5.	Interface Meeting with Governor of Kerala at Raj Bhavan, Thiruvananthapuram	20 January 2024
6.	Third meeting of IX Research Advisory Committee	22-23 January 2024
7.	Institute Biosafety Committee Meeting (IBSC)	25 January and 31 December 2024
8.	Rooting for Tubers Festival in Bengaluru	4 February 2024
9.	Brainstorming on Elephant Foot Yam for Empowering Stakeholders: Challenges and Strategies	13 February 2024
10.	Diagnostics of Plant Diseases through Novel Approaches	16-23 February 2024
11.	National Science Day	28 February 2024
12.	International Women's Day	March 07 2024
13.	Webinar on Planting Material Storage and Pests and Diseases in Tuber Crops in Malayalam	27 March 2024
14.	H.H. Sree Visakham Thirunal Endowment Lecture	03 June 2024
15.	World Environment Day	05 June 2024
16.	50th Annual Institute Research Council Meeting	10-13 June 2024
17.	International Yoga Day	21 June 2024
18.	61st Foundation Day of ICAR-CTCRI	09 July 2024
19.	Brainstorming Workshop on Harnessing Crop Wild Relatives for Tuber Crops Improvement	29 July 2024
20.	National Training on Advances in Integrated Plant Health Management	05-09 August 2024
21.	Launching of Sweet Potato Agri-Food System Project in Attappadi	12 August 2024
22.	Foundation Stone Laying Ceremony of Bio-agents Mass Production Unit under RKVY at Regional Station ICAR-CTCRI, Bhubaneswar	13 September 2024
23.	National Training on Advances in Quality Planting Material Production of Tropical Tuber Crops	23-27 September
24.	*Swachh Bharat Special Campaign 4.0*	02- 31 October 2024
25.	Vigilance Awareness Week 2024	28 October to 03 November 2024
26.	National Training on Tuberous vegetables based nutri gardens by organic and urban farming	18–22 November 2024
27.	Rooting for Tubers 2024 in Bengaluru	01 December 2024
28.	Quinquennial Review Team meetings (4) At ICAR-CTCRI, Thiruvananthapuram; MPUAT, Udaipur; AAU, Jorhat and ICAR-CTCRI Regional Station, Bhubaneswar	08-09 October ,07 November , 25-26 November, 16-17 December 2024
29.	Meeting with Shri. Gabriel D. Wangsu, Minister of Agriculture, Arunachal Pradesh	02 December 204
30.	National Brainstorming Workshop on Formalization of Seed System In Tropical Tuber Crops	03 December 2024
31.	World Soil Day	05 December 2024
32.	Tuber Crops Day	13 December 2024
33.	ISMPP Zonal Meet and National Seminar 2024	14 December 2024
34.	*Swachhta Pakhwada*	16-31 December
35.	Hindi Workshops (4)	23 February 2024 19 June 2024 02 August 2024 and 17 December 2024

Weather Data-2024

ICAR-CTCRI, Head quarters, Thiruvananthapuram, Kerala

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Min.	Max.	FN	AN		
January	22.9	33.5	93.80	54.50	25.2	4
February	23.3	34.8	92.1	50.8	3.8	2
March	24.4	35.1	86.3	51.3	31.4	3
April	26.1	35.1	87.9	61.8	60.3	8
May	25.2	32.6	88.3	72.1	444.2	22
June	24.5	31.3	89.9	78.5	258.9	22
July	23.8	30.5	89.8	78.1	141.9	21
August	24.1	31.6	89.8	72.8	427.1	21
September	24.1	31.9	89.8	71.8	157.1	21
October	27.7	31.6	89.8	72.8	386.3	23
November	23.5	31.7	94.8	71.3	75.8	7
December	23.4	32.4	94.4	64.3	17.5	1

ICAR-CTCRI, Regional Station, Bhubaneswar, Odisha

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Min.	Max.	FN	AN		
January	16.6	27.9	91	54	22.6	1
February	20.5	32.9	90	51	6.2	1
March	23.4	34.2	92	55	50.2	5
April	25.6	39.7	84	42	24.2	3
May	26.8	38.0	85	55	168.6	7
June	26.8	37.1	89	64	163.5	6
July	26.4	32.3	96	88	258.9	14
August	25.6	32.4	96	88	443.3	16
September	25.7	32.8	96	90	221.7	14
October	24.9	33.6	91	70	124.5	10
November	20.4	31.6	88	54	9.8	2
December	17.8	28.1	86	58	92.9	5

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