2023 वार्षिक प्रतिवेदन
ANNUAL REPORT

Diamond Jubilee 60 Years ICAR-CTCRI

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

भा कृअनु प ICAR

केकफअसं CTCRI

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Annual Report
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Diamond Jubilee of ICAR-CTCRI

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From the Director

Dr. G. Byju

Ensuring food and nutrition security under changing climate, while conserving natural resources without exerting unprecedented pressure on production systems is indispensable. This necessitates development of sustainable and resilient agri-food systems under climate change. Roots and tubers are important staples in the developing world, and are decisive components in agri-food systems. I proudly present the annual report of research achievements and development activities of ICAR-CTCRI for 2023, which is particularly significant as it commemorates its 60th anniversary.

The genetic wealth was enriched with 65 new collections and a total of 5542 accessions were conserved for valued traits. Three varieties were released and two are ready for release. Sree Kaveri, a cassava mosaic disease resistant variety, was centrally released for the states of Kerala, Tamil Nadu and Andhra Pradesh. Two taro varieties, Sree Hira, tolerant to taro leaf blight and Sree Telia, an early maturing one were released for the state of Odisha. Anthocyanin rich purple flesh biofortified sweet potato hybrid, SPH-31, has been submitted for release in Odisha in the name Sree Arunima. A high yielding variety of yam bean, YBH-3×8, has been submitted for release in Odisha as Sree Chandrika.

Two cropping systems viz., taro+vegetable cowpea and rice-short duration cassava-cucumber will help to support agri-food systems and improve livelihoods of small-holder farmers. Pursuit to evolve scientific recommendations on the flag-ship programmes of Govt. of India viz., natural farming, organic farming, nano urea, nano DAP, Per Drop More Crop are ongoing with greater focus. Water saving techniques in cassava, water requirement of sweet potato and fertigation schedule of greater yam were standardized. A novel technique for seed tuber production in yams using two node vine cuttings and IBA pretreatment was developed. A nutrient management package for cassava comprising customized fertilizers, green manuring *in situ* with cowpea, nutrient use efficient genotypes viz., 7III E3-5 and CI-906, enabling saving of 75% NPK and Zn application proved sustainable.

Three bio-capsules that provide growth promotion and suppression of major fungal diseases of tropical tuber crops and vegetable crops, identification of *Ipomoea mauritiana* as a source of resistant genes against sweet potato weevil, biorational management of postharvest rot in elephant foot yam, management of root knot nematodes and yam anthracnose using new generation nematicides and fungicides, respectively as well as first report of pathogens causing leaf blight in sweet potato and bacterial storage rot in elephant foot yam are noteworthy.

Optimization of conditions for making particle boards from cassava stem and agro-residues and methylene blue dye adsorption of cassava starch phosphate carbamate hydrogel; development of millet incorporated sweet potato cookies, rice analogue and pasta from cassava and millets, prototype tractor operated Chinese potato harvester and portable self-propelled tapioca sett cutter add prospects for value addition and would set a platform for CTCRI as a global leader for innovation.

An interactive database of genomic variations in cassava, CasGVD; web based statistical analysis software, AgriAnalytics@R; women empowerment index in sweet potato; a workflow for the analysis of whole genome sequence data of cassava and R package baseq, submitted to CRAN, that provides function to process biological data, were also developed.

Six technologies were licensed and two MoUs for contract research and one for consultancy service were signed. A patent application for an apparatus for peeling agricultural products was filed. Eight technologies were certified by ICAR. It is a matter of great pride that the technology on eCrop based smart fertigation system

was selected as one of the five best technologies in horticulture sector.

Out-reach programmes like NEH, SCSP, TSP, and 717 FLDs/OFTs ensured impact and delivery of the technologies, products and services of ICAR-CTCRI to the society. The Govt. of India programmes, '*Mera Gaon Mera Gaurav'* and 'Swachh Bharat Abhiyan Mission', continued with greater zeal and outcome. A National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food systems & Resilience (NCTTC 4 STAR 2023) and two Brainstorming Sessions were also organized enhancing the visibility of this institute.

The research outcomes were translated into high quality publications totalling to 382, including 75 research papers in high impact international and national journals and six technical bulletins on package of practices for major tuber crops. As we enter into a new era of global challenges including climate change, we recognise the importance of reequipping ourselves for science-led greater societal impact and reach. I am thankful for the collaborative and productive partnerships with CGIAR institutes like CIP, CIAT; Govt. of India organizations like CDB, RKVY, DST, DBT, NAIF, DAE, PPV&FRA, NABARD; ICAR Institutes, AICRP (on tuber crops) Centres, KVKs; Govt. of Kerala organizations like KSCSTE, KSPB, and State Department of Agriculture & Farmers' Welfare.

I sincerely thank Dr. Himanshu Pathak, Secretary (DARE) & Director General (ICAR); Dr. Sanjay Kumar Singh, DDG (Hort. Sci), Dr. A.K. Singh, former DDG (Hort. Sci), Dr. T.R. Sharma DDG (i/c) (Hort Sci.), ICAR and Dr. Sudhakar Pandey, ADG (FVS&MP), ICAR for their valuable guidance and support.

This document is a testimony to the hard and committed services of all the staff. Thanks to their unwavering support and creativity! I compliment the sincere efforts of the Chief Editor and members of the Editorial Committee in bringing out this Annual Report.

15 March 2024

G. Byju
Director

विशिष्ट सारांश

46 संस्थान परियोजनाओं के साथ-साथ 27 बाहरी वित्त पोषित परियोजनाओं के तहत विकसित नए संग्रह, जारी की गई किस्मों, प्रक्रियाओं, प्रोटोकॉल, प्रौद्योगिकियों, विधियों, उच्च मूल्य वाले यौगिकों और कटाई के बाद की मशीनरी के साथ संरक्षित आनुवंशिक संपदा नीचे दी गई है:

1. कुल 5542 परिग्रहण, जिसमें 1221 कसावा, 1110 शकरकंद, 1023 रतालू, 689 खाद्य एरोइड, 229 छोटी कंद फसलें और क्षेत्रीय स्टेशन से 1270 संग्रह शामिल थे, जो फील्ड जीन बैंक में बनाए रखा और संरक्षित किया गया था। इनमें, कंद फसलों के 65 नए संग्रह भी शामिल है - कसावा(5), रतालू(13), खाद्य एरोइड (25) और छोटी कंद फसलें (22)।

2. विभिन्न वांछनीय गुणों वाले कसावा जीनोटाइप की पहचान की गई, जैसे उच्च फसल सूचकांक (>0.8), उच्च कंद वजन प्रति पौधा (>10 किग्रा)और सीएमडी के लिए प्रतिरोध(8); उच्च फसल सूचकांक(>0.8) और सीएमडी के प्रति प्रतिरोध(5); मीठा स्वाद और उच्च कंद वजन(9); मीठे स्वाद के साथ β-कैरोटीन से भरपूर पीले कंद(3); सीएमडी प्रतिरोधी, कम चीनी सामग्री(17S-1, 19S-4-3 और 17S-247) और उच्च उपज देने वाले जीनोटाइप(>50 टन प्रति हेक्टेयर) वाले प्रारंभिक थोकिंग जीनोटाइप, अर्थात, 17S-48, 19S-4-3 और 19S-4-2 के साथ-साथ 7 दिन तक सहनशीलता के साथ आशाजनक पीपीडी सहिष्णु क्लोनल संतानें (133)।

3. वांछनीय गुणों वाले शकरकंद के जीनोटाइप की पहचान की गई, जैसे 14.5 मिलीग्राम प्रति 100 ग्राम ताज़ा वचन की कैरोटीन सामग्री के साथ बायोफोर्टिफाइड उच्च कैरोटीन ओएफएसपी हाइब्रिड 38/15, 8-10 मिलीग्राम प्रति 100 ग्राम ताज़ा वचन की कैरोटीन सामग्री के साथ क्रीम फ्लेश्ड 38/46 और स्टार्च सामग्री 20%; हाइब्रिड 110/28 जिसमें कैरोटीनॉयड(9 मिलीग्राम प्रति 100 ग्राम ताज़ा वचन)और एंथोसायनिन(60 मिलीग्राम प्रति 100 ग्राम ताज़ा वचन) दोनों हैं; ओएफएसपी संकर (43/83 और 536/6) जिनमें 22.50% और 19.00% की उच्च स्टार्च सामग्री के साथ-साथ सूखा सहिष्णु लाइनें हैं, जैसे देंकनल लोकल-2, 84×14, SB21/57, हावड़ा और S-783।

4. रतालू में, वांछनीय गुणों वाले जीनोटाइप की पहचान की गई, जैसे उच्च उपज देने वाले बडे रतालू जीनोटाइप, DaH-10-425 (67.65 टन प्रति हेक्टेयर) और DaH-10-116 (67.03 टन प्रति हेक्टेयर) और साथ ही कॉम्पैक्ट कंद वाले जीनोटाइप DaH-10-116 (औसत लंबाई 53 से. मी. और घेरा 60 से. मी.)। सफेद रतालू में, DRS-1050 सबसे अधिक उपज(59.25 टन प्रति हेक्टेयर) था। कॉम्पैक्ट बेलनाकार कंदों वाली प्री-रिलीज़ किस्म SD-15 ने गैर-अनुगामी परिस्थितियों में 47.54 टन प्रति हेक्टेयर उपज दी। एक टन न्यूक्लियस बीज सामग्री का उत्पादन किया गया। बौने सफेद रतालू में, DrD-1033 सबसे अधिक उपज देने वाला (45.67 टन प्रति हेक्टेयर) था।

5. जर्मप्लाज्म में एक अनोखा बैंगनी-मांसल अरबी संग्रह में जोड़ा गया था। अरबी में चार टीएलबी प्रतिरोधी लाइनों (NEH-77, IC330438, BRAD-2021-1 और Line-48) की पहचान की गई। बायोफोर्टिफाइड अरबी जीनोटाइप की पहचान की गई, जैसे Ce-558, जिंक से भरपूर(10.57 मिलीग्राम प्रति 100 ग्राम) और CE-334357, जो आयरन से भरपूर (12.50 मिलीग्राम प्रति 100 ग्राम)। फेनोलॉजिकल विकास चरणों को समझने के लिए अरबी में एक विस्तारित बीबीसीएच (बायोलॉजिस बुंडेसनस्टाल्ट, बुंडेसॉर्टेनमंट और केमिसचे इंडस्ट्री) स्केल विकसित किया गया था। याम बीन में, YBH-9×10 (25.47 टन प्रति हेक्टेयर) को एक आशाजनक कम अवधि वाली किस्म (105 दिन) के रूप में पहचाना गया था। अरारोट में, परिग्रहण M-3 की पहचान उच्च प्रकंद उपज (30.04 टन प्रति हेक्टेयर), उच्च स्टार्च उपज (5.95 टन प्रति हेक्टेयर) और कम फाइबर सामग्री (0.84%) के साथ प्रसंस्करण के लिए और फसल में पहली किस्म के रूप में जारी करने के लिए उपयुक्त पायी गई थी।

6. कॉलसिंग मीडिया [BA (2 मिलीग्राम प्रति लिटर) + NAA (0.5 मिलीग्राम प्रति लिटर)] को टैनिया में मानकीकृत किया गया था। याम बीन में कैनेटिन (1.5 मिलीग्राम प्रति लिटर) के साथ 4.80 अंकुर पैदा करने वाला एक तीव्र पुनर्जनन प्रोटोकॉल विकसित किया गया था। कसावा जीनोटाइप श्री कावेरी (एक इनब्रेड S 2 लाइन) और 9S-127 (एक हाइब्रिड) के पूरे जीनोम अनुक्रम को भारतीय जैविक डेटा सेंटर (आईबीडीसी) डेटाबेस (INCARX100021; INCARX100023) में जमा किया गया था और एक डेटाबेस, CasGVD डेटाबेस विकसित किया गया था। बायोप्रोस्पेक्टिंग अध्ययन में, उच्च करक्यूमिन सामग्री से जुड़ी कर्कुमा एंजस्टिफोलिया (Ca1 और Ca2) की निचली CURS2 अभिव्यक्ति स्टैफिलोकोकस ऑरियस के खिलाफ जीवाणुरोधी प्रभाव को उचित ठहराती है।

7. इस वर्ष तीन किस्में जारी की गई। श्री कावेरी (51 टन प्रति हेक्टेयर), एक सीएमडी प्रतिरोधी किस्म, जो भारतीय कसावा मोज़ेक वायरस और श्रीलंकाई कसावा मोज़ेक वायरस दोनों के लिए प्रतिरोधी है, जो केरल, तमिलनाडु और आंध्र प्रदेश राज्यों के लिए केंद्रीय रूप से जारी किया गया था। अरबी की दो किस्में, श्री हीरा (16-20 टन प्रति हेक्टेयर) और श्री तेलिया (10-12 टन प्रति हेक्टेयर) को ओडिशा राज्य के लिए राज्य किस्म रिलीज समिति (SVRC) के माध्यम से आईसीएआर-सीटीसीआरआई, भुवनेश्वर के क्षेत्रीय स्टेशन से जारी की गई। श्री हीरा टीएलबी के प्रति सहनशील है, जबकि श्री तेलिया जल्दी पकने वाली (120 दिन) किस्म है। इनके अलावा, दो प्रविष्टियाँ रिलीज़ के लिए 2023 के दौरान एसवीआरसी, ओडिशा को प्रस्तुत की गई। शकरकंद

प्रविष्टि SPH-31 (IC650535) एक एंथोसायनिन समृद्ध लाइन(133-157 एम. जी. प्रति 100 ग्राम ताज़ा वचन) है जिसकी उपज 26.06 टन प्रति हेक्टेयर है जिसे श्री अरुणिमा नाम से जारी किया जाएगा। याम बीन प्रविष्टि YBH-3×8 (IC650536) एक उच्च उपज देने वाली (33.27 टन प्रति हेक्टेयर) है जिसे श्री चंद्रिका नाम से जारी किया जाएगा।

8. दो फसल प्रणालियों अर्थात अरबी+सब्जी लोबिया और चावल-कम अवधि के कसावा-ककड़ी को जैविक रूप से कुशल और उत्पादक के रूप में पहचाना गया। वनस्पति लोबिया (1:1) के साथ अरबी की अंतरवर्ती खेती के परिणाम स्वरूप काफी अधिक कॉर्मेल समतुल्य उपज (20 टन प्रति हेक्टेयर), अधिक भूमि समतुल्य उपज (>1) और B:C अनुपात (2.44) प्राप्त हुआ। चावल-कम अवधि वाला कसावा (वर. श्री विजया या वेल्लायणी ह्रस्वा)-खीरा (वर. KAU विशाल) ने उच्च कंद समतुल्य उपज (98.15 टन प्रति हेक्टेयर), उत्पादन क्षमता (272.63 कि.लो. प्रति हेक्टेयर प्रति दिन) और ऊर्जा का उत्पादन किया कम उर्वरता स्तर पर समतुल्य (323.63×103 एम.जे. प्रति हेक्टेयर) (आधा एफवाईएम और एन, कसावा के लिए शून्य पी; ककड़ी के लिए आधा एफवाईएम, एन और पी)।

9. कसावा-सब्जी लोबिया और कसावा-मूंगफली 100% जैविक के तहत मूल्यांकन के लगातार सातवें वर्ष उत्पादक थे (कंद समतुल्य उपज क्रमशः 28.39 टन प्रति हेक्टेयर और 24.97 टन प्रति हेक्टेयर) और लाभकारी (शुद्ध आय ₹ 455,313 प्रति हेक्टेयर और ₹ 454,756 प्रति हेक्टेयर और B:C अनुपात क्रमशः 2.15 और 2.55)। इन प्रणालियों की उत्पादन क्षमता और ऊर्जा समकक्ष भी 100% जैविक के तहत उच्चतम थे।

10. दूसरे वर्ष कसावा में प्राकृतिक खेती के प्रयोग से पता चला कि दोनों एकीकृत फसल प्रबंधन (ICM) प्रथाओं ने काफी अधिक उपज (क्रमशः 44.25 टन प्रति हेक्टेयर और 43.69 टन प्रति हेक्टेयर) पैदा की, इसके बाद जैविक (AINPOF) पैकेज (31.91 टन प्रति हेक्टेयर) का उत्पादन हुआ। व्हापासा के बिना प्राकृतिक खेती में अंतरफसल सब्जी लोबिया (झाड़ीदार प्रकार) की उपज सबसे अधिक (2541.23 किलोग्राम प्रति हेक्टेयर) और आईसीएम में हरे चने की उपज (160.84 किलोग्राम प्रति हेक्टेयर) थी।

11. 50% सीपीई पर ड्रिप सिंचाई के साथ छिद्रपूर्ण ग्राउंड कवर मल्चिंग को कसावा (वर. श्री विजया) (64.84 टन प्रति हेक्टेयर) में सर्वोत्तम जल बचत उपचार के रूप में पहचाना गया था। 20.82 टन प्रति हेक्टेयर की उच्चतम उपज के साथ शकरकंद के लिए 100% सीपीई पर ड्रिप सिंचाई स्तर आदर्श था। बड़े रतालू में, 100% सीपीई के साथ एनपीके @ 100:60:100 किलोग्राम प्रति हेक्टेयर के परिणामस्वरूप उच्च कंद उपज (40.40 टन प्रति हेक्टेयर), जल उपयोग दक्षता (56.3 किलोग्राम हेक्टेयर-मिमी$^{-1}$) और B:C अनुपात प्राप्त हुआ (2.95)। इसी प्रकार, 3 दिनों के अंतराल पर और 60 विभाजनों में फर्टिगेशन के परिणामस्वरूप उच्च कंद उपज (39.80 टन प्रति हेक्टेयर) और B:C अनुपात (2.87) प्राप्त हुआ।

12. शकरकंद के 90 विशिष्ट पोषक तत्वों के उपयोग के कुशल जीनोटाइप का मूल्यांकन किया गया, किशन ने सबसे अधिक कंद उपज (14.12 टन प्रति हेक्टेयर) का उत्पादन दिया। एसिड अल्फिसोल्स में बायोफोर्टिफाइड शकरकंद के लिए NPK @ 75:25:75 किलोग्राम प्रति हेक्टेयर एन, P_2O_5 और K_2O के साथ 5 टन प्रति हेक्टेयर की दर से एफवाईएम का एकीकृत अनुप्रयोग इष्टतम खुराक था। 45 से.मी. मेड़ ऊंचाई और 90 से.मी. पंक्ति से पंक्ति की दूरी पर भूकृष्ण बेलों के रोपण से काफी अधिक विपणन योग्य कंद उपज (13.7 टन प्रति हेक्टेयर) के साथ-साथ B:C अनुपात (3.42) प्राप्त हुआ।

13. उच्चतम औसत टिकाऊ उपज सूचकांक (SYI) अनुकूलित उर्वरकों (CF) (0.830), लोबिया के साथ यथास्थान हरी खाद (0.617), 7III E3-5 (0.834) के तहत पीओपी की 25% अनुशंसित खुराक पर NUE जीनोटाइप और ज़िंक अनुप्रयोग के साथ देखा गया। (मिट्टी और पत्ते दोनों में अनुप्रयोग) (0.775)।

14. कसावा में सूखा सहनशीलता प्रदान करने के लिए खनिज पोषक तत्वों में, 120-150 DAP के दौरान 1% पर KNO_3 और 1% सांद्रता पर सोलूबोर के पत्तेदार अनुप्रयोग के परिणामस्वरूप नियंत्रण की तुलना में क्रमशः 22.05 और 22.48 टन प्रति हेक्टेयर की उच्चतम कंद पैदावार हुई 13.86 टन प्रति हेक्टेयर)।

15. कुल 1,39,500 कसावा के तने, 29 टन जिमीकंद, 14 टन बडे रतालू, 12 टन सफेद रतालू, 3 टन छोटे रतालू, 7 टन अरबी, 17,30,000 शकरकंद की कतरनें, 50,000 बेल गुणवत्तापूर्ण रोपण सामग्री के रूप में चीनी आलू और 150 किलोग्राम रतालू की फलियों का उत्पादन किया गया। केरल, तमिलनाडु, ओडिशा और आंध्र प्रदेश में 188 एकड़ क्षेत्र में उष्णकटिबंधीय कंद फसलों जैसे कसावा, शकरकंद, जिमीकंद और चीनी आलू के गुणवत्तापूर्ण रोपण सामग्री उत्पादन के लिए कुल 43 बीज गांव स्थापित किए गए थे। केरल, तमिलनाडु और ओडिशा के कुल 42 किसानों (57.35 एकड़ को कवर करते हुए) को कंद फसलों के गुणवत्तापूर्ण रोपण सामग्री उत्पादन के लिए DSM के रूप में पंजीकृत किया गया है।

16. रतालू बीज कंद उत्पादन के लिए बेल की कटिंग का उपयोग एक व्यवहार्य विकल्प है और IBA 100 ppm से उपचारित दो नोड कटिंग की बेल की कटिंग उपज मापदंडों के संबंध में सबसे अच्छा उपचार था। जिमीकंद में मिनीसेट प्रसार के शोधन से पता चला कि उच्चतम अंकुर शक्ति सूचकांक और क्षेत्र स्थापना (91%) और सबसे बड़ा चंदवा प्रसार (0.566 m^2) 200 ग्राम सेट आकार में देखा गया था। थायोयूरिया के साथ-साथ 1% कवकनाशी (कार्बेन्डाजिम + मैंकोजेब) के परिणामस्वरूप शत-प्रतिशत अंकुरण हुआ। उच्चतम क्षेत्र स्थापना कवकनाशी और ट्राइकोडर्मा उपचार (क्रमशः 85.60 और 85.44%) के तहत थी।

17. छह अलग-अलग उपचारों की राइजोस्फीयर मिट्टी से निगरानी की गई सूक्ष्मजीवों (बैक्टीरिया और कवक) और माइक्रोआर्थ्रोपॉड की विविधता और प्रचुरता से संकेत मिलता है कि बेसिलस और स्यूडोमोनास प्रमुख जेनेरा थे और कीटनाशक लागू मिट्टी में जीवाणु प्रजातियों की विविधता सर्वाधिक थी। देखे गए मृदा माइक्रोआर्थ्रोपोड्स को छह समूहों में विभाजित किया जा सकता है: कोलेम्बोला, कोलोप्टेरा, हाइमनोप्टेरा, अरनेई, एकरी और डिप्लोपोडा।

18. अईपोमिया मॉरिटियाना की पहचान शकरकंद घुन के विरुद्ध प्रतिरोधी जीन के स्रोत के रूप में की गई थी। शकरकंद की पत्तियों में प्रोटीएज़ अवरोधक की अभिव्यक्ति को विनियमित किया गया था, जबकि सिस्टीन प्रोटीएज़ अवरोधक और कुनित्ज़ ट्रिप्सिन अवरोधक की

अभिव्यक्ति में कोई बदलाव नहीं हुआ था। प्रोटीएज़ अवरोधक जीन की अभिव्यक्ति को संक्रमण के एक सप्ताह बाद जड़ों में अपग्रेड किया गया था और सिस्टीन प्रोटीएज़ अवरोधक की अभिव्यक्ति को संक्रमण के तीन सप्ताह बाद जड़ों में अपग्रेड किया गया था।

19. नया नेमाटाइड, फ्लुओपाइरम 34.48% एसएल (0.5 मि.ली.) कम क्षति (15% और 11%) और अधिक उपज (3.30 और 2.20 किलोग्राम प्रति पौधा) के साथ जिमीकंद (वर. श्री पद्मा) और चीनी आलू (वर. श्री धरा) में मेलोइडोगाइन इन्कोग्निटा के खिलाफ प्रभावी था।

20. कटाई के बाद सबसे अधिक सड़ांध जिमीकंद किस्म, गजेंद्र (62.60%) में देखी गई और सबसे कम घटना श्री आतिरा (52.60%) में देखी गई। वनस्पति विज्ञान, हल्दी पाउडर 1% और कुचले हुए लहसुन 1% के साथ अकेले या नन्मा (0.7%) के साथ कॉर्म का उपचार अनुशंसित रणनीतियों के बराबर था [ट्राइकोडर्मा समृद्ध गाय-गोबर घोल या कार्बेन्डाजिम 12% + मैन्कोजेब 63 % WP (0.2%) के साथ कॉर्म का उपचार करना]।

21. रतालू में एन्थ्रेक्नोज की उच्चतम कमी एज़ोक्सीस्ट्रोबिन + डिफेनोकोनाज़ोल (88%) (1 मि.ली. प्रति लिटर) के अनुप्रयोग के कारण प्राप्त हुई, जिसके बाद डिफेनोकोनाज़ोल (1 मि.ली. प्रति लिटर) और कार्बेन्डाजिम (0.5 ग्राम प्रति लिटर) का उपयोग किया गया।

22. श्रीलंकन कसावा मोज़ेक वायरस की LAMP आधारित पहचान और दशीन मोज़ेक वायरस की DAC-ELISA आधारित पहचान का सत्यापन पूरा हो गया और स्थिरता, परंपरा, कृषि-खाद्य प्रणालियों और लचीलेपन के लिए उष्णकटिबंधीय कंद फसलों पर राष्ट्रीय सम्मेलन के दौरान नैदानिक किट के रूप में जारी किया गया।

23. लासियोडिप्लोडिया थियोब्रोमे और पेक्टोबैक्टीरियम कैरोटोवोरा को पहली बार क्रमशः शकरकंद में पत्ती झुलसा और जिमीकंद में जीवाणु भंडारण सड़न पैदा करने वाले रोगजनकों के रूप में रिपोर्ट किया गया था।

24. कसावा स्टेम-कॉयर पिथ आधारित और कसावा स्टेम-चावल भूसी-आधारित कण बोर्डों का उत्पादन करने के लिए प्रक्रिया स्थितियों को अनुकूलित किया गया था। पार्टिकल बोर्ड तैयार करने के लिए कसावा के तने को गर्म पानी से पूर्व उपचारित करने को मानकीकृत किया गया है।

25. कसावा और शकरकंद के साल भर के चारे के उत्पादन में क्रमबद्ध तरीके से पत्तियों की कटाई के प्रभाव का अध्ययन किया गया। 6 महीने तक के अध्ययन से पता चला कि कसावा में, श्री जया किस्म ने उच्च पत्ती उपज (19 टन प्रति हेक्टेयर) पैदा की, इसके बाद श्री रक्षा किस्म (14.10 टन प्रति हेक्टेयर) का उत्पादन हुआ। शकरकंद में, किशन किस्म में बेल की पैदावार अधिक (20.70 टन प्रति हेक्टेयर) थी, इसके बाद क्रमशः 7-पत्ती की कटाई और 6-बेल की कटाई के उपचार के बाद श्री भद्रा किस्म की पैदावार हुई।

26. उच्च जल अवशोषण क्षमता वाले कसावा स्टार्च फॉस्फेट कार्बामेट का पानी से मेथिलीन ब्लू डाई हटाने के लिए सफलतापूर्वक मूल्यांकन किया गया था। संतुलन अवस्था में हाइड्रोजेल द्वारा डाई हटाने का प्रतिशत लगभग 98.30-99.20% था जिसमें डाई सांद्रता 10 और 20 ppm और अधिशोषक सांद्रता 20 और 30 मिलीग्राम थी। मिट्टी की नमी बनाए रखने में सुधार के लिए हाइड्रोजेल का मृदा योज्य के रूप में भी परीक्षण किया गया था। कसावा स्टार्च फॉस्फेट कार्बामेट हाइड्रोजेल संशोधित मिट्टी के नमूनों की सरंध्रता, जल धारण क्षमता और पोषक तत्व की स्थिति में उल्लेखनीय वृद्धि हुई।

27. भौतिक रसायन, चिपकाने और पाचन गुणों पर पौधे/पशु स्रोतों से प्रोटीन के साथ कसावा स्टार्च के संयोजन के प्रभाव का अध्ययन किया गया था। प्रोटीन के स्रोत ने संशोधित स्टार्च के गुणों को महत्वपूर्ण रूप से प्रभावित किया। चिपचिपाहट, सूजन शक्ति, इन विट्रो स्टार्च पाचनशक्ति में उल्लेखनीय कमी आई, जबकि जटिलता के बाद जल धारण क्षमता में वृद्धि हुई।

28. मैदा-मुक्त शकरकंद और ज्वार-आधारित पतली कुकीज़ विकसित की गईं और 40% शकरकंद के आटे, 40% ज्वार के आटे और 20% गेहूं के आटे में तुलनात्मक रूप से उच्च पोषण और संवेदी गुण थे। शकरकंद, मोती बाजरा और गेहूं के आटे पर आधारित चोको से भरे कुकीज़ में पोषण संबंधी विशेषताओं का अध्ययन किया गया था और 40% शकरकंद का आटा, 40% मोती बाजरा का आटा और 20% गेहूं का आटा युक्त उत्पाद अन्य योगों की तुलना में पोषण और संवेदी विशेषताओं में बेहतर था। शकरकंद-ज्वार कम कैलोरी वाली कुकीज़ के विकास के लिए प्राकृतिक स्वीटनर (स्टीविया) का उपयोग किया गया था। 45 ग्राम शकरकंद और ज्वार और 10 ग्राम गेहूं के आटे का संयोजन पोषण और संवेदी गुणों के मामले में सबसे अच्छा था।

29. चावल के एनालॉग्स को कसावा (40-50%), मोती बाजरा (25-35%), ग्वार गम (0.5 और 1.0%) आधारित मिश्रित आटे के साथ-साथ कसावा आटा (40-50%), बार्नयार्ड बाजरा आटा (25-35%) और अलसी (2 और 3%) से विकसित किया गया था, जो उनके जैव रासायनिक, भौतिक और खाना पकाने के गुणों को निर्धारित करके विशेषता थी। पास्ता को कसावा-मोती बाजरा-सोया आटा आधारित मिश्रित आटे से विकसित किया गया था और अनुकूलित पैरामीटर कसावा - 40%, मोती बाजरा - 58.38% और सोया आटा - 15% थे।

30. रिज और नाली प्रणाली में उगाए गए चीनी आलू कंदों की कटाई के लिए एक ट्रैक्टर संचालित प्रोटोटाइप हार्वेस्टर विकसित किया गया है। हार्वेस्टर की वास्तविक क्षेत्र क्षमता और क्षेत्र दक्षता क्रमशः 0.13 ha h^{-1} और 81.15% है और यांत्रिक हार्वेस्टर की तुलना में प्रति हेक्टेयर कटाई की लागत ₹ 18,400 है और ₹ 94,100 प्रति हेक्टेयर की बचत होती है। खेत में ही गुणवत्तापूर्ण टैपिओका सेट तैयार करने के लिए एक पोर्टेबल स्व-चालित टैपिओका सेट कटर विकसित किया गया, जिसे हाथ या पैडल द्वारा संचालित किया जा सकता है। मशीन की कटिंग दक्षता, क्षतिग्रस्त सेटों का प्रतिशत और आउटपुट क्षमता क्रमशः 98%, 0.45% और 3600 सेट प्रति घंटा है।

31. सेलम जिले में आयोजित एफएलडी से पता चला कि श्री अतुल्य की उपज स्थानीय किस्मों की तुलना में 9.42% अधिक थी, जिसका B:C अनुपात 2.74 था और नामक्कल जिले में श्री अतुल्य की उपज स्थानीय किस्मों की तुलना में 11.91% अधिक थी, जिसका B:C अनुपात 2.07 था। सेलम और नामक्कल जिलों में उच्च उपज देने वाली कसावा मोज़ेक रोग प्रतिरोधी किस्म श्री कावेरी पर ओएफटी से पता चला कि स्थानीय किस्मों की तुलना में सिंचित स्थितियों के तहत उपज 9.80% अधिक (2.78 के B:C अनुपात के साथ) और 7.97% अधिक (2.60

के B:C अनुपात के साथ) थी। तेंकाशी जिले में आयोजित चीनी आलू में SSNM पर एफएलडी से पता चला कि श्री धारा के SSNM उपचारित भूखंड की उपज 2.74 के B:C अनुपात के साथ स्थानीय किस्मों की तुलना में 12.15% अधिक उपज देती है और तिरुनेल्वेली जिले में श्री धारा के उपचारित भूखंड की उपज 2.81 के B:C अनुपात के साथ स्थानीय किस्मों की तुलना में 9.78% अधिक था।

32. अट्टपाडी तालुक में किए गए तीन एफएलडी से पता चला कि भू कांति ने भू सोना और भू जा की तुलना में सबसे अधिक कंद उपज (20.27 टन प्रति हेक्टेयर) पैदा की। छात्रों द्वारा बाजरा दलिया की स्वीकार्यता ने संकेत दिया कि माल्टेड रागी को इसकी उपस्थिति ($t=3.38$; $p<0.05$), स्वाद ($t=2.24$; $p<0.05$) और मुंह का अनुभव ($t=3.202$; $p<0.05$) के लिए फोलेट समृद्ध रागी की तुलना में काफी अधिक रेटिंग दी गई है।

33. बेलगाम जिले में शकरकंद उत्पादन में महिला सशक्तिकरण में 60 पुरुष और 60 महिला किसान शामिल थे, जिससे पता चला कि शकरकंद में समग्र सशक्तिकरण सूचकांक पुरुषों के लिए 0.82 और महिलाओं के लिए 0.58 था।

34. तमिलनाडु में 300 किसानों के बीच कसावा की उन्नत किस्मों पर प्रभाव मूल्यांकन से पता चला कि 47.31% किसानों ने कसावा की उन्नत किस्मों को अपनाया जिससे क्रमशः 13% और 17% की अतिरिक्त उपज और आय हुई।

35. एक इंटरैक्टिव कसावा जीनोमिक वेरिएंट डेटाबेस विकसित किया गया था, जिसमें श्री कावेरी और 9S-127 किस्मों के लिए SNP और इनडेल डेटा शामिल था। AgriAnalytics@R ver. 3.10 ने कृषि अनुसंधान के लिए सांख्यिकीय विश्लेषण और डेटा विज़ुअलाइज़ेशन के लिए प्रस्ताव मॉड्यूल विकसित किए। CRAN को प्रस्तुत R पैकेज baseq, जैविक डेटा को संसाधित करने के लिए कार्य प्रदान करता है।

36. 10,000 किलोग्राम बडे रतालू, 1000 किलोग्राम जिमीकंद, 400 किलोग्राम अरबी, 100 किलोग्राम याम बीन, शकरकंद की 10, 00,000 कलमें और कसावा के 6000 तने, चार प्रकार के छोटे उपकरण (प्रत्येक 300 सं) की रोपण सामग्री आईसीएआर-सीटीसीआरआई-टीएसपी कार्यक्रम के तहत ओडिशा के तीन जिलों और आंध्र प्रदेश के एक जिले के 310 आदिवासी किसानों को वितरित किए गए। कंदीय फसलों के साथ फसल विविधीकरण और मूल्य संवर्धन पर दस ऑन-फार्म प्रशिक्षण आयोजित किए गए। एससीएसपी कार्यक्रम के तहत, केरल के परक्कोड ब्लॉक, पत्तनमत्तिट्टा जिले और तमिलनाडु के कड्डालोर और करूर जिलों में कसावा और जिमीकंद की उन्नत किस्मों पर 120 क्षेत्रीय प्रदर्शन किए गए। 140 लाभार्थी किसानों को श्री कावेरी जैसे कसावा के 25,000 तनों की रोपण सामग्री, इनपुट, कृषि उपकरण और उपकरण वितरित किए गए। 717 किसानों और अन्य हितधारकों के लाभ के लिए सत्रह आउटरीच कार्यक्रम आयोजित किए गए।

37. एनईएच कार्यक्रम के तहत, असम में कसावा किस्म श्री रक्षा की पत्तियों को खिलाकर एरी रेशम के कीड़ों को पालना लाभदायक था, प्रति एकड़ 6000 किलोग्राम कसावा की पत्तियां सालाना 400 लार्वा का समर्थन करती थीं, जिससे ₹ 60,000 का शुद्ध लाभ होता था। मेघालय और त्रिपुरा राज्यों में भु सोना और भू कृष्णा की बायोफोर्टिफाइड शकरकंद किस्मों पर कुल 43 प्रदर्शन आयोजित किए गए, जिसमें पता चला कि भु कृष्णा ने भु सोना (8.78 टन प्रति हेक्टेयर) की तुलना में अधिक कंद उपज (10.94 टन प्रति हेक्टेयर) का उत्पादन किया। त्रिपुरा, मेघालय और असम में भू सोना और भू कृष्णा की बायोफोर्टिफाइड शकरकंद किस्मों के पांच पोषक गांव स्थापित किए गए, जिसमें टिकाऊ कृषि पद्धतियों और आर्थिक विकास को बढ़ावा देने के लिए 10 किसानों को DSM बीज योजना में नामांकित किया गया।

38. छह प्रौद्योगिकियों को लाइसेंस दिया गया और अनुबंध अनुसंधान के लिए दो और परामर्श सेवा के लिए एक समझौता ज्ञापन पर हस्ताक्षर किए गए। कृषि उत्पादों को छीलने के लिए एक उपकरण के लिए एक पेटेंट आवेदन दायर किया गया था। आईसीएआर द्वारा आठ प्रौद्योगिकियों को प्रमाणित किया गया।

39. आईसीएआर-सीटीसीआरआई कंद फसलों पर Ph.D. कार्यक्रम चलाने के लिए एक अनुमोदित अनुसंधान केंद्र है। इस अवधि के दौरान, संस्थान ने B.Sc./B.Tech. छात्रों को एक्सपोज़र प्रशिक्षण, M.Sc. छात्रों के लिए प्रोजेक्ट कार्य, Ph.D. छात्रों को तकनीकी मार्गदर्शन प्रदान किया, कुल मिलाकर 198

40. आईसीएआर-सीटीसीआरआई द्वारा देश के विभिन्न हिस्सों से कुल 5916 किसानों, 105 छात्रों और 703 अधिकारियों को प्रशिक्षण दिया गया। आईसीएआर-सीटीसीआरआई ने 28 प्रदर्शनियों और 717 एफ़एलडी/ओएफ़टी में भाग लिये।

41. स्थिरता, परंपरा, कृषि-खाद्य प्रणालियों और लचीलेपन के लिए उष्णकटिबंधीय कंद फसलों विषय पर राष्ट्रीय सम्मेलन 27-29 नवंबर 2023 के दौरान देश भर से 150 से अधिक प्रतिनिधियों की भागीदारी के साथ आयोजित किया गया था। दो विचार-मंथन सत्र भी आयोजित किए गए, एक कसावा मीलीबग्स पर और दूसरा चीनी आलू पर।

42. संस्थान में कुल प्रकाशन थे 382: जिसमें शोध पत्र: 75; संगोष्ठी: 126; पुस्तकें: 4; पुस्तक अध्याय: 41; तकनीकी बुलेटिन: 13; तकनीकी फ़ोल्डर/पत्रक/पर्चे: 25; लोकप्रिय लेख: 46; पाठ्यक्रम/प्रशिक्षण मैनुअल: 24; ई-प्रकाशन: 4; संस्थान प्रकाशन: 13; रेडियो टॉक: 6 और टीवी कार्यक्रम: 5 शामिल थे।

Executive Summary

The genetic wealth conserved with newer collections, varieties released, processes, protocols, technologies, methods, high value compounds and post-harvest machinery developed under 46 Institute projects, as well as 31 external funded projects are given below:

1. A total of 5542 accessions, comprising 1221 cassava, 1110 sweet potato, 1023 yams, 689 edible aroids, 229 minor tuber crops and 1270 collections from Regional Station were maintained and conserved in the field gene bank. Of these, the 65 new collections of tuber crops comprised cassava (5), yams (13), edible aroids (25) and minor tuber crops (22).
2. Cassava genotypes having various desirable traits were identified viz., high harvest index (>0.80), high tuber weight plant^{-1} (>10 kg) and resistance to cassava mosaic disease (CMD) (8); high harvest index (>0.80) and resistance to CMD (5); sweet taste and high tuber weight (9); β-carotene rich yellow tubers with sweet taste (3); CMD resistant, early bulking genotypes with low sugar content (17S-1, 19S-4-3 and 17S-247) and high yielding genotypes (>50 t ha^{-1}) viz., 17S-48, 19S-4-3 and 19S-4-2 as well as promising PPD tolerant clonal progenies with tolerance up to 7 days (133).
3. Sweet potato genotypes with desirable traits were identified viz., biofortified high carotene OFSP hybrid 38/15 with a carotene content of 14.50 mg 100g^{-1} FW, cream fleshed 38/46 with an anthocyanin content of 8-10 mg 100g^{-1} FW and starch content of 20%; hybrid 110/28 having both carotenoids (9 mg 100g $^{-1}$ FW) and anthocyanins (60 mg 100g^{-1} FW); OFSP hybrids (43/83 and 536/6) with high starch contents of 22.50% and 19% as well as drought tolerant lines viz., Dhenkanal local-2, 84×14, SB21/57, Howrah and S-783.
4. In yams, five genotypes with desirable traits were identified viz., high yielding greater yam genotypes, DaH-10-425 (67.65 t ha^{-1}) and DaH-10-116 (67.03 t ha^{-1}) as well as genotype with compact tubers DaH-10-116 (average length of 53 cm and girth of 60 cm). In white yam, DRS-1050 was the highest yielder (59.25 t ha^{-1}). The pre-release variety SD-15 with compact cylindrical tubers yielded 47.54 t ha^{-1} under non-trailing conditions. One ton nucleus seed material was produced. In dwarf white yam, DrD-1033 was the highest yielder (45.67 t ha^{-1}).
5. A unique purple-fleshed taro collection was added to the germplasm. Four taro leaf blight (TLB) resistant lines were identified (NEH-77, IC330438, BRAD-2021-1 and Line-48). Biofortified taro genotypes identified are CE-558, rich in zinc (10.57 mg 100g^{-1}) and CE-334357, rich in iron (12.50 mg 100g^{-1}). An extended BBCH (Biologische Bundesanstalt, Bundessortenamnt and Chemische Industrie) scale was developed in taro for understanding the phenological growth stages. In yam bean, YBH-9×10 (25.47 t ha^{-1}) was identified as a promising short duration variety (105 days). In arrowroot, accession M-3 was identified as the best with high rhizome yield (30.04 t ha^{-1}), high starch yield (5.95 t ha^{-1}) and low fibre content (0.84%) suitable for processing and release as the first variety in the crop.
6. Callusing media [BA (2 mg l^{-1}) + NAA (0.5 mg l^{-1})] was standardized in tannia. A rapid regeneration protocol was developed in yam bean with Kinetin (1.5 mg l^{-1}) producing 4.80 shoots. Whole genome sequences of cassava genotypes Sree Kaveri (an inbred S2 line) and 9S-127 (a hybrid) were deposited to the Indian Biological

Data Centre (IBDC) database (INCARX100021; INCARX100023) and a database, CasGVD Database was developed. In the bioprospecting study, the lower *CURS2* expression of *Curcuma angustifolia* (Ca1 and Ca2), associated with higher curcumin content justifies the anti-bacterial effect against *Staphylococcus aureus*.

7. Three varieties were released this year. Sree Kaveri (51 t ha^{-1}), a CMD resistant cassava variety, resistant to both *Indian Cassava Mosaic Virus* and *Sri Lankan Cassava Mosaic Virus,* was released centrally for the states of Kerala, Tamil Nadu and Andhra Pradesh. Two taro varieties, Sree Hira (16-20 t ha^{-1}) and Sree Telia (10-12 t ha^{-1}) were released from the Regional Station of ICAR-CTCRI, Bhubaneswar through State Variety Release Committee (SVRC) for the state of Odisha. Sree Hira is tolerant to TLB, whereas Sree Telia is an early maturing (120 days) variety. Apart from these, two entries were submitted to the SVRC, Odisha during 2023 for release. The sweet potato entry SPH-31 (IC650535) is an anthocyanin rich line (133-157 mg $100g^{-1}$ FW) with an yield of 26.06 t ha^{-1} submitted for release in the name Sree Arunima. The yam bean entry YBH-3×8 (IC650536), a high yielder (33.27 t ha^{-1}) is submitted for release in the name Sree Chandrika.

8. Two cropping systems viz., taro+vegetable cowpea and rice-short duration cassava-cucumber were identified as biologically efficient and productive. Intercropping taro with vegetable cowpea (1:1) resulted in significantly higher cormel equivalent yield (20 t ha^{-1}), greater land equivalent yield (>1) and B:C ratio (2.44). Rice-short-duration cassava (var. Sree Vijaya or Vellayani Hraswa)-cucumber (var. KAU Vishal) producedhighertuberequivalentyield(98.15tha^{-1}), production efficiency (272.63 kg ha^{-1} day^{-1}) and energy equivalent (323.63×10^3 MJ ha^{-1}) at reduced fertility levels (half FYM & N, zero P to cassava; half FYM, N & P to cucumber).

9. Cassava-vegetable cowpea and cassava-groundnut under 100% organic were productive for the seventh consecutive year of evaluation (tuber equivalent yield of 28.39 t ha^{-1} and 24.97 t ha^{-1}, respectively) and remunerative (net income of ₹ 455,313 ha^{-1} and ₹ 454,756 ha^{-1} and B:C ratio of 2.15 and 2.55, respectively). The production efficiency and energy equivalent of these systems were also highest under 100% organic.

10. Natural farming experiment in cassava for the second year indicated that both the integrated crop management (ICM) practices produced significantly higher yield (44.25 t ha^{-1} and 43.69 t ha^{-1}, respectively), followed by organic (AINPOF) package (31.91 t ha^{-1}). The yield of the intercrop vegetable cowpea (bushy type) was highest in natural farming without whapasa (2541.23 kg ha^{-1}) and that of green gram in ICM (160.84 kg ha^{-1}).

11. Porous ground cover mulching with drip irrigation at 50% CPE was identified as the best water saving treatment in cassava (var. Sree Vijaya) (64.84 t ha^{-1}). Drip irrigation level @ 100% CPE was ideal for sweet potato with highest yield of 20.82 t ha^{-1}. In greater yam, 100% CPE along with NPK @ 100:60:100 kg ha^{-1} resulted in higher tuber yield (40.40 t ha^{-1}), water use efficiency (56.3 kg ha-mm^{-1}) and B:C ratio (2.95). Similarly, fertigation at 3 days interval and in 60 splits resulted in higher tuber yield (39.80 t ha^{-1}) and B:C ratio (2.87).

12. Among the 90 elite nutrient use efficient genotypes of sweet potato evaluated, Kishan produced significantly highest tuber yield (14.12 t ha^{-1}). Integrated application of FYM @ 5 t ha^{-1} along with NPK @ 75:25:75 kg ha^{-1} of N, P_2O_5 and K_2O was the optimum dose for biofortified sweet potato in acid Alfisols. Planting of Bhu Krishna vines on ridges of 45 cm height and at 90 cm row to row spacing resulted in significantly higher marketable tuber yield (13.70 t ha^{-1}) as well as B:C ratio (3.42).

13. Highest mean sustainable yield index (SYI) was observed with customized fertilizers (CF) (0.830), green manuring *in situ* with cowpea (0.617), NUE genotypes at 25% recommended dose of PoP under 7III E3-5 (0.834) and Zn application (both soil and foliar application) (0.775).

14. Among the mineral nutrients for imparting drought tolerance in cassava, foliar application of KNO_3 at 1% and Solubor at 1% concentration during 120-150 DAP resulted in the highest tuber yields of 22.05 and 22.48 t ha^{-1}, respectively as compared to control (13.86 t ha^{-1}).

15. A total of 1,39,500 cassava stems, 29 tonnes of elephant foot yam, 14 tonnes of greater yam, 12 tonnes of white yam, 3 tonnes of lesser yam, 7 tonnes of taro, 17,30,000 vine cuttings of sweet potato, 50,000 vine cuttings of Chinese potato and 150 kg of yam bean were produced as quality planting materials. A total of 43 seed villages were established for quality planting material production of tropical tuber crops viz., cassava, sweet potato, elephant foot yam and Chinese potato in Kerala, Tamil Nadu, Odisha and Andhra Pradesh covering an area of 188 acres. A total of 42 farmers from Kerala, Tamil Nadu and Odisha (covering 57.35 acres) have been registered as decentralised seed multipliers (DSM) for quality planting material production of tuber crops.

16. The use of vine cuttings is a viable option for yam seed tuber production and vine cuttings of two node cuttings treated with IBA 100 ppm was the best treatment with respect to yield parameters. Refinement of minisett propagation in elephant foot yam showed that highest sprout vigour index and field establishment (91%) and greatest canopy spread (0.566 m^2) was observed in 200 g sett size. Thiourea as well as 1% fungicide (carbendazim + mancozeb) resulted in cent percent sprouting. The highest field establishment was under fungicide and *Trichoderma* treatments (85.60 and 85.44%, respectively).

17. The diversity and abundance of microorganisms (bacteria and fungi) and microarthropods monitored from rhizosphere soil of six different treatments indicated that *Bacillus* and *Pseudomonas* were the predominant genera and the bacterial species diversity was high in insecticide applied soil. Soil microarthropods observed could be divided into six groups: Collembola, Coleoptera, Hymenoptera, Araneae, Acari and Diplopoda.

18. *Ipomoea mauritiana* was identified as source of resistant genes against sweet potato weevil. The expression of protease inhibitor was upregulated in the sweet potato leaves, whereas there was no change in expression of cysteine protease inhibitor and kunitz trypsin inhibitor. The expression of protease inhibitor genes was upregulated in the roots one week after infestation and the expression of cysteine protease inhibitor was upregulated in the roots three weeks after infestation.

19. Newer nematicide, Fluopyram 34.48% SL (0.5 ml) was effective against *Meloidogyne incognita* in elephant foot yam (var. Sree Padma) and Chinese potato (var. Sree Dhara) with less damage (15% and 11%) and higher yield (3.30 and 2.20 kg $plant^{-1}$).

20. Highest postharvest rot was observed in elephant foot yam variety, Gajendra (62.60%) and the least incidence was in Sree Athira (52.60%). Treating the corms with botanicals, turmeric powder 1% and crushed garlic 1% alone or in combination with *Nanma* (0.7%) was on par with the recommended strategies [treating the corms with *Trichoderma* enriched cow-dung slurry or carbendazim 12% + mancozeb 63% WP (0.2%)].

21. Highest reduction of anthracnose in yam was obtained due to the application of azoxystrobin + difenoconazole (88%) (1 ml l^{-1}), which was followed by difenoconazole (1 ml l^{-1}) and carbendazim (0.5 g l^{-1}).

22. Validation of LAMP based detection of *Sri Lankan Cassava Mosaic Virus* and DAC-ELISA based detection of *Dasheen Mosaic Virus* was completed and released as diagnostic kit

23. *Lasiodiplodia theobromae* and *Pectobacterium carotovora* were reported for the first time as pathogens causing leaf blight in sweet potato and bacterial storage rot in elephant foot yam, respectively.

24. Process conditions were optimized to produce cassava stem-coir pith based and cassava stem-rice husk-based particle boards. Pretreatment of cassava stem with hot water has been standardized for preparing particle boards.

25. The effect of staggered leaf harvesting in year-round fodder production of cassava and sweet potato was studied. The study up to 6 months revealed that in cassava, var. Sree Jaya produced highest leaf yield (19 t ha^{-1}), followed by var. Sree Reksha (14.10 t ha^{-1}). In sweet potato, var. Kishan had highest vine yield (20.70 t ha^{-1}), followed by var. Sree Bhadra after 7-leaf harvesting and 6-vine cuttings treatment, respectively.

26. Cassava starch phosphate carbamate with high water absorption capacity was successfully evaluated for methylene blue dye removal from water. The dye removal percentage by the hydrogel at the equilibrium state was about 98.30-99.20% with 10 and 20 ppm of the dye concentrations and 20 and 30 mg of the adsorbent concentrations. The hydrogel was also tested as a soil additive to improve soil moisture retention. There was a significant increase in the porosity, water holding capacity and nutrient status of the cassava starch phosphate carbamate hydrogel amended soil samples.

27. The effect of complexation of cassava starch with proteins from plant/animal sources on the physicochemical, pasting and digestive properties was studied. The source of protein significantly affected the properties of the modified starches. There was a significant reduction in viscosity, swelling power, *in vitro* starch digestibility, whereas the water holding capacity increased after complexation.

28. Maida-free sweet potato and sorghum-based thin cookies were developed and 40% of sweet potato flour, 40% of sorghum flour and 20% of wheat flour had comparatively higher nutritional and sensory attributes. The nutritional characteristics were studied in the sweet potato, pearl millet and wheat flour based choco-filled cookies and the product containing 40% of sweet potato flour, 40% of pearl millet flour and 20% of wheat flour was superior in nutritional and sensory attributes compared to other formulations. Natural sweetener (stevia) was used for the development of sweet potato-sorghum low-calorie cookies. The combination of 45 g each of sweet potato and sorghum and 10 g of wheat flour was the best in terms of nutritional and sensory attributes.

29. Rice analogues were developed from cassava (40-50%), pearl millet (25-35%), guar gum (0.5 and 1%) based composite flour as well as from the composite flour containing cassava flour (40-50%), barnyard millet flour (25-35%) and flaxseed (2 and 3%), which were characterized by determining their biochemical, physical and cooking properties. Pasta was developed from cassava-pearl millet-soy flour based composite flour and the optimized parameters were cassava-40%, pearl millet-58.38% and soy flour-15%.

30. A tractor operated prototype harvester has been developed to harvest Chinese potato tubers grown in ridge and furrow system. The actual field capacity and field efficiency of the harvester are 0.13 ha h^{-1} and 81.15%, respectively and the cost per hectare of harvesting is ₹ 18,400 with a savings of ₹ 94,100 ha^{-1} compared to the mechanical harvester. A portable self-propelled tapioca sett cutter was developed for producing quality tapioca setts in the field itself, which can be operated by hand or pedal. The cutting efficiency, percentage of damaged setts and output capacity of the machine are 98%, 0.45% and 3600 setts per hour, respectively.

31. FLDs conducted in Salem district revealed that the yield of Sree Athulya was 9.42% higher than the local varieties with a B:C ratio of 2.74 and in Namakkal district the yield of Sree Athulya was 11.91% higher than the local varieties with a B:C ratio of 2.07. OFTs on high yielding CMD resistant variety Sree Kaveri in Salem and Namakkal districts revealed that the yield was 9.80% higher (with a B:C ratio of 2.78) under irrigated conditions and 7.97% higher (with a B:C ratio of 2.60) under rainfed conditions than the local varieties. FLDs on SSNM in Chinese potato conducted in Tenkasi district revealed that the yield of SSNM treated plot of Sree Dhara gave 12.15% higher yield than the local varieties with a B:C ratio of 2.74 and in Tirunelveli district the yield of treated plot of Sree Dhara was 9.78% higher than the local varieties with a B:C ratio of 2.81.

32. Three FLDs conducted in Attapadi taluk showed that Bhu Kanti produced the highest tuber yield (20.27 t ha^{-1}) than Bhu Sona and Bhu Ja. Acceptability of millet porridge by students indicated that malted ragi rated significantly higher than the folate enriched ragi for its appearance ($t=3.38$; $p<0.05$), taste ($t=2.24$; $p<0.05$) and mouth feel ($t=3.202$; $p<0.05$).

33. Women empowerment in sweet potato production in Belgaum district involving 60 men and 60 women farmers revealed that the overall empowerment index in sweet potato was 0.82 for men and 0.58 for women.

34. Impact assessment on improved varieties of cassava conducted among 300 farmers in Tamil Nadu revealed that 47.31% of the farmers adopted improved varieties of cassava which gave an additional yield and income of 13% and 17%, respectively.

35. An interactive cassava genomic variant database was developed, including SNP and InDel data for Sree Kaveri and 9S-127 varieties. AgriAnalytics@R Ver. 3.10 developed offer modules for statistical analysis and data visualization for agricultural research. The R package baseq, submitted to CRAN, provides function to process biological data.

36. Planting material of 10,000 kg of greater yam, 1000 kg of elephant foot yam, 400 kg of taro, 100 kg of yam bean, 10,00,000 cuttings of sweet potato and 6000 stems of cassava, four types of small tools (each 300 nos.) were distributed to 310 tribal farmers from three districts of Odisha and one district of Andhra Pradesh under ICAR-CTCRI-TSP programme. Ten on-farm trainings were organized on crop diversification with tuber crops and value addition. Under SCSP programme, 120 field demonstrations on improved varieties of cassava and elephant foot yam was carried out in Parakkode block, Pathanamthitta district of Kerala and Cuddalore and Karur districts of Tamil Nadu. Planting materials of 25,000 stems of cassava such as Sree Kaveri, Sree Athulya inputs, farm tools and implements were distributed to 140 beneficiary farmers. Seventeen outreach programs were conducted for the benefit of 717 farmers and other stakeholders.

37. Under NEH programme, rearing Eri silk worms in Assam by feeding with the leaves of cassava variety Sree Reksha was profitable, with 6000 kg of cassava leaves per acre annually supporting 400 larvae, yielding a net profit of ₹ 60,000. A total of 43 demonstrations on biofortified sweet potato varieties of Bhu Sona and Bhu Krishna conducted in Meghalaya and Tripura States showed that Bhu Krishna produced higher tuber yield (10.94 t ha^{-1}) compared to Bhu Sona (8.78 t ha^{-1}). Five nutriseed villages of biofortified sweet potato varieties of Bhu Sona and Bhu Krishna were established in Tripura, Meghalaya and Assam, with 10 farmers enrolled in the DSM seed scheme for promoting sustainable farming practices and economic growth.

38. Six technologies were licensed and two MoUs for contract research and one MoU for consultancy service were signed. A patent application for an apparatus for peeling agricultural products was filed. Eight technologies were certified by ICAR. The technology on e-Crop based smart fertigation system was selected as one of the five best technologies in horticulture sector.

39. ICAR-CTCRI is an approved Research Centre for undertaking Ph.D. programmes. During the period, the Institute has offered internship training to B.Sc./B.Tech students, project work of M.Sc. students, imparted technical guidance to Ph.D. scholars, totaling to 198.

40. A total of 5916 farmers, 105 students and 703 officials from different parts of the country were imparted training by ICAR-CTCRI. The institute participated in 28 exhibitions and carried out 717 FLDs/OFTs.

41. The National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR 2023) was organized during 27-29 November 2023 with the participation of more than 150 delegates across the nation. Two brainstorming sessions on cassava mealybugs and Chinese potato were also organized.

42. Institute had a total of 382 publications: Research papers: 75; Symposia: 126; Books: 4; Book chapters: 41; Technical bulletins: 13; Technical folders/leaflets/pamphlets: 25; Popular articles: 46; Course/training manuals/book of abstracts/ proceedings: 24; E-publications: 4; Institute publications: 13; Radio talks: 6; TV programmes: 5.

Introduction

ICAR-CTCRI, Headquarters, Thiruvananthapuram (48.19 ha)

ICAR-CTCRI Regional Station, Bhubaneswar (20 ha)

ICAR-CTCRI (1963-2023)

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 premier research organization in the world dedicated solely to the research on tropical tuber crops. The Institute celebrated its Diamond Jubilee in 2023 and 60 years of concerted research has led to the development of several sustainable production, protection and processing technologies for tuber crops, besides release of 71 improved varieties. The target group of most of the technologies being marginal and resource poor farmers, adequate emphasis is also given for onfarm evaluation and popularization of the technologies. In

addition, several technologies were also developed in the recent past enabling resource generation through consultancies and commercialization.

ICAR-CTCRI has a germplasm wealth of tuber crops, totalling 5542. The pioneering role in classical breeding of tropical tuber crops attracted international collaborations in the breeding and genetic improvement of these crops. Research on molecular based improvement is also being continued. The ICAR-CTCRI has released 71 varieties with various quality traits and preferences. The cassava starch and sago production in the country is mostly dependent on four major industrial varieties of cassava released from ICAR-CTCRI, viz., H-165, H-226, Sree Athulya and Sree Apoorva. These varieties are promising and acceptable to the farmers as well as industries. The three cassava varieties, Sree Reksha, Sree Sakthi and Sree Suvarna are resistant to cassava mosaic disease (CMD) and are high yielding. A new variety in cassava viz., Sree Kaveri was recently released by Central Variety Release Committee (CVRC) for the states of Tamil Nadu, Andhra Pradesh and Kerala. Sree Kaveri is resistant to cassava mosaic disease, drought tolerant and has high nutrient use efficiency. The β-carotene rich sweet potato varieties, Bhu Sona, Bhu Kanti and Bhu Ja; anthocyanin rich Bhu Krishna and mid-season drought tolerant Bhu Swami have gained wide popularity among the rural and tribal people. Two varieties in taro viz., Sree Telia and Sree Hira were released for the state of Odisha by State Variety Release Committee (SVRC). The Institute has strong research programmes on biotechnology, which includes the development of diagnostic tools for viral and fungal diseases and transgenic plants for conferring resistance to cassava mosaic disease and to enhance the starch content and develop waxy varieties.

Eco-region specific agro-techniques are available for tuber crops in different production systems of the country. Besides, technologies were developed for quality planting material production, sustainable nutrient management (INM, SSNM and organic practice), natural farming, water (micro-irrigation, drip fertigation) and weed management, which help in enhancing the yield, soil fertility and farm income. Improved tuber crop varieties are gaining popularity in Kerala, Tamil Nadu, Andhra Pradesh, Odisha, Bihar, Uttar Pradesh, Gujarat, North eastern states and Lakshadweep Islands through RKVY and other schemes. Integrated crop protection technologies developed for cassava mosaic disease, cassava tuber rot, taro leaf blight, collar rot of elephant foot yam, anthracnose of greater yam and sweet potato weevil would help the farming community in eventualities. Management of banana pseudostem weevil through cassava based bioformulations, viz., *Nanma* and *Menma* was a success in the farmers' fields. In collaboration with ICAR-IISR, Kozhikode, three biocapsules were developed based on encapsulation technology of ICAR-IISR (Indian Patent No. 361021 dated 13.08.2013) containing *Trichoderma asperellum* and *Bacillus* spp. in a gelatine capsule for delivery to agricultural crops. These organisms ensure growth promotion and disease suppression in tuber crops and vegetables.

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 power operated size based Chinese potato grader was recently developed and commercialized for boosting farmers' income. In addition, there are technologies for several value-added food products, which include pasta, noodles, fried snack foods etc. Development of functional foods from cassava, sweet potato, yams and elephant foot yam are the recent contributions. Two ICAR-CTCRI technologies, '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 utilization and farm income by the farmers and other stakeholders. 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 important developmental programmes implemented successfully and have greatly helped to increase livelihood security of the farmers and other stakeholders across the country.

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) has been active in 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. During 2023, six MoUs were signed with Digital University of Kerala; MG University, Kerala; Mar Baselios College of Engineering and Technology, Thiruvananthapuram; Rubber Research Institute of India, Kottayam; IIT, Palakkad and MoA with a-IDEA, Techno Business Incubator, ICAR-NAARM, Hyderabad have strengthened the collaboration for research and education on tuber crops. MoUs were also signed recently for commercializing wax coating technology for fresh cassava tubers, Chinese potato foliar micronutrient formulations, commercializing cassava based bioformulations and value added products of tuber crops etc., which will help in building agribusiness and entrepreneurship development.

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. 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 can be accessed at https://www.ctcri.org, which provides comprehensive information about the various activities of the Institute and online facilities like sales counter, discussion forum etc.

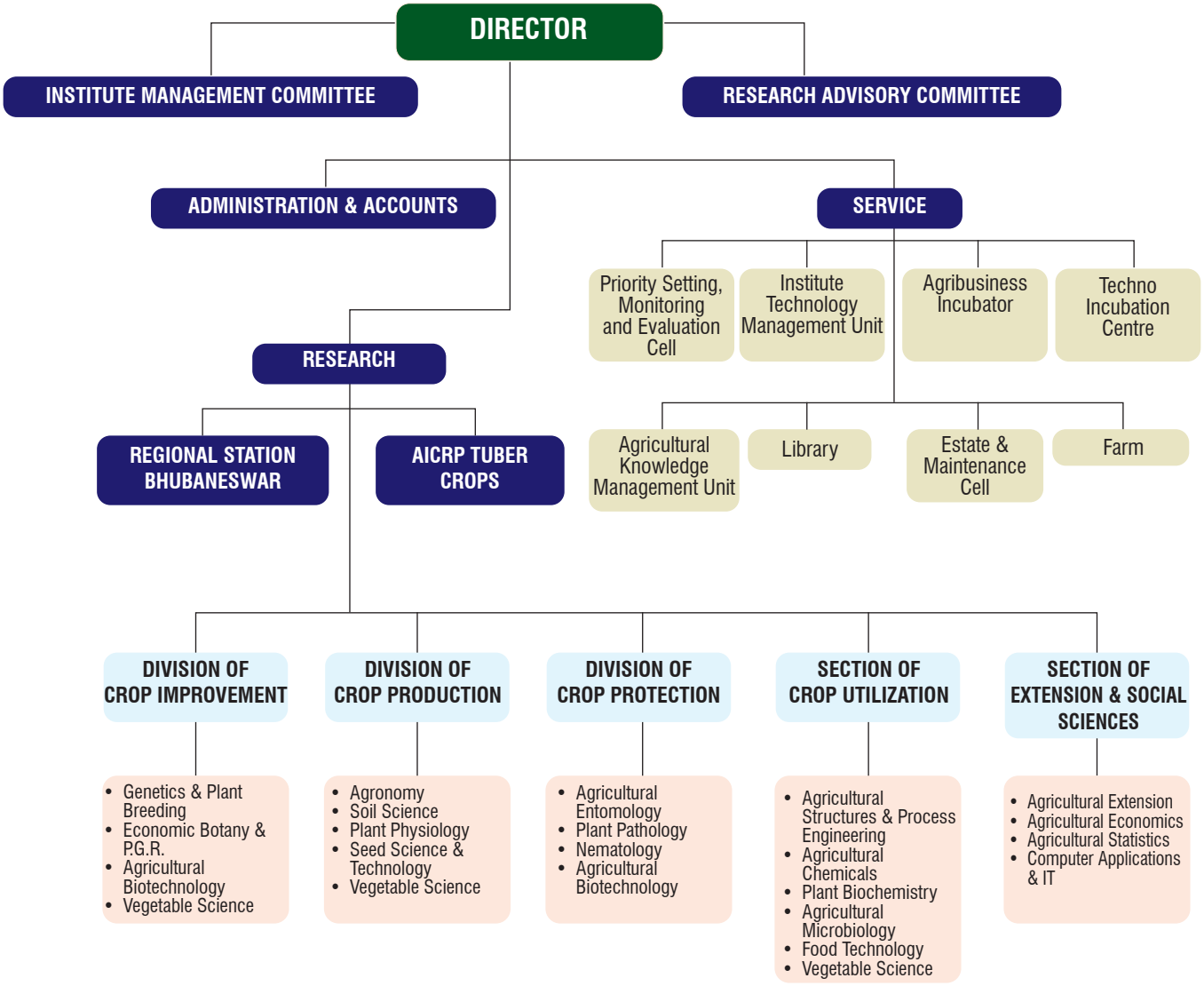
The ICAR-CTCRI celebrated its 60th Foundation Day (Diamond Jubilee Celebration) on 22 July 2023 in the esteemed presence of Dr. Himanshu Pathak, Secretary, DARE and DG, ICAR. During the event, Climate controlled plant growth facility, Farmer facilitation centre and Agribusiness Incubator (ABI) were inaugurated. ICAR-CTCRI in collaboration with Indian Society for Root Crops (ISRC) jointly organized the National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR 2023) during 27-29 November 2023 with the participation of more than 150 delegates across the nation. Two brainstorming sessions were organised one on cassava mealybugs and another on Chinese potato to address the challenges faced by the farmers.

As a part of IYoM celebrations, the Institute has established a Millet Museum for creating awareness among the farmers and common public for the production and consumption of millets. The Institute also celebrated International Year of Millets by organizing various programmes for creating awareness among farmers and other clients.

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 (2023)

Category	Sanctioned	In position	Vacant
RMP	1	1	0
Scientific Staff	44	43	1
Technical Staff	37	31	6
Administrative Staff	30	18	12
Skilled Support Staff	38	17	21
Total	**150**	**110**	**40**

Progressive Expenditure (2022-23)

Sl. No.	Head of Account	RE 2022-23 (Scheme) (₹ in lakhs)	RE 2022-23 (Non Scheme) (₹ in lakhs)	Progressive Expenditure (Scheme+Non Scheme (₹ in lakhs)
	CAPITAL			
1.	Works			
	A. Land			
	B. Building			
	i. Office building	32.96	0.00	32.96
2.	Equipments - Institute	51.32	0.00	51.32
	- SCSP	2.00	0.00	1.99
	- TSP	2.00	0.00	2.00
3.	Information Technology	0.92	0.00	0.92
4.	Library Books and Journals	1.44	0.00	1.44
5.	Vehicles & Vessels	9.50	0.00	9.50
6.	Furniture & Fixtures	3.86	0.00	3.86
	Total – Capital	**104.00**	**0.00**	**103.99**
	REVENUE			
1.	A. Establishment Charges	2032.35	0.00	2032.35
	B. Pension & Other Retirement Benefits	216.72	0.00	216.72
	C. Loans & Advances	0.00	0.00	0.00
2.	Traveling Allowances	340.00	138.00	32.30
3.	Research & Operational Expenses			193.40
4.	Administrative Expenses			245.86
5.	Miscellaneous			6.46
6.	NEH	15.00	0.00	15.00
7.	TSP	40.00	0.00	40.00
8.	SCSP	60.00	0.00	60.00
	Total – Revenue	**2704.07**	**138.00**	**2842.09**
	GRAND TOTAL (Capital + Revenue)	**2808.07**	**138.00**	**2946.08**

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, P. Murugesan, A. Asha Devi, Shirly Raichal Anil, N. Krishna Radhika, Kalidas Pati **Project Associates** K.M. Senthilkumar, M.L. Jeeva, C. Visalakshi Chandra, S.S. Veena, V.B.S. Chauhan, T. Makeshkumar, K. Hanume Gowda, J. Sreekumar, E.R. Harish, R. Arutselvan, A.N. Jyothi, H. Kesava Kumar, T.P. Sujatha
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	K.I. Asha, C. Mohan, A. Asha Devi, T. Makeshkumar, G. Suja, S. Sunitha, K. Susan John, N. Krishna Radhika, A.N. Jyothi, C. Visalakshi Chandra, E.R. Harish, K.M. Senthilkumar, J. Sreekumar, T. Krishnakumar, P. Prakash, 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, A.N. Jyothi, J.Sreekumar, T. Makeshkumar, R. Saravanan
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, R. Saravanan, K.I. Asha, J. Sreekumar, A.N. Jyothi
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, C. Mohan, R. Saravanan, N. Krishna Radhika, J. Sreekumar, CC-PI Monika Dalal (ICAR- NIPB)
5.	**Project 5:** Gene editing in cassava for waxiness	N. Krishna Radhika	K.I. Asha, Shirly Raichal Anil, K.M. Senthilkumar, M.N. Sheela
6.	**Project 6:** Molecular characterisation of nutrient homeostasis in tubers for biofortification of cassava	T.P. Sujatha	M.N. Sheela, J. Sreekumar, A.N. Jyothi
7.	**Project 7:** Phenomics approaches for physiological trait based breeding for drought and PPD tolerance in cassava	C. Mohan	C. Visalakshi Chandra, J. Sreekumar, K.M. Senthilkumar, R. Saravanan, N. Krishna Radhika,V.S. Santhosh Mithra

8.	**Project 8:** 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, R. Saravanan, A.N. Jyothi, J. Sreekumar
9.	**Project 9:** Harnessing the genetic potential of wild *Ipomoea* spp. through wide hybridization for improvement of sweet potato	L.K. Bharathi	Kalidas Pati, C. Visalakshi Chandra, T. Makeshkumar, E.R. Harish
10.	**Project 10:** 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
11.	**Project 11:** Genetic improvement for drought tolerance in sweet potato and high yielding, disease tolerant nutritionally rich lines in taro	V.B.S. Chauhan	Kalidas Pati, K. Hanume Gowda, R. Arutselvan, M. Nedunchezhiyan, K. Laxminarayana
12.	**Project 12:** Breeding for earliness, quality traits and salinity tolerance in sweet potato	K. Hanume Gowda	K. Laxminarayana, V.B.S. Chauhan, Kalidas Pati, K.M. Senthilkumar, R. Saravanan
13.	**Project 13:** Genetic improvement of edible aroids for resistance to biotic stress and quality parameters	A. Asha Devi	Shirly Raichal Anil, S. Sunitha, N. Krishna Radhika, S.S. Veena, K.M. Senthilkumar
14.	**Project 14:** Developing breeder seed standards and precocity of genetic vigour for tropical tuber crops	P. Murugesan	Kalidas Pati, Shirly Raichal Anil, R. Arutselvan, CC-PI Padmakshi Thakur (IGKV)
15.	**Project 15:** Inducing genetic variability, characterization, grouping and developing breeding lines with large tuber size and short duration in Chinese potato	P. Murugesan	L. K. Bharathi, H. Kesava Kumar, T.P. Sujatha, C. Visalakshi Chandra
16.	**Project 16:** Genetic improvement of cassava through gene editing for modified starch	N. Krishna Radhika	K.M. Senthilkumar, T.P. Sujatha, T. Makeshkumar, A.N. Jyothi
III	**HORTCTCRISIL 202001101465 Mega Project 3: Resource management and climate smart agriculture for sustainable production of tropical tuber crops**	**G. Suja**	
1.	**Project 1:** Crop diversification involving tropical tuber crops	G. Suja	M. Nedunchezhiyan, G. Byju, J. Suresh Kumar, S. Sunitha, K. Laxminarayana, S.S. Veena, E.R. Harish, V.B.S. Chauhan, D. Jaganathan, R. Saravanan, K. Sunilkumar
2.	**Project 2:** Weed management in tropical tuber crops	J. Suresh Kumar	S. Sunitha, P. Prakash, M. Nedunchezhiyan, S.S. Veena
3.	**Project 3:** Precision management of water and nutrients in tropical tuber crops	S. Sunitha	G. Suja, V. Ramesh, J. Suresh Kumar
4.	**Project 4:** Drip irrigation and fertigation management in greater yam	M. Nedunchezhiyan	Kalidas Pati
5.	**Project 5:** Sustainable nutrient management in tropical tuber crops	K. Laxminarayana	M. Nedunchezhiyan, K. Susan John, J. Suresh Kumar, A.N. Jyothi
6.	**Project 6:** Long term integrated nutrient management in tropical tuber crops	K. Susan John	V. Ramesh, R. Muthuraj, S.S. Veena, T. Makeshkumar, J. Suresh Kumar
7.	**Project 7:** Soil carbon quality and conservation studies in tropical tuber crops	V. Ramesh	S. Sunitha, P. Prakash, H. Kesava Kumar
8.	**Project 8:** Climate change adaptation and mitigation in tropical tuber crops	V. Ramesh	K. Susan John, R. Saravanan, J. Suresh Kumar, P. Prakash, T. Krishnakumar

9.	**Project 9:** Physiological studies related to climate change in tropical tuber crops	R. Saravanan	J. Sreekumar, K.I. Asha, Shirly Raichal Anil, K.M. Senthilkumar
IV	**HORTCTCRISIL 202001201468 Mega Project 4: Quality planting material production of tropical tuber crops**	**R. Muthuraj**	
1.	**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	K. Sunilkumar, J. Suresh Kumar, G. Suja, K. Susan John, R. Saravanan, M. Nedunchezhiyan, K. Laxminarayana, T. Makeshkumar, D. Jaganathan, P.S. Sivakumar
2.	**Project 2:** Investigations on rapid multiplication of yams and aroids	K. Sunilkumar	R. Muthuraj, J. Suresh Kumar, K. Laxminarayana, M. Nedunchezhiyan
V	**HORTCTCRISIL 202001301469 Mega Project 5: Development of innovative technologies for the intensification of pest management in tuber crops through biorational approaches**	**E.R. Harish**	
1.	**Project 1:** Management of important pests and documentation of emerging pests in tuber crops	E.R. Harish	B.G. Sangeetha, R. Arutselvan, H. Kesava Kumar, Berin Pathrose (KAU)
2.	**Project 2:** Characterization of insect resistance genes in sweet potato and related *Ipomoea* species against sweet potato weevil infestation	B.G. Sangeetha	Shirly Raichal Anil, E.R. Harish
3.	**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, 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**	
1.	**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
2.	**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, R. Saravanan
3.	**Project 3:** Virus and phytoplasma diseases of tropical tuber crops and their management	T. Makeshkumar	M.L. Jeeva, S.S. Veena, M.N. Sheela, R. Arutselvan, A. Asha Devi, V.S. Santhosh Mithra, Shirly Raichal Anil, B.G. Sangeetha, J. Sreekumar
4.	**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, Kalidas Pati, K. Laxminarayana, H. Kesava Kumar, M. Nedunchezhiyan

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**	
1.	**Project 1:** Non-conventional applications of cassava starch in construction and building materials	M.S. Sajeev	T. Krishnakumar, A.N. Jyothi, C. Pradeepika
2.	**Project 2:** Development of cassava and sweet potato based animal feed	M.S. Sajeev	M. Nedunchezhiyan, A.N. Jyothi, T. Krishnakumar
3.	**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, M.N. Sheela, A. Asha Devi
4.	**Project 4:** Design and development of pre- and post-harvest machineries/storage systems in tuber crops	T.Krishnakumar	M.S. Sajeev, C. Pradeepika
5.	**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, Kalidas Pati, T. Krishnakumar, C.Visalakshi Chandra, M. Nedunchezhiyan
VIII	**HORTCTCRISIL 202001601472** **Mega Project 8: Developing methodologies and tools for assessment and transfer of tuber crops technologies**	**Sheela Immanuel**	
1.	**Project 1:** Technological interventions and documentation of farmers' innovations including ITKs in tropical tuber crops	D. Jaganathan	Sheela Immanuel, V.S. Santhosh Mithra, P. Sethuraman Sivakumar, P. Prakash, G. Suja, R. Muthuraj, H. Kesava Kumar, T. Krishnakumar, P. Murugesan, M. Nedunchezhiyan
2.	**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 Tengli (CAU (I), Umiam B. Shanmughasundaram (RARS, Pattambi) M. Elavarasan (KVK, Tenkasi) P. Mooventhan (ICAR-NIBSM, Raipur) Bineeta Satpathy (RPCAU, Pusa) Sandeep K. Panda (KIIT, Odisha) Ipsa Mohapatra (KIMS, Odisha)
3.	**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
4.	**Project 4:** Impact assessment of technologies of tropical tuber crops	P. Prakash	D. Jaganathan, Sheela Immanuel, J. Sreekumar, Prabhat Kishore
5.	**Project 5:** Development of intelligent smart technologies for tuber crops	V.S. Santhosh Mithra	S. Sunitha, D. Jaganathan
6.	**Project 6:** Generation and application of statistical and bioinformatics tools for tuber crops research and development	J. Sreekumar	K.M. Senthilkumar, T. P. Sujatha, C. Visalakshi Chandra

Developmental Projects

Sl. No	Title	PI	Co-PIs	Funding agency	Budget (₹ in lakhs)
1.	ICAR-CTCRI-TSP Livelihood improvement of tribal farmers through tuber crops technologies	M. Nedunchezhiyan	Kalidas Pati V.B.S. Chauhan K. Hanume Gowda R. Arutselvan	ICAR, New Delhi	29.00
2.	ICAR-CTCRI-SCSP: Empowerment of tuber crops farmers through sustainable use of resources and tuber crops technologies	V. Ramesh	M.N. Sheela M.S. Sajeev S.S. Veena D. Jaganathan H. Kesava Kumar J. Suresh Kumar T. Krishnakumar	ICAR, New Delhi	40.00
3.	ICAR-CTCRI-NEH: Scaling up biofortified tuber crops through 'Rainbow Diet Approach' in the North Eastern Hills Region	P. Sethuraman Sivakumar	K. Laxminarayana H. Kesava Kumar P. Prakash T. Krishnakumar R. Arutselvan V.B.S. Chauhan R. Muthuraj C. Mohan E.R. Harish Mahesh Tengli (CAUCI, Umiam) Ashok Chhetri (CAU, Imphal) R Sasikumar (NEHU, Tura)	ICAR, New Delhi	15.00

Externally Aided Projects

Sl. No	Title	PI	Co-PIs	Funding agency	Budget (₹ in lakhs)
1.	Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in taro and elephant foot yam	Kalidas Pati	--	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	Total:13.60 2023-24: 7.60
2.	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)	J. Sreekumar	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	Total: 21.00 2023-24: 7.70
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*)	Kalidas Pati (Collaborating Centre)	--	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	Total: 9.26 2023-24: 5.15

4.	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 (Main Centre)	K.I. Asha A. Asha Devi Shirly Raichal Anil N. Krishna Radhika	Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	Total: 21.00 2023-24: 5.95
5.	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)		Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi	Total: 13.40 2023-24: 7.60
6.	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 R. Saravanan	International Potato Centre (CIP), New Delhi	Total: 42.26 2023-24: 13.50
7.	ICAR-Bioversity International & CIAT Alliance collaborative work plan activity on Germplasm exchange, improvement and testing advanced clean seed technology in cassava (*Manihot esculenta* Crantz)	M.N. Sheela T. Makeshkumar S. Sunitha	G. Byju K.I. Asha K.M. Senthilkumar P. Murugesan R. Muthuraj	ICAR-Bioversity International & CIAT Alliance	Total: 43.23 2023-24: 11.38
8.	Micro tuber production and gene prospecting for photo responsive tuberization in *Ipomoea batatas* (L.) Lam.	Shirly Raichal Anil	N. Krishna Radhika K.M. Senthilkumar	DST-Science and Engineering Research Board (Core Research Grant), New Delhi	Total: 30.36 2023-24: 10.00
9.	*In vitro* quality planting material production of tuber crops to meet the demand of Odisha	V.B.S. Chauhan	Kalidas Pati K. Hanume Gowda M. Nedunchezhiyan	Rashtriya Krishi Vikas Yojana (RKVY), Dept. of Agriculture Development & Farmers Welfare, Govt. of Odisha	Total: 250.23 2023-24: 17.57
10.	Collection and database creation of important named landraces of tuber crops from southern districts of Kerala	K. I. Asha	M. N. Sheela A. Asha Devi Shirly Raichal Anil N. Krishna Radhika	Kerala State Biodiversity Board, Govt. of Kerala	Total: 8.00 2023-24: 4.00
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 D. Jaganathan	ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut, Uttar Pradesh	Total: 145.42 2023-24: 28.66
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	Total: 138.00 2023-24: 55.42
13.	Establishment of Biotech-KISAN hub at DBT-ILS, Bhubaneswar for carrying out activities in tribal districts of Odisha	Rajeeb K. Swain	M. Nedunchezhiyan, G.C. Acharya, ICAR-IIHR (CHES), J.K. Sundaray, ICAR-CIFA	DBT-ILS, Govt. of India	Total: 8.00 2023-24: 4.00

14.	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	Total: 10.00 2023-24: 5.00
15.	ICAR-CRP on Vaccines and diagnostics: Development and application of diagnostics to viruses infecting tropical tuber crops	T. Makeshkumar	M.L. Jeeva R. Arutselvan R. Muthuraj	ICAR-CRP on vaccines and diagnostics	Total: 25.60 2023-24: 10.85
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
17.	Abiotic stress-hormesis to enhance the phenolic-linked antioxidant protective system in biofortified sweet potatoes for designing functional food ingredients	C. Pradeepika	--	DST-Science and Engineering Research Board, Govt. of India	Total: 47.87 2023-24: 27.00
18.	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	Total: 395.35 2023-24: 78.05
19.	AICRP on Post-harvest Engineering and Technology	M.S. Sajeev	T. Krishnakumar	ICAR, New Delhi	7.20
20.	Developing the Standard Operating Procedures (SOP) for good manufacturing practices and Hazard Analysis and Critical Control Point (HACCP) for tapioca starch and sago production	A.N. Jyothi	M.S. Sajeev T. Krishnakumar J. Sreekumar P. Prakash	SAGOSERVE, Salem, Tamil Nadu	Total: 31.11 2023-24: 9.01
21.	Cassava custard	C. Pradeepika	A.N. Jyothi M.S. Sajeev	Contract Research Project, KCM Agri Clinic, Tirunelveli, Tamil Nadu	8.42
22.	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 Foods, Bengaluru, Karnataka	6.50
23.	IP & TM scheme: National Agricultural Innovation Fund (NAIF) component I: Innovation Fund	P. Sethuraman Sivakumar	Sheela Immanuel R. Muthuraj P. Prakash	IP&TM, ICAR, New Delhi	Total: 56.00 2023-24: 38.00
24.	IP & TM Scheme: National Agricultural Innovation Fund (NAIF) Component 2 : Incubation Fund	P. Sethuraman Sivakumar	Sheela Immanuel R. Saravanan M.S. Sajeev R. Muthuraj M. Nedunchezhiyan P. Prakash T. Krishnakumar	IP&TM, ICAR, New Delhi	Total: 53.50 2023-24: 52.00
25.	Development of smart solutions for managing biotic and abiotic stresses in cassava, sweet potato and taro through artificial intelligence	V.S. Santhosh Mithra	G. Byju T. Makeshkumar M.S. Sajeev E.R. Harish	DST, Govt. of India	35.43

26.	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	Total: 33.00 2023-24: 11.00
27.	Demonstration of applications of drones in agriculture	V.S. Santhosh Mithra	G. Byju D. Jaganathan M.S. Sajeev T. Makeshkumar C. Mohan E.R. Harish	ICAR, New Delhi	Total: 35.00 2023-24: 34.40
28.	Rainbow diet campaign for Odisha-Development and scaling of customized rainbow diet food matrices for combating malnutrition among children in Keonjhar District, Odisha	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

Research Highlights

Institute Projects

Crop Improvement

Conservation and utilization of germplasm of tuber crops for sustaining production

Cassava

A total of five new collections of cassava comprising three landraces (Thiruvananthapuram and Kottayam) and two wild (Thiruvananthapuram) were collected from Kerala. One thousand two hundred and sixteen accessions comprising 545 indigenous, 315 exotic, 115 landraces and 241 breeding lines were replanted in the field during 2022-2023 for maintenance, characterization and preliminary evaluation.

Three hundred and seven accessions were subjected to morphological characterization and preliminary evaluation for 18 tuber traits and yield parameters (13 qualitative+5 quantitative) viz., weight of tubers, fresh weight of foliage, number of tubers roots/plant, number of commercial tubers, single tuber weight, tuber length, tuber diameter, extent of root peduncle, tuber constrictions, tuber shape, external colour of tuber, color of tuber cortex, colour of tuber pulp, ease of peeling of cortex, cortex thickness, texture of tuber epidermis, tuber taste and tuber growth attribute as well as screening for cassava mosaic disease (CMD) tolerance. It was observed that accession CE-238 lacked proper tuberization.

Among the 18 tuber traits studied, tuber growth direction varied from horizontal in 205 accessions to vertical in 52 and irregular in 49 accessions. The tuber peduncle among the accessions varied from sessile (97) to pedunculate (172) and mixed (37). The tuber periderm colour varied from the basic dark brown (154), followed by light brown (122) and cream (30). Texture of tuber epidermis showed variations viz., rough (124), smooth (92) and intermediate (90). Root constrictions varied from many (5), some (39) and few to none (262). Tuber cortex nature varied from thick (245), thin (42) and intermediate (19) and ease of peeling varied from easy (250) to difficult (56). The colour of tuber cortex ranged from cream (151), pink (99), purple (55) and yellow (1). The tuber pulp/flesh colour varied from cream (290) to white (13) and yellow (3). Thus, β-carotene rich yellow tuber flesh accessions with sweet taste were identified (Table 1). The accession CE-430 with greatest yellow colour flesh had a total carotenoid content of 0.9447 mg $100g^{-1}$ fresh weight. The shape of tubers varied from conical (124), cylindrical (119), conical-cylindrical (52) to irregular (11). Tuber length varied from long (242), medium (43) to short (21) and diameter from wide (182), medium (89) to narrow (33).

Among the five quantitative traits studied, the mean weight of tuber ranged from 0.23 to 27.28 kg, in which 203 accessions were in the range of 0.10-5.00, 74 in 5.01-10.00, 19 in 10.01-15.00, 5 in 15.01-20.00, 2 in 20.01-25.00 and 3 in 25.01-30.00. CE-71 (27.28 kg) had the highest tuber weight, followed by CE-656 (25.71 kg), CE-89 (25.34 kg), CE-48 (21.77 kg), CE-463 (20.66 kg), CE-34 (17.87 kg), CE-(16.77 kg), CE-16A (16.34 kg), CE-25 (15.25 kg) and CE-39 (14.73 kg). The mean fresh weight of foliage ranged from 0.33 to 14.74 kg, in which 14 accessions were in the range 0.10-1.00, 129 in 1.01-3.00, 110 in 3.01-6.00, 44 in 6.01-9.00, 9 in 9.01-12.00 and 1 in 12.01-15.00. CE-594 produced the highest foliage fresh weight (14.74 kg), followed by CE-198 (11.94 kg), CE-239 (11.79 kg), CE-152 (11.39 kg) and CE-219 (11.39 kg). The mean number of tubers per plant ranged from 2 to 26, in which 64 were in the range of 1-5, 140 in 6-10, 78 in 11-15, 17 in 16-20, 4 in 21-25 and 3 in 26-30. The accessions, CE-108 and CE-434 had the highest number of tubers (26), followed by CE-198 (22), CE-432 (21) and CE-152 (21). The mean number of commercial tubers ranged from 1 to 24. CE-434 had the highest number of commercial tubers (24), followed by CE-108 (22), CE-432, CE-38 (20) and CE-152 (19). The mean single tuber weight ranged from 0.08 to 10.13 kg, where 293 accessions were in the range of 0.01-3.00, 11 in 3.01-6.00, 1 each in the range of 6.01-9.00 and 9.01-12.00. CE-71 had the highest single tuber weight (10.13 kg),

followed by CE-48 (7.25 kg), CE-428 (5.86 kg), CE-34 (5.83 kg) and CE-219 (5.47 kg). Taste of the tuber varied from sweet in 152 accessions to intermediate in 91 and bitter in 63 accessions. Nine promising accessions with sweet taste and high tuber weight were identified (Table 1).

The average harvest index ranged between 0.14 (CE-532) to 0.87. Eight superior accessions were identified for harvest index above 0.80 and among these, CE-52 had the highest value of 0.87, followed by CE-40A (0.86), CE-48 (0.84), CE-82 (0.83), CE-39 and CE-140 (0.82) and CE-23 as well as CE-76 (0.80). The superior five accessions with high harvest index and resistance to CMD were identified (Table 1). Eight accessions were also identified for multi-traits viz., high harvest index, high tuber weight per plant and resistance to CMD (Table 1). CMD symptom free cassava accessions (for the 2nd year at the 3rd, 6th and 9th months) were identified (Table 1).

Table 1. Promising accessions identified in cassava

Character	Number of accessions evaluated	Number of promising accessions	Promising accessions
High harvest index (above 0.80), high tuber weight plant^{-1} (>10 kg plant^{-1}) and resistance to CMD	100	8	CE-14, CE-16A, CE-39, CE-48, CE-71, CE-82, CE-89 and CE140
High harvest index (above 0.80) and resistance to CMD	100	5	CE-23, CE-39, CE-48, CE-82 and CE-140
Sweet taste and high tuber weight (>10 kg plant^{-1})	100	10	CE-16A, CE-38, CE-71, CE-140, CE-198, CE-219, CE-239, CE-455, CE-463 and CE-656
β-carotene rich yellow tubers with sweet taste	100	3	CE-174, CE-348 and CE-430
CMD symptom free (for the 2nd year at the 3rd, 6th and 9th months)	100	25	CE-28A, CE-38, CE-48, CE-50, CE-89, CE-90, CE-97, 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-394 A, CE-403, CE-428 and CE-456

Sweet potato

One thousand one hundred and ten accessions of sweet potato were maintained in the field during 2023-24 and characterized.

Two hundred sweet potato accessions were characterized for 17 above ground characters such as plant type, ground cover, four vine traits (vine internode length, vine internode diameter, vine colour, vine tip pubescence), two petiole traits (petiole length, pigmentation), eight leaf traits (outline of leaf, leaf lobe type, lobe number, shape of central leaf lobe, mature leaf size, abaxial leaf pigmentation, mature leaf colour, immature leaf colour) and flowering as per IPGRI descriptor (Huaman, 1991). The plant type variants were mostly semi-erect and spreading; the vine internode length was mostly intermediate; vine internode diameter varied from intermediate to thick; vine colour variants were mostly green, green with purple spots and purple; petiole length varied from short to intermediate with only one with long petiole (S-1288); petiole pigmentation variants were green, green with purple base, tips and mostly purple; leaf lobe type was mostly triangular and lobed; leaf colour variants were green and green with purple edges, except two, which was purple (S-1803) and yellow (S-1267), respectively.

Two hundred sweet potato accessions as well as 15 released varieties were established in pots inside polyhouse for bench conservation.

Yams

A total of 13 accessions were collected from Thrissur and Thirvananthapuram, Kerala comprising greater yam (8), lesser yam (2) and potato yam (3). One thousand and ten accessions of yams comprising greater yam (590), white yam (138), lesser yam (200), potato yam (6) and wild yam (76) were replanted and maintained in the field genebank at ICAR-CTCRI, Thiruvananthapuram. Under morphological characterization, 421 greater yam accessions were evaluated for 20 morphological descriptors. Tuber yield ranged from 0.11 (Da-61) to 5.45 kg plant^{-1} (Da-811). The highest tuber yield was recorded in Da-811 (67.28 t ha^{-1}), followed by Da-367 (63.82 t ha^{-1}), Da-234 (60.49 and Da-226 (58.02 t ha^{-1}) (Table 2). Da-811 produced compact tubers with an average length of 33 cm and girth of 55 cm.

In white yam, 100 accessions were evaluated for seven tuber traits. Dr-313 produced the highest tuber yield (78.39 t ha^{-1}), followed by Dr-37 (61.73 t ha^{-1}). Ten profusely flowering white yam accessions were identified to be used as parents in breeding programmes, including eight males and two females with good seed set (Table 2).

In lesser yam, among 200 accessions evaluated, the highest tuber yield was recorded in CTDE-3 (51.85 t ha^{-1}), followed by CTDE-6 and CTDE-78 (46.91 t ha^{-1}).

Table 2. Promising accessions identified in yams

Crop	Character	Number of accessions evaluated	Number of promising accessions	Promising accessions
Greater yam	High yield (>4 kg plant^{-1})	421	4	Da-811, Da-367, Da-234 and Da-226
White yam	Profusely flowering male lines	100	8	Dr-24, Dr-26, Dr-29, Dr-37, Dr-57, Dr-59, Dr-62, Dr-73
White yam	Profusely flowering female lines	100	2	Dr-93 and Dr-146
Lesser yam	High yield (>4 kg plant^{-1})	200	3	CTDE-3, CTDE-6 and CTDE-78

For genetic characterization in lesser yam and white yam, crops with high amounts of polysaccharides, polyphenols and secondary metabolites, a modified DNA isolation protocol by CTAB method without liquid nitrogen was standardized. DNA was isolated from 12 genotypes of lesser yam and 11 genotypes of white yam for DNA fingerprinting using Inter Simple Sequence Repeat (ISSR) markers. Genomic DNA from 12 lesser yam genotypes and 11 white yam genotypes with better quality and five ISSR primers (out of ten primers tested) that gave good amplification were selected for genetic diversity analysis. A dendrogram was constructed using DARwin6 software. The 12 lesser yam genotypes clustered into three groups, whereas one genotype DE-53 was genetically distinct and did not fall into any group. The 11 white yam genotypes were clustered into three groups, whereas one genotype DR-87 of one of the groups was genetically distinct showing greater genetic distance from the rest.

Edible aroids

A total of 25 edible aroids comprising taro (9), tannia (5), elephant foot yam (9) and *Alocasia* (2) were collected from Kerala, Tamil Nadu, Manipur, West Bengal, Chhattisgarh, Andhra Pradesh and Jharkhand. One unique purple-fleshed taro collection from Imphal was added to the field gene bank. Six hundred and sixty four edible aroid germplasm comprising 415 taro, 200 elephant foot yam, 45 tannia and 4 *Alocasia* are being maintained in the field gene bank at ICAR-CTCRI, Thiruvananthapuram.

In elephant foot yam, among 203 accessions evaluated, three flowering accessions were identified viz., NL/2019, Am-75 and Gajendra, which were used in hybridization program. In the case of taro, among 45 accessions screened, flowering was observed during November-December 2023 in 11 accessions. Field screening of 45 taro accessions for taro leaf blight (TLB) occurrence during December 2023 showed that four accessions were resistant (NEH-77, IC330-438 (L-8), BRAD-2021-1 and Line-48) (8.89%); 28 moderately resistant (62.22%); nine susceptible (20%) and three highly susceptible (6.67%).

Sixteen corm characters of 20 accessions of elephant foot yam comprising landraces, accessions, hybrids and wild genotypes were recorded as per NBPGR minimal descriptors. The corm shape was depressed and globose in 10 accessions, flat and globose in nine and pyramidal and globose in one. Colour of corm surface top and bottom (dark brown), re-emergence (present), skin texture (rough) and bract colour of main bud (light pink) showed no variation. Skin thickness ranged from medium (16) to thick (4). The tuber flesh colour showed variation ranging from light yellow (1) to yellow (11) to dark yellow (8). Six accessions (AmW-26, Am-139, Am-141, Navasari EFY, Am-66 and Am-39-6) showed no visible signs of any biotic stress. Rest of the tubers showed low incidence of tuber rot/scale insect infestation. The tuber weight ranged from 730 g (TCR-98) to 3.52 kg plant^{-1} (AP-03). Height of the corm ranged from 6.70 (Am-139) to 13.53 cm (AP-03). The corm diameter ranged from 36.67 (Am-139) to 64.60 cm (ADSK/2021-1). Least number of cormels was produced by Am-39 (1.67).

Minor tuber crops

A total of 22 minor tuber crops accessions with desirable horticultural traits comprising arrowroot (6), Chinese potato (3), *Curcuma* sp. viz., *C. malabarica* (1) and *C. zedoaria* (1) as well as Queensland arrowroot (11) were collected from various locations within Kerala (Thiurvananthapuram, Kollam and Wayanad) and Tamil Nadu (Tenkasi, Tirunelveli and Dindigul) are conserved in the field gene bank of ICAR-CTCRI. Two hundred and seven accessions comprising 110 Chinese potato, 53 yam bean, 6 Queensland arrowroot (*Canna edulis*), 25 East Indian arrowroot (*Curcuma angustifolia*), 12 West Indian arrowroot (*Maranta arundinacea*) and 1 *Curcuma zedoaria* are being maintained in the field gene bank.

Queensland arrowroot

The Queensland arrowroot germplasm was evaluated morphologically and grouped into two types namely red and green capsule, which was morphologically different from ornamental *Canna* spp. Morphological and biochemical characterization as per PPV&FRA's guidelines revealed that one accession of Queensland arrowroot of green capsule type from Sirumalai (IC650829) had a highly desirable trait of bulky rhizome, sterile green capsule with high rhizome starch content (16.50%).

Chinese potato

Seven Chinese potato genotypes collected from different locations of Kerala and Tamil Nadu were characterized for stable morphological and biochemical characters. Indigenous collection numbers (IC641828 to IC641834) were assigned for the above accessions collected from Varavoor, Kunnamkulam, Kullaparachal, Vandamedu, Cumbum, Ettayapuram and Kovilpatti. These germplasm accessions were evaluated and characterized for three years during 2021 to 2023 adopting standard procedures. Significant variability was observed for tuber skin colour and shape in all the above accessions. The accession from Kullaparachal (IC641830) had unique morphological characters viz., dark red skin tubers and anthocyanin pigments in leaves and stems. The moisture, crude protein, crude fat, total ash, crude fibre and nitrogen free extract of 84.50, 11.95, 1.56, 7.80, 5.11 and 73.58%, respectively were observed in this accession. Nitrogen free extract is a desirable parameter which can be explored for fish feed industry.

East Indian arrowroot

Six *Curcuma angustifolia* accessions (IGBT-10-4, IGDMT-10-1, IGBT-10-2, IGSJT-10-2, IGDMT-10-1 and IC641837) were characterized for morphological and biochemical characters. CG Tikhur 1 had the highest starch content (15%) with lengthy rhizome fingers and distant type internodal length, whereas IC641837 had unique compact rhizome habit, close venation and short internodal length.

Proximate analysis of nutrients in *C. angustifolia* germplasm accessions for starch and other biochemical parameters showed that Chhattisgarh Tikhur 1, the released variety from Indira Gandhi Krishi Vishwavidyalaya, Raipur, showed better nutritional qualities than the local landraces. This had nutrients values of 0.30, 15.80, 0.20, 0.59, 68.45 and 0.45 for sugar (%), total starch (%), crude fat (%), crude fibre (%), moisture (%) and total ash (%), respectively and average values recorded for six germplasm accessions were 0.31, 13.21, 0.17, 0.46, 70.00 and 0.42 for the above parameters, respectively.

Germplasm conservation and evaluation at Regional Station

At the Regional Station, ICAR-CTCRI, Bhubaneswar, germplasm of different tuber crops totaling to 1270 accessions are being maintained in the field genebank comprising cassava (113), sweet potato (380), yams (51), taro (510), elephant foot yam (40), tannia (1), *Alocasia* (3), yam bean (165), Chinese potato (5) and arrowroot (2).

For the development of phenological growth stages in taro according to the extended BBCH (Biologische Bundesanstalt, Bundessortenamnt und Chemische Industrie) scale, a study was initiated using a three-digit numerical coding system for its description. A total of nine principal growth stages were described such as germination (0), leaf development (1), elongation of shoot/stem elongation (2), tuber formation (3), development of inflorescence/spadix (5), flowering (6), development of berries/fruiting (7), ripening of berries and seed development (8) and senescence and beginning of dormancy (9). The

study of extended BBCH scale for taro has immense importance in crop management, crop improvement, germplasm characterization and assessment of impact of the climate on phenology under different agroclimatic conditions for the selection of suitable genotypes.

Morphological characterization in sweet potato at ICAR-CTCRI, Regional Station, Bhubaneswar, Odisha for 25 sweet potato genotypes was taken up for studying the nature and extent of genetic variability for growth and yield parameters, to study the inter-relationship between yield and other yield contributing traits and to study the genetic diversity among sweet potato germplasm. Observations were recorded for various growth, yield and quality parameters. The cluster analysis grouped these 25 genotypes into six clusters. The cluster I contained 6 genotypes, followed by cluster II with 10 genotypes, cluster III with 4 genotypes, cluster IV with 3 genotypes and cluster V and VI with one genotype each. The inter-cluster distance between the cluster III and cluster IV (2802.06) was maximum,which indicated that the genotypes included in these clusters are diverse in nature. The genotypes, SP-1198, SP-1165, SP-90/235 and SP-903 produced higher tuber yield per vine, which indicated that these genotypes may be used for improvement of yield and yield component traits by selection.

The initial documentation of bacterial storage rot disease within the elephant foot yam germplasm has been reported. The 16S ribosomal RNA gene of *Pectobacterium carotovorum* strain PC1 has been successfully identified and documented in the National Centre for Biotechnology Information (NCBI) and the accession number OR675420 was obtained. This partial genetic sequence serves as a valuable resource for comprehending the genetic composition and attributes of this specific strain present in the germplasm of elephant foot yam corms. Researchers can leverage this accession number to retrieve and scrutinize the genetic information linked to the specified 16S ribosomal RNA gene, facilitating a deeper understanding of the strain's taxonomy, phylogeny and potential applications across diverse research domains.

In vitro conservation of tuber crops

At the headquarters, *in vitro* cultures comprising cassava (17), sweet potato (6), yams (28) and aroids (3) are being maintained. In addition to this, newly initiated and established cultures of cassava (4), sweet potato (1), taro (2), tannia (1) and arrowroot (3) are also conserved.

Under the experiment on cryopreservation studies using yam pollen, pollen grains were collected from *Dioscorea alata* as well as *D. rotundata* and stored in cryo-storage at (-196°C) for up to 45 days. The viability was tested at intervals of 15, 30 and 45 days through acetocarmine staining. It was observed that *D. alata* pollen was viable under cryo-storage even up to 45 days.

At the Regional Station, about 400 cultures comprising pre-release, exotic, and released lines were maintained *in vitro*. These cultures included 10 cassava released varieties, 11 sweet potato varieties, five taro varieties, four yam varieties, two elephant foot yam varieties, and four Chinese potato, genotypes.

A rapid regeneration protocol was developed in yam bean through *in vitro* techniques and the regenerants were evaluated for their genetic fidelity. A high yielding variety of yam bean was used for the new protocol with nodes, leaves and tubers as explants. A number of hormonal combinations were tried including cytokinin (Kinetin, BAP, TDZ) and auxins (NAA, IBA) in MS media in an attempt to develop the rapid proliferation method. Among the explants tried, nodal segments were most effective in producing *in vitro* plants. The best combination of hormones for maximum shoot proliferation was Kinetin (1.50 mg l^{-1}), which resulted in a mean shoot length of 6.32 cm, highest number of shoots (4.80), and number of leaves per plant (14.40), followed by Kinetin (1.5 mg l^{-1}) + IBA (2 mg l^{-1}), with a mean shoot length of 5.66 cm, highest number of shoots (4), and number of leaves per plant (12). None of the hormone combinations studied produced roots, even after multiple sub-culturing. The micro-propagated plants were checked for genetic fidelity using RAPD markers.

Gene bio-prospecting for novel traits in tuber crops

The antibacterial effects of methanolic extract of *Curcuma angustifolia* (Ca) accessions were reported in Chhattisgarh Tikhur-1 variety (Ca 1) and IC641835 (IGBT) (Ca 2), a collection from Chhattisgarh. Differential expression was studied for estimating curcumin expression variation in *C. angustifolia* using Diketide CoA synthase (*DCS*) and multiple curcumin synthases (*CURS*) viz., curcumin synthase 1 (*CURS1*), curcumin synthase 2 (*CURS2*) and curcumin synthase 3 (*CURS3*). The expression was studied in leaf sprouted *in vitro* from different genotypes of *Curcuma angustifolia* and *C. zedoaria*. *DCS* gene and *CURS3* was expressed in *C. angustifolia* Ca 1, 2, 3 and 5, whereas Ca 4 and *C. zedoaria* (Cz 6) lacked the expression. CURS2 expression was relatively low in Ca1 and Ca2, compared to Ca3 and Ca5. Ca4 and Cz 6 lacked expression of *CURS2*. In this study, *CURS2* expression was found up-regulated in lower curcumin containing lines. In the case of Ca1 and Ca2 from Chattisgarh, the *CURS2* expression was lower owing to its high curcumin content, and these two lines showed antibacterial effects as compared to the other genotypes.

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

Evaluation of cassava mosaic disease-resistant genotypes was conducted to identify early bulking genotypes for culinary purposes. Among the 11 genotypes evaluated along with short duration variety Sree Jaya as control, five genotypes viz. 17S-48 (0.61), Sree Reksha (0.53), Sree Sakthi (0.52), Sree Kaveri (0.52), PDP CMR-1 (0.51) and 19S-4-2 (0.46) resulted in higher harvest index at sixth month than Sree Jaya (0.41). The highest number of tubers was recorded in Sree Sakthi (17.50), followed by 17S-48 (17) and all the genotypes produced higher number of tubers than Sree Jaya, the check variety. Single tuber weight was highest for 19S4-2 (1.99 kg), followed by 19S-17-3 (1.54 kg), PDP CMR-1 (1.46 kg) and 17S-1 (1.20 kg) compared to Sree Jaya (0.63 kg). The highest tuber yield was recorded in PDP CMR-1 (10.20 kg plant^{-1}), followed by Sree Reksha (8.13 kg plant^{-1}) and 17S-48 (7.87 kg plant^{-1}) compared to 3.40 kg plant^{-1} in Sree Jaya. The highest dry matter content was recorded in 17S-247 (41.89%) at sixth month, followed by Sree Kaveri (39.76%). The highest starch content on fresh weight basis was recorded in Sree Kaveri (23.52%) at sixth month, followed by 19S-17-3 (22.04%), 17S-247 (22.03%) and 19S 4-3 (21.87%) compared to 19.36% in Sree Jaya. Sugar content on fresh weight basis ranged from 0.31% (17S-1) to 1.20% (Sree Kaveri). 17S-1, 19S-4-3 and 17S-247 also had lower sugar content than the low sugar landrace, known as *Diabetics kappa* (0.50%). Three genotypes viz., 17S-48, 19S-4-3 and 19S-4-2 with higher yield (>50 t ha^{-1}) than short duration check variety Sree Jaya (42.20 t ha^{-1}) and local variety *Diabetes kappa* (23.33 t ha^{-1}) were selected for further evaluation. A CMD-resistant semi-dwarf genotype, 17S-36, was developed in cassava with a height of 85 cm as compared to 294 cm in Sree Reksha.

A high quality draft genome assembly of two cassava genotypes, Sree Kaveri and 9S-127, was developed through whole-genome sequencing. These elite breeding lines were developed at ICAR-CTCRI and are widely used in cassava breeding programmes. Sree Kaveri is an inbred (S_2) line, while 9S-127 is a hybrid line. The whole genome sequences of Sree Kaveri and 9S-127 were deposited to the Indian Biological Data Centre (IBDC) database (INCARX100021; INCARX100023). A database, CasGVD Database was developed for accessing and downloading the genomic datasets of Sree Kaveri and 9S-127 for molecular marker studies.

SREE KAVERI: A CMD resistant variety of cassava

Sree Kaveri, a cassava mosaic disease resistant variety, resistant to both Indian cassava mosaic virus and Sri Lankan cassava mosaic virus was released centrally for the states of Kerala, Tamil Nadu and Andhra Pradesh (Fig. 1). Sree Kaveri is an inbred (S_2)

Fig. 1. Sree Kaveri, the centrally released cassava variety

line. The variety has an average tuber yield of 51.00 t ha^{-1}. It showed a 27.50% increase over local check. It has 27-28% starch and is good for industrial purpose. The variety showed a high drought tolerance index value (1.54), gave an additional income of ₹ 30,000 ha^{-1} (replacement of CMD susceptible variety) and also is an N and K efficient variety. Morphologically, this is similar to H-226, the popular cassava variety cultivated in Tamil Nadu.

Yams

In yams, the evaluation trials were planted during April 2023 at ICAR-CTCRI, Thiruvananthapuram as a rainfed crop. In the advanced yield trial of greater yam entries, DaH-10-425 produced the highest tuber yield (67.65 t ha^{-1}), followed by DaH-10-116 (67.03 t ha^{-1}). DaH-10-116 produced compact tubers with an average length of 53 cm and girth of 60 cm. In the advanced yield trial of white yam entries, DRS-1050 yielded the highest (59.25 t ha^{-1}). Among the dwarf white yam genotypes evaluated, DrD-1033 produced the highest tuber yield (45.67 t ha^{-1}). The pre-release variety SD-15 yielded 47.54 t ha^{-1} under non trailing conditions. It has compact cylindrical tubers. The planting material of the pre-release variety was multiplied and one ton of nucleus seed material was produced.

Arrowroot

In the arrowroot trial for identification of a high yielding, high starch line with less fibre content, the fifth year advanced yield trial of seven arrowroot genotypes showed that the rhizome yield ranged from 31.41 t ha^{-1} (M-2) to 43.44 t ha^{-1} (M-3), followed by 39.18 t ha^{-1} (M-6), 37.21 t ha^{-1} (M-5), 35.78 t ha^{-1} (M-4), 34.74 t ha^{-1} (M-1) and 33.42 t ha^{-1} (M-7). Yield per plant ranged from 900 g in M-2 to 1130 g in M-4. Number of rhizomes plant^{-1} ranged from 18 (M-2) to 23 (M-4, M-7). Single rhizome weight ranged from 95 g in M-5 to 113.33 g in M-6. Single rhizome length x girth was highest in M-6 (27.94 x 8.61 cm) and lowest in M-3 (23.40 x 8.40 cm).

Biochemical characterization of the rhizome of these seven genotypes showed that total starch content ranged from 16.22% (M-6) to 17.65% (M-1) on fresh weight basis. Total sugars ranged from 0.98% (M-6) to 1.03% (M-7). Fat content in all the genotypes was very low ranging from 0.04% (M-3) to 0.09% (M-1). Fibre content of the rhizome was lowest in M-1 (1.06%) and highest in M-2 (1.34%). Ash content ranged from 0.95% (M-4) to 1.58% (M-6). Moisture content ranged from 65.25% (M-4) to 68.20% (M-5). The dry matter content ranged from 31.84% (M-6) to 36.84% (M-3).

Among the arrowroot genotypes, M-3 with the highest rhizome yield (43.44 t ha^{-1}) and dry matter content (36.84%), M-1 with high starch (17.65%) and low fibre content (1.06%) and M-4 with highest yield plant^{-1} (1130 g) and number of rhizomes plant^{-1} (23) were identified as promising lines. In the pooled data of advanced yield trials from 2018-2023, M-6 produced the highest yield (38.40 t ha^{-1}), followed by M-7 (36.93 t ha^{-1}) and M-3 (36.24 t ha^{-1}).

Onfarm trials were done in ten different locations in Kerala. Results revealed that the genotype M-3 produced the highest rhizome yield of 30.04 t ha^{-1} with a potential yield of 49 t ha^{-1} over the locations and was identified promising (Table 3). Biochemical analysis identified M-3 as the best genotype with high starch yield (5.95 t ha^{-1}), high dry matter content (36.84%), low fat (0.04%) and low fibre content (0.84%) (Table 4).

From the pooled data of the trials, M-3 was selected as the best arrowroot genotype with high rhizome yield (30.04 t ha^{-1}), high starch yield (5.95 t ha^{-1}) and low fibre content (0.84%) suitable for processing (Fig. 2) and for release as the first variety in the crop.

Table 3. Yield data of the pooled onfarm trials of arrowroot genotypes

Genotype	Rhizome yield (t ha^{-1})										Mean
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	
M-1	36.89	47.44	32.40	26.67	13.33	12.06	24.30	23.75	27.50	25.66	27.00
M-2	34.22	47.22	26.67	13.22	11.11	7.34	37.22	19.97	22.95	21.94	24.19
M-3	34.67	49.00	35.56	26.28	16.64	12.25	37.28	24.58	31.30	32.87	30.04
M-4	27.78	29.56	23.33	14.44	11.11	10.33	29.75	19.87	22.98	26.91	21.61
M-5	36.44	43.56	57.78	12.11	14.22	10.91	31.30	16.42	24.75	21.22	26.87
M-6	35.56	42.22	35.56	13.33	18.22	10.42	20.60	30.47	23.00	28.92	25.83
M-7	34.67	36.00	38.89	25.33	13.33	12.96	22.92	28.52	31.35	25.51	26.95
CD (0.05)											4.95
CV (%)											21.11
SEm ±											0.55

Table 4. Pooled biochemical data of arrowroot genotypes under onfarm trials

Genotype	Starch (%) FW basis	Starch yield (t ha^{-1})	Dry matter (%)	Fibre (%) FW basis	Fat (%) FW basis	Crude protein (%)
M-1	19.19*	5.18*	33.32	0.89	0.09	6.90*
M-2	18.81*	4.55	36.63	0.93	0.05	4.23
M-3	19.82*	5.95*	36.84	0.84	0.04	6.11
M-4	19.99*	4.32	33.75	0.87	0.06	6.03
M-5	18.17	4.88	33.35	0.92	0.06	5.96
M-6	18.89*	4.88	31.84	0.99	0.06	5.95
M-7	18.33	4.94	33.53	0.94	0.06	6.05
CD (0.05)	1.25	1.32	NS	NS	0.02	0.13
CV(%)	5.56	5.81	7.07	17.17	21.92	1.22
SEm ±	0.18	0.20	0.81	0.01	0.01	0.02

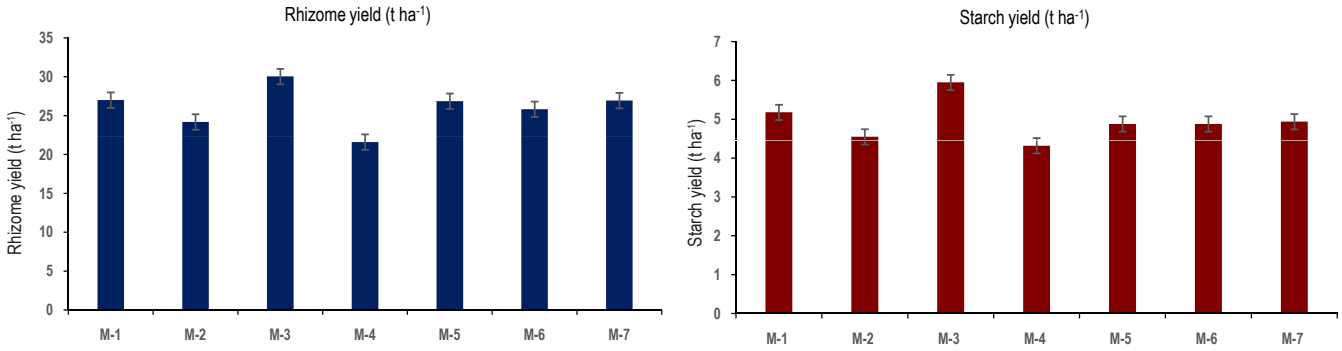


Fig. 2. Rhizome yield and starch yield of arrowroot genotypes

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

The CMD screening done in Sree Jaya x 9S-127 population, identified 185 resistant seedlings that segregated in a 1:1 ratio, which indicated that the resistance in the parent 9S-127 was in the heterozygous condition. To confirm the nature of gene action for CMD in the resistant parent, 80 seedling progenies were developed from self-pollination of 9S-127 parent. Screening for CMD was done in these seedlings where, 61 resistant and 19 susceptible were recorded and it showed a 3:1 segregation ratio. This confirmed the heterozygous (Rr) nature of resistance in the parent 9S-127. Among 250 CMD resistant clonal (C_1F_1) population, the yield of 50 clones ranged from 4-10 kg plant^{-1} and about 45 clones produced 3-4 kg plant^{-1}. From this trial, 175 C_1F_1-clones were established in the field for yield and biometric observations. The CMD resistant (Sree Jaya x 9S-127) seedling population and 35 C_1F_1-clonal progenies were established in the field for evaluation.

To identify the genes involved in the resistance, the parents, Sree Jaya and 9S-127 were grown in controlled condition as well as treated condition where, viruliferous whiteflies (flies collected from CMD susceptible plants) were challenge inoculated in both the parents. In the control cages, no challenge inoculation was done. The transcriptome profile of both normal as well as whitefly challenge inoculated samples was done for Sree Jaya and 9S-127 parents and data analysis is in progress.

Starch mapping population progenies

The parents, Sree Vijaya and 9S-127 were used to develop 104 starch mapping population. Dry matter contents were estimated in 50 randomly selected seedlings ranging from 27.76 to 52.05% in hybrids and the corresponding values for Sree Vijaya and 9S-127 were 37.00 and 49.20%, respectively. The starch content of the hybrids ranged from 13.88 to 33.46% and the corresponding values for Sree Vijaya and 9S-127 were 20.30 and 30.75%, respectively. In the progenies, 12 seedling hybrids with more than 29.00% starch were identified. Wide variations for dry matter and starch contents were observed in the hybrid seedling progenies and these lines will be evaluated to develop high starch lines for industry and low starch lines for chips making purpose.

Drought tolerant population

In the drought tolerant population, 200 C_1F_1 clones were evaluated. The yield of the harvested clones ranged from 3 to 6 kg plant^{-1}. The C_2F_1 clonal generation were planted from the selected C_1F_1 clones and established in the field for drought screening.

Genetic analysis and QTL mapping for determining genetic basis of post-harvest physiological deterioration (PPD) tolerance and enhanced shelf life in cassava

PPD evaluation of cassava genotypes

The PPD evaluation of nine breeding lines and varieties of cassava grown under irrigated and rainfed conditions was done at 5 days after harvest. Significant variation was observed among the genotypes and also between the treatments. Two cassava genotypes, KBH-18 and PDP CMR-1 were tolerant to PPD under both irrigated and rainfed conditions.

Clonal evaluation

The clonal progenies (560) along with parents were harvested and observations on yield traits were, recorded. The yield per plant ranged from 1.54 to 9.77 kg plant^{-1}. The average dry matter content was 35.21% and average CMD score was 2.1.

Yield trial of clonal progenies

The average yield per plant recorded for clonal progenies under preliminary yield trial (AYT) was 3.48 kg. The average dry matter content recorded was 32.33%. 13 clonal progenies with PPD tolerance up to 7 days after harvest were planted in advanced yield trial (AYT II) with 15 plants each in replicated trials along with checks. The average sprouting percentage and CMD score recorded were 72.16% and 1.29, respectively. The average CMD score at 3 MAP was 1.82.

Phenotyping for PPD tolerance

The clonal progenies and parents were characterized for tolerance to PPD at 1, 3, 5 and 7 days after harvest and 133 progenies with tolerance up to 7 days were identified. These progenies were selected for yield trials. Under parental polymorphism studies, 78 SSR markers were screened and 24 markers were selected for progeny screening.

Transcriptome sequencing

The RNA–seq analysis of four transcriptome samples including tolerant control (T_0), tolerant treatment (T_7), susceptible control (S_0) and susceptible treatment (S_7) was done. Approximately, 23.43 million clean reads (94.77%) were uniquely mapped, while only 1.70% was located in several positions. The number of DEGs in the T_7 S_7 comparison was higher than that of T_0 S_0, indicating effect of PPD on gene expression. One hundred and forty three gene ontology terms related to biological process (BP), 26 related to molecular function (MF) category, and 62 related to cellular component (CC) were identified in the T_7T_0 comparison that outlined the resistance mechanism of Kalpaka, the PPD tolerant cassava genotype. The major transcription factors (TFs) identified to be up and downregulated were of basic helix-loop-helix' (bHLH) transcription factor, myeloblastosis-related' (MYB-related), ethylene responsive transcription factor (ERF061), auxin response factor, GATA

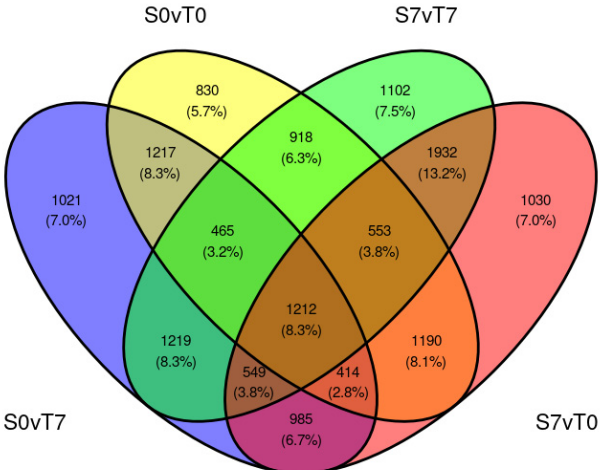


Fig. 3. Venn diagram depicting co-expressed and specific expressed DEGs in the pairwise comparisons

transcription factor, heat stress transcription factor, zinc finger AN1 and C2H2 domain-containing stress associated protein, scarecrow-like protein 9, LOB domain-containing protein, in all the comparisons (Fig. 3). The functional annotation of differentially expressed genes was completed and 168 SSR primers were designed for validation.

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

Analysis of transcriptome datasets of sweet potato variety Sree Kanaka revealed that 967, 1461 and 109 genes were upregulated in the leaf, fibrous root and tuberous root tissues, respectively whereas, 904, 1264 and 2701 genes were downregulated in the leaf, fibrous root and tuberous root tissues, respectively during high temperature stress. Sixty genes were differentially regulated in the leaf, fibrous root and tuberous root tissues, out of which, six genes (*DnaJ-domain, amino acid transporter 1 (AATI), nuclear transport factor 2 (NTF2), heat shock protein 90.1 (Hsp90.1), major facilitator superfamily protein, ABC transporter* and *hydrolase*) were upregulated whereas, 26 genes were downregulated in the leaf, fibrous root and tuberous root tissues, respectively during high temperature stress (Fig. 4). The pathway genes viz., DNA replication, galactose metabolism, glyoxylate and dicarboxylate metabolism, starch and sucrose metabolism, phenylpropanoid biosynthesis, carbon metabolism, plant hormone signal transduction etc. were modulated in the leaf tissue whereas, biosynthesis of nucleotide sugars, glyoxylate and dicarboxylate metabolism, amino sugar and nucleotide sugar metabolism, secondary

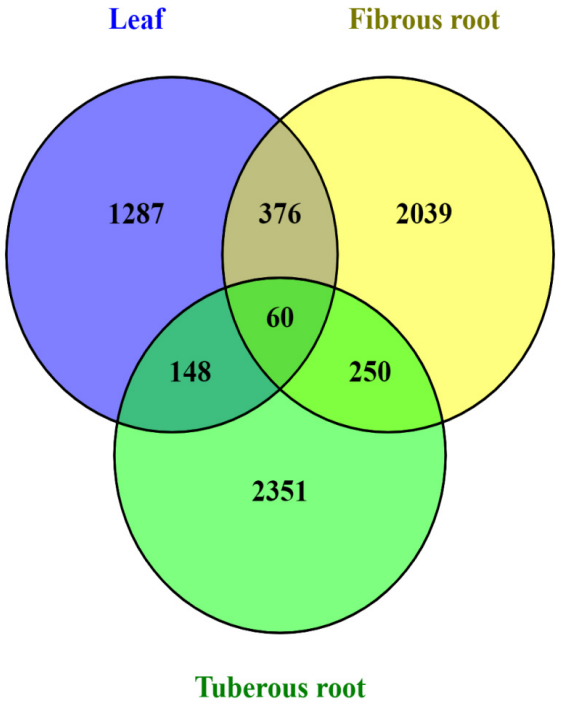


Fig. 4. Transcriptome response in the leaf, fibrous root and tuberous root tissues of sweet potato during high temperature stress in comparison with control condition

metabolites, etc. were modulated in the fibrous root tissues. Similarly, in the tuberous root tissues ribosome, aminoacyl-tRNA biosynthesis, oxidative phosphorylation, protein export, snare interactions in vesicular transport, endocytosis, ABC transporters, nucleocytoplasmic transport, etc. were modulated.

Genetic improvement of cassava through gene editing for modified starch

Friable embryogenic callus of cassava genotypes 9S-127, 8S-501 and H-226 were maintained and subjected to regeneration. H-226 and 9S-127 regenerated, with H-226 showing higher regeneration potential in a shorter span of time, within 11-25 days. In 9S-127, regeneration started on the 45th day after inoculation onto regeneration media. Number of regenerants obtained in H-226 was 9, whereas only one clump regenerated in 9S-127. No regeneration was obtained for 8S-501. The regenerated tissues were maintained in differentiation media. The regenerated calli of H-226 and 9S-127 were inoculated in elongation media.

Cassava variety H-226 responded to elongation with stem elongation after 10 days.

Molecular characterization of nutrient homeostasis in tubers for biofortification of cassava

Seven cassava genotypes with high and low protein content in leaves and tubers were selected for protein profiling at various growth stages and four cassava genotypes were chosen for vitamin A profiling and planted in June 2023. Samples were collected from various tissues such as root, stem, leaves and tubers at various growth stages from 1, 2, 3 and 6 months after planting. Fresh weight of the tissues was noted and the tissues were dried and stored for biochemical analysis. Simultaneously, the plant tissues were also collected for isolation of DNA/RNA/protein for molecular studies and stored. Analysis of total soluble protein content in various tissues of few samples of genotype V4 revealed a gradation in protein content in cassava stem and tubers at various growth stages by three months after planting. *In silico* analysis of cassava genome was carried out for candidate genes involved in protein metabolism and five candidate genes possibly involved in protein metabolism were selected and primers were designed for gene expression studies.

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

For drought tolerance, 25 C_2 clones from the cross between H-97 x 9S-127 were planted (September, 2023) in control and drought conditions. From this, 15 C_2 clones and parents were used for recording physiological characters viz., plant height, leaf retention, leaf area index (LAI) and canopy temperature at 15 days interval from December 2023 along with drone image using RGB camera. Whereas, the chlorophyll, carotene and osmolyte contents, photosynthesis rate and chlorophyll florescence was recorded at 60 days interval.

The observation on physiological characters was completed thrice. The average LAI increased from 1.76 to 2.38, plant height increased two times (30 to 60 cm), whereas, the average leaf retention increased from 17 to 36. The photosynthetic rates among cassava genotypes varied, with D21/10 exhibiting the lowest rate of 10 ± 1.8 (µmol $m^{-2}s^{-1}$), while D21/17 showed the highest rate at 30 ± 3.9 (µmol $m^{-2}s^{-1}$). Overall, there was a notable range of 20 units, emphasizing diversity in photosynthetic capabilities among parents and progenies.

For PPD studies, observations on physiological traits such as plant height, leaf retention and LAI were recorded in 30 C2 clones from the cross 9S-127 x CO-1 every 15 days. The average plant height and LAI recorded was 79.46 cm and 2.01, respectively. The physiological characters recorded from the field and drone image data, will be used in machine learning or deep learning methods to develop the best model for drought and PPD studies.

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

To understand the nutritional profile of biofortified sweet potato hybrids, anthocyanin, carotenoids, Fe and Zn were estimated in tubers of 10 selected hybrids. Total carotenoid content in the tubers ranged from 0.10 to 14.50 mg 100 g^{-1} FW, while the total anthocyanin content ranged from 4.06 to 121.86 mg 100g^{-1} FW. Iron content ranged from 0.75 to 1.06 mg 100g^{-1} FW and zinc content from 56.53 to 85.09 µg 100g^{-1} FW.

In the preliminary yield trial of 115 hybrids during kharif season, the genotype 678/36 with dark orange flesh yielded highest (500 g $plant^{-1}$). The yield ranged from 25-500 g $plant^{-1}$. Based on the data over six seasons (2020-2022), onfarm trials were initiated with five biofortified hybrids (38/46, 38/15, 110/28, 43/83, 536/6) along with Sree Kanaka, Bhu Krishna and Sree Arun in farmers field with 50 vine cuttings of each genotype in seven locations in Kerala viz., Thiruvananthapuram (Venkadampu, Mavilakkadavu, Vlathankkara), Kannur (Payyavur), Wayanad (Edavaka) and Ernakulam (Ayavana) with a spacing of 60 x 20 cm. Results of onfarm trials at Venkadampu during February 2023 showed that the tuber yield of five genotypes ranged from 17.80 to 20.90 t ha^{-1}, while Bhu Krishna yielded 4.60 t ha^{-1}, Sree Kanaka 17.60 t ha^{-1} and Sree Arun 16.50 t ha^{-1}. The yield at Plamoottukkada (Thiruvananthapuram) showed a

yield ranging from 17.60 to 19.25 t ha^{-1}. The check variety Bhu Krishna gave poor tuberization, whereas, Sree Kanaka and Sree Arun yielded 14.30 and 13.50 t ha^{-1}, respectively.

Biochemical analysis of these selected lines revealed that the carotenoid content of genotype 38/15, a bushy plant type was highest, 14.5 mg 100g^{-1} FW and the cream-fleshed hybrid 38/46 contained anthocyanin (8-10 mg 100g^{-1} FW) and starch content of 20%. The hybrid 110/28 was high in both carotenoids (9 mg 100g^{-1} FW) and anthocyanins (60 mg 100g^{-1} FW) with medium starch content (13.87%). The other two 43/83 and 536/6 (Fig. 5) are orange-fleshed hybrids with starch contents of 22.50% and 19%, respectively and total carotenoid content of 2.20 mg 100g^{-1} FW and 4.64 mg 100g^{-1} FW, respectively.

In an experiment on evaluation of leaf yield of 12 biofortified hybrids for use as vegetable/ornamental purpose, the leaves were harvested once in a month for two months. The total leaf yield and marketable leaf yield were recorded. The average marketable leaf yield for two harvests ranged from 1.04 t ha^{-1} (in hybrid 22/6) to 2.85 t ha^{-1} (in hybrid 401/1).

Twenty five sweet potato hybrids with suitability to processing were evaluated for 17 above ground traits and replanted for tuber evaluation. The tuber skin variants were pink and cream, whereas, the flesh colour variants were yellow, cream, light to dark orange.

Fig. 5. A. H-43/83; B. H-536/6
Promising biofortified sweet potato hybrids

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

Thirty four hybrids were developed previously, among them, 13 best sweet potato hybrid lines including four white flesh (SPH 65, SPH 19, SPH 61 and SPH 60), four orange (SPH 44, SPH 21, SPH 52 and SPH 40) and five purple flesh (SPH 31, SPH 30, SPH 29, SPH 15 and SPH 14) were evaluated. In the Initial Evaluation Trial (IET) among the purple flesh sweet potato entries (SPH 31, SPH 14, SPH 15, Sankar, Kalinga and Bhu Krishna), the highest yield was recorded in SPH-31 (26.20 t ha^{-1}) over check variety Bhu Krishna (22.42 t ha^{-1}). The entry SPH-31 performed well in the multi-location trial (2nd year) in five districts of Odisha (Khurdha, Jajpur, Koraput, Kandhamal and Gajapati) and yielded (26.06 t ha^{-1}) over check variety Bhu Krishna (20.03 t ha^{-1}). Amongst the entries tested, SPH-31 had the highest content of anthocyanin (133-157 mg 100g^{-1} FW). SPH-31 (IC650535) was submitted to State Varietal Release Committee (SVRC), Odisha during 2023 for release in Odisha in the name of Sree Arunima (Fig. 6).

Fig. 6. Sweet potato hybrid, SPH-31 (Sree Arunima)

Fig. 7. Orange flesh sweet potato hybrid, SPH-52

In the IET for orange flesh sweet potato entries (SPH-52, SPH-40, Bhu Ja, Bhu Kanti, Gouri and Bhu Sona), SPH-52 yielded the highest (24.56 t ha^{-1}) over check variety Bhu Sona (18.36 t ha^{-1}). The entry SPH-52 performed best (23.87 t ha^{-1}) (Fig. 7) in the multi-location trial (1st year) in five districts of Odisha (Khurdha, Jajpur, Koraput, Kandhamal and Gajapati) over the check variety Bhu Sona (17.80 t ha^{-1}).

In the IET for white flesh sweet potato, among the six entries (SPH-60, SPH-61, SPH-19, Sourin, Kalinga, Kishan), SPH-60 produced the highest yield (25.23 t ha^{-1}) over check variety Kishan (20.42 t ha^{-1}). The entry SPH-60 performed best (24.86 t ha^{-1}) in the multi-location trial (1st year) in five districts of Odisha (Khurdha, Jajpur, Koraput, Kandhamal and Gajapati) over check variety Kishan (19.03 t ha^{-1}).

In October 2022, inter-varietal hybridization was initiated in sweet potato and 48 single cross F1 hybrids were produced. Following germination in October 2023, these hybrids were grown in a polybag for further evaluation.

Yam bean

In the IET for development of high yielding varieties in yam bean, among the six entries (YBH-3x8, PH-7, PH-10, DPH-5, DPH-21 and RM-1) tested, the highest yield was recorded in YBH-3x8 (34.05 t ha^{-1}) over check variety RM-1 (26.42 t ha^{-1}). The entry YBH-3x8 performed best (33.27 t ha^{-1}) in the multi-location trial (2nd year) in five districts of Odisha (Khurdha, Jajpur, Koraput, Kandhamal and Gajapati) over check variety RM-1 (26.88 t ha^{-1}). The high yielding yam bean variety YBH-3x8 (IC650536) was submitted to SVRC, Odisha during 2023 for

Fig. 8. High yielding yam bean variety, YBH-3x8 (Sree Chandrika)

release in Odisha in the name of Sree Chandrika (Fig. 8).

In the IET for the development of short duration varieties of yam bean, among the seven entries (YBH-9x10, PH-7, PH-10, DPH-5, DPH-21 and RM-1), the highest yield was recorded in YBH-9x10 (25.47 t ha^{-1}) after 105 days of harvesting (short duration) over check variety RM-1 (20.26 t ha^{-1}). The entry YBH-9x10 was the highest yielder (24.18 t ha^{-1}) in multi-location trial (1st year) in five districts of Odisha (Khurdha, Jajpur, Koraput, Kandhamal and Gajapati) over check variety RM-1 (19.15 t ha^{-1}).

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-3, Bx7, SP-123 and S-162 were planted along with checks Bhu Sona, Bhu Krishna and Kisan for evaluation. Highest yield per plant were recorded in Bx7 (1.76 kg), followed by D/21/57 (1.64 kg), RS-III (1.63 kg) and SxP-162 (1.49 kg). Drought tolerant genotypes were also planted in crossing block along with high yielding and nutritionally rich varieties, Bhu Sona, Bhu Krishna and Kisan for hybridization. A total 15 single

F_1 crosses were made and seeds were collected and planted in pots for raising the F1 hybrid seedlings for further evaluation.

Under the experiment on development of drought tolerant lines in sweet potato, morphological characterization of 50 sweet potato genotypes was done using a randomized complete block design and results revealed significant differences in leaf, vine and root characters. Analysis of variance indicated variability, leading to the grouping of genotypes into four clusters through cluster analysis. Principal component analysis (PCA) justified 61.78% of variations, with genotypes BP-2, Bx132, 123, and 90-91-13 showing high PC1 and PC2 values. Biplot analysis highlighted BP-2, DPS-34, Bx132, 90-91-13 and 497 as distinct, emphasizing plant type, petiole pigmentation and mature leaf colour. Discriminant analysis identified Bx132, 84x14, S-187, DPS-34, DPS-30, DPS-31, BP-2 and SBS37/16 as highly divergent genotypes based on actual and predicted discriminant scores. Multiple statistical procedures and descriptors identified Bx132, BP-2, 84x14, DPS-34 and 90-91-13 as the most diverse genotypes, recommended for sweet potato improvement. For drought tolerance, stress-tolerant indices, correlation analysis, ranking methods, cluster analysis, PCA and biplot analysis were employed. Stress tolerance indices (mean productivity index, geometric mean productivity, yield index, and harmonic mean productivity) were effective indicators. Dhenkanal local-2, 84x14, SB21/57, Howrah and S-783 emerged as the most drought-tolerant genotypes based on various analyses, including cluster and PCA. These genotypes will be used for breeding programs aimed at enhancing drought tolerance in sweet potato.

Taro

Clonal generation and selected high yielding nutritionally rich lines of taro were planted in July 2022 at Regional Station, ICAR-CTCRI and harvested in January 2023. The highest free radical scavenging activity DPPH assay was recorded in 18×TCR-369 (59.80%), followed by CE-334357 (55.36%), 12×TCR 369 (54.33%) and 12×IC022067 (54.10%). The highest CUPRIC assay was recorded in 18×TCR 369 (27.08 µ moltrolox g^{-1}), followed by 12×TCR 429 (27.00 µ moltrolox g^{-1}), 12×IC022067 (26.95 µ moltrolox g^{-1}) and 12×TCR 369 (26.82 µ moltrolox g^{-1}). The highest phenolic content was recorded in 18×TCR 369 (6.22 mg gallic acid g^{-1}), followed by 12×IC022067 (6.10 mg gallic acid g^{-1}), 12×TCR 429 (6.08 mg gallic acid g^{-1}) and CE-334357 (5.10 mg gallic acid g^{-1}). The highest sugar content was recorded in 12×TCR 369 (2.55%), followed by 12×TCR 429 (2.16%), CE-087949 (2.16%) and CE-334357 (2.15%). The highest starch content was recorded in 12×TCR 369 (55.10%), followed by 12×TCR 429 (51.00%), CE-334357 (49.50%) and CE-558 (48.02%). The highest protein content was recorded in 12×IC022067 (13.16 g$100g^{-1}$), followed by 12×TCR 369 (11.05 g$100g^{-1}$), Nycle×224 (8.90 g$100g^{-1}$) and 18×TCR 369 (8.52 g$100g^{-1}$). The highest phosphorous content was recorded in 12×TCR 429 (391.33 mg$100g^{-1}$) followed by 12×IC022069 (356.50 mg$100g^{-1}$), CE-334357 (321.89 mg$100g^{-1}$) and CE-558 (318.10 mg$100g^{-1}$). The highest potassium content was recorded in 12×IC022069 (1142.17 mg$100g^{-1}$), followed by 12×TCR 429 (1120.38 mg$100g^{-1}$), CE-087949 (1056.23 mg$100g^{-1}$) and CE-334357 (1025.67 mg$100g^{-1}$). The highest iron content was recorded in 12×TCR 429 (13.25 mg$100g^{-1}$), followed by 12×TCR 369 (12.56 mg$100g^{-1}$), CE-334357 (12.50 mg$100g^{-1}$) and 12×IC022067 (10.08 mg$100g^{-1}$). The highest copper content was recorded in Nycle×224 (1.26 mg$100g^{-1}$), followed by TCR 813×IC419746 (0.95 mg$100g^{-1}$), 12×TCR 369 (0.85 mg$100g^{-1}$) and CE-416937 (0.81 mg$100g^{-1}$). The highest zinc content was recorded in Nycle×224 (12.85 mg$100g^{-1}$) followed by 18×TCR 369 (10.74 mg$100g^{-1}$), CE-558 (10.57 mg$100g^{-1}$) and TCR 813×IC419746 (7.89 mg$100g^{-1}$). The highest manganese content was recorded in Nycle×224 (6.25 mg$100g^{-1}$), followed by TCR 813×IC419746 (5.00 mg$100g^{-1}$), CE-416937 (4.70 mg$100g^{-1}$) and CE-334357 (4.68 mg$100\ g^{-1}$). Yield ranged from 4.30 to 10.42 t ha^{-1}. The highest yield was recorded in CE-558 (10.42 t ha^{-1}), followed by CE-334357 (10.09 t ha^{-1}), CE-087949 (9.12 t ha^{-1}) and CE-416937 (9.05 t ha^{-1}). Taro genotypes, CE-558 was identified as a rich source of zinc (10.57 mg$100g^{-1}$) with a yield of 10.42 t ha^{-1} and CE-334357 as a rich source of iron (12.50 mg$100g^{-1}$) with a yield of 10.09 t ha^{-1}.

SREE HIRA: A novel variety of taro for Odisha

The Sree Hira, a new elite taro (*Colocasia esculenta* (L.) Schott.) variety was developed through clonal

Fig. 9. Sree Hira. A. Kharif crop field view; B. Rabi crop field view; C. Plant structure; D. Cormels; E. Cormels clump with corm; F. Harvested cormels; G. Mother corms

selection from the Regional Station of ICAR-CTCRI, Bhubaneswar (Fig. 9). It is suitable for the rainfed upland and irrigated, medium and low land conditions of Odisha. The plants are semi-erect, medium plant type with green petiole and leaf blade. It is tolerant to leaf blight disease. It bears 12-16 cormels per plant, which are long elliptical with brown skin and white flesh colour. The average weight of each cormel is 60-100 g. Sree Hira produces a cormel yield of 16-20 t ha^{-1} and can be harvested after 180 days of planting. The cormels have a starch content of 17.40% and sugar 1.20% on fresh weight basis. The cormels have good palatability, are mealy and have aroma. Cooked cormels are liked extremely by the consumers. It has low acridity (calcium oxalate 9.2 mg 100 g^{-1}). The farmers get a net return of ₹ 2.50-2.70 lakh ha^{-1} by cultivating this variety.

SREE TELIA: A new short duration variety of taro for Odisha

Taro (*Colocasia esculenta* (L.) Schott.) is a popular tuber crop in Odisha, where it is cultivated under rainfed conditions during kharif. The taro variety Sree Telia (Fig. 10) is a clonal selection developed from the Regional Station of ICAR-CTCRI, Bhubaneswar. It is a short duration variety (120 days). The plants are semi-erect, medium plant type with purple petiole and green leaf blade. It bears 7-9 cormels per plant. The cormels are elliptical with brown skin and white flesh colour. The average weight of each cormel is 30-50 g. This variety produces a cormel yield of 10-12

Fig. 10. A. Sree Telia field view; B. Sree Telia plant structure; C. Mother corms; D. Cormels

t ha^{-1}. The cormels have a starch content of 16.40% and sugar 1.20% on fresh weight basis. The cormels have good palatability, are mealy and have aroma. Cooked cormels are liked extremely by the consumers. It is having low acridity (calcium oxalate 12.60 mg 100 g^{-1}). The farmers can get net return of ₹1.30-1.50 lakh ha^{-1} by cultivating Sree Telia.

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

The assessment of 40 sweet potato genotypes for salinity tolerance *in vitro*, exposure to varying concentrations of NaCl (0%, 0.5%, 1%, and 1.5%) showed that at a concentration of 0.5%, four genotypes viz., SP-12, SP-13, SP-24 and SP-27, displayed optimal values for key growth parameters, encompassing shoot length, root length, shoot number, root number and leaf number. At a concentration of 0.5% NaCl, SP-12 produced a shoot length of 1.5 cm, with four shoots and two leaves. SP-13 had a shoot length of 2.20 cm, along with two shoots, five leaves, two roots and a root length of 4.50 cm. SP-24 showed a shoot length of 2.80 cm, two shoots, five leaves, four roots, and a root length of 4.8 cm. SP-27 showed a shoot length of 2.60 cm, three shoots, two leaves, three roots, and a root length of 2.80 cm. Fifty sweet potato genotypes were planted in the field to assess their performance in terms of high yield, early maturity, and quality traits.

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

Under the genetic improvement program of taro, OP seeds of elite line, BCC-38 (♀) with pollen parents C-149 from RAU, Dholi and Sree Hira, the newly released variety of ICAR-CTCRI, showed almost 100% germination.

Under elephant foot improvement experiment, three crosses were made between Gajendra (♀) with Am-75 and NL/2019 (♂). However, the crosses were not successful and resulted in zero seed set. About 200 F1 progenies of elephant foot yam was crossed in the previous year and AmH 22 series (Gajendra ♀ x AD/2022-1 ♂) was planted in pots. Seedling germination studies showed 100% germination, but only 86.30% established. Number of days taken to germination showed wide variation with 5.40% taking less than one month, 43.60% between 1 to 2 months, 48% between 2 to 3 months, 2.50% between 3 to 4 months and 0.50% taking more than 4 months, to germinate. Number of pseudostems produced per seedlings ranged from 1 to 6 with maximum seedlings showing 2 pseudostems per plant (47.70%). Nature of pseudostem showed that 83.50% were smooth, 7.30% slightly rough and 9.10% rough. Smooth pseudostem surface is indicative of non-acrid nature of the corm and hence can be used as selection criteria. The pseudostem pattern also showed variation. Leaf type was mostly normal (86.90%), whereas, few showed narrow leaves (9.10%) and variegated leaves (4%). Except for one plant with narrow leaves, none of the other seedlings with narrow/variegated leaves survived. Leaf colour ranged from dark green (2.80%) to green (60.20%) to light green (27.30%). Apart from this, yellow (1.70%) and albinos (4%) were also observed. However, none of the seedlings with yellow leaves/albinos survived. Average number of leaflets was five or more in 85.80% and below five in 14.20%. The F1 progenies were harvested at the end of the season. About 60 seedlings produced corms and these were treated with cow dung slurry and *Trichoderma* for planting in the next season.

For standardization of *in vitro* micropropagation protocol in tannia, effect of various combinations of BA/Kin in combination with IAA/IBA has been initiated. The combination of BA (2 mg l^{-1}) + NAA (0.5 mg l^{-1}) produced compact basal callusing, which could be used for creation of variability.

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

Seven indigenous genotypes of Chinese potato namely Varavoor (IC641828), Kunnamkulam (IC641829) (Thrissur district), Kullaparachal (IC641830), Vandamedu (IC641831) (Idukki district), Cumbum (IC641832) (Theni district), Ettayapuram (IC641833) and Kovipatti (IC641834) (Thoothukudi district)) were evaluated (days to sprouting, % final sprouts, shoot length, number of shoots per tuber, total number of leaves and vigour index) with an aim to assess breeder tuber quality and seedling variation for genetic vigour, in the laboratory condition. The overall evaluation indicated that the tubers took 3-6 days to initiate sprouts with final sprout germination ranging from 51 to 91%. The standard deviation observed for sprout initiation and final germination were 0.96 and 12.29, respectively. The range of values observed for the number of shoots and vigour index were 2 to 8 and 146 to 424, respectively with CV% of 0.43 and 0.32 for these parameters. The genotype from Cumbum had the highest average final germination of 85% followed by the one from Varavoor (84.5%). Kallaparachal had the highest numbers of shoots per tuber (7.33), followed by the genotype from Kovilpatti (4.35). Vigour index was highest in the genotype from Varavoor (347), followed by that from Kallaparachal (322). The overall results indicated that Chinese potato genotypes had variations for seed quality performance under lab conditions and the local genotype from Varavoor (IC641828) and Kallaparachl (IC641830) showed better seed quality and genetic vigour.

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

For inducing genetic variability in Chinese potato, gamma irradiation treatments to Chinese potato tubers of variety Sree Dhara showed that irradiation doses of 5, 10, 15, 20 and 25 Gray (Gy) promoted sprout germination of 58, 61.30, 76, 76 and 73%,

respectively, whereas, control showed only 50% germination. The laboratory evaluation of tubers revealed that the highest CV% was observed for number of leaves per tuber (39.50%), followed by shoot length (30.60%) and least CV% was recorded for sprout germination (15.40%). Irrespective of irradiation Gy dosage, three samples (tubers) of Sree Dhara, which received 15 Gy and another one sample (tuber) from 20 Gy responded well to mutation treatments. All the three tubers, which received 15 Gy dose showed early initiation of tubers at 8th week after incubation under *in vitro* lab condition, whereas, one sample from 20 Gy treatment had multiple plantlets as well as early tuber initiation (8th week after treatment). It is inferred that the photo insensitivity character was reflected in all the "mutated plants" for gamma radiation, as they initiated early tuberization under laboratory condition (*in vitro*). Similarly, significant variations were established for important traits viz., number of leaves and number of plantlets etc. through gamma irradiation. The variety Nidhi exhibited no effect of gamma irradiation treatments.

Crop Production

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

Crop diversification involving tropical tuber crops

Cropping systems involving tropical tuber crops

Vegetable intercropping systems in taro: A field experiment was conducted during 2023 at the Regional Station of ICAR-CTCRI, Bhubaneswar, Odisha, for third consecutive season to confirm the effect of intercropping vegetable crops in taro on productivity, biological efficiency and economics. The experiment consisted of seven treatments, sole taro (T_1), sole okra (T_2), sole vegetable cowpea (T_3), sole cluster bean (T_4), taro + okra (T+O 1:1) (T_5), taro + vegetable cowpea (T+VC 1:1) (T_6) and taro + cluster bean (T+CB 1:1) (T_7) laid out in RBD with three replications. Intercropping in taro resulted in higher cormel equivalent yield than sole cropping. The treatment taro + vegetable cowpea resulted in significantly higher cormel equivalent yield (20 t ha^{-1}), followed by taro + cluster bean (16.90 t ha^{-1}). The land equivalent ratios (LER) for T_5, T_6 and T_7 were >1, indicating their higher biological efficiency (Fig. 11). The treatment taro + vegetable cowpea resulted in greater LER, higher gross (₹ 3,00,000 ha^{-1}) and net returns (₹ 1,77,000 ha^{-1}). The B:C ratio was highest (2.64) in sole okra, followed by taro + vegetable cowpea (2.44).

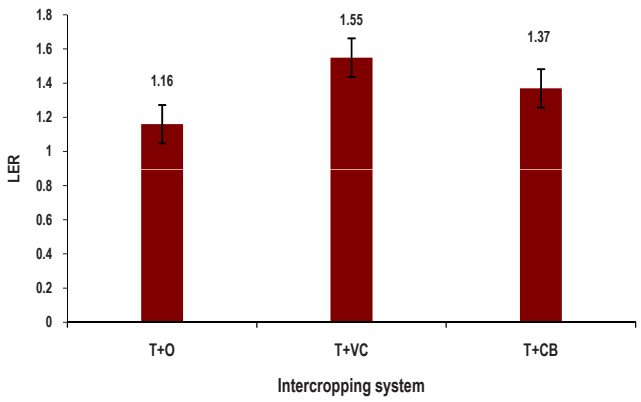


Fig.11. Effect of taro + vegetable intercropping system on LER

Sequential cropping system involving short-duration cassava and vegetables in rice based system: Short-duration rice var. Manu Ratna was taken up as first crop (June-August), followed by short-duration cassava (var. Sree Vijaya and Vellayani Hraswa) during the second season (September-February) in main plots and two fertility levels in sub plots. Thereafter, vegetables (amaranthus (var. KAU Vaika), cucumber (var. KAU Vishal) and water melon (var. Shonima) were sown under two fertility levels during March-April. Sole crop of cassava under full dose of manures and fertilizers were also maintained for comparison.

Of the three systems involving vegetables, rice-short-duration cassava (var. Sree Vijaya or Vellayani Hraswa)-cucumber (var. KAU Vishal) was the most productive with higher tuber equivalent yield (98.15 t ha^{-1}), production efficiency (272.63 kg ha^{-1} day^{-1}) and energy equivalent (323.63 x 10^3 MJ ha^{-1}) at reduced fertility levels (half FYM & N, zero P to cassava; half FYM, N & P to cucumber).

Organic farming of tuber crops-based cropping systems

Organic farming of cassava based cropping systems: A field experiment in split plot design with cassava (var. Sree Reksha) + vegetables (3 vegetables; chilli (var. Vellayani Athulya, cluster bean (var. Gloria), tomato (var. Vellayani Vijai) in main plots and five management options viz., 100% organic, 75% organic + innovative practices (75% organic + 3% *Panchagavya* + cow urine), integrated 1 (75% organic + 25% inorganic), integrated 2 (50% organic + 50% inorganic) and the present package of practices (PoP) of the respective crops in subplots is being carried out for the first season.

The vegetable intercrops have been harvested. Management options did not significantly influence

yield of vegetables. However, 100% organic in the case of chilli (2.88 t ha^{-1}) and tomato (3.17 t ha^{-1}) and 75% organic in cluster bean (2.36 t ha^{-1}) resulted in highest yield (Fig. 12). Thus, yields were higher by 42% in organic over PoP in chillli and tomato and +24% in 75% organic over PoP in cluster bean. Cassava crop is yet to be harvested.

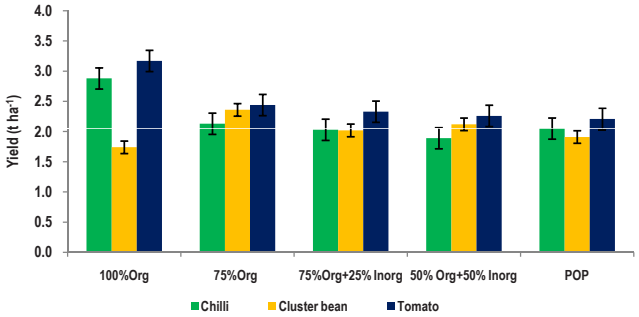


Fig. 12. Yield of vegetable intercrops under different management options

Weed management in tropical tuber crops

Integrated weed management in taro

A field experiment was conducted for the third season to study the effect of integrated weed management in taro on yield and economics. The experiment was laid out in Randomised Block Design. The treatments were replicated thrice. The variety Muktakeshi (taro) was planted on 04 July 2022 and harvested on 12 January 2023.

The results revealed that the use of weed control ground cover perforated mat (nursery men mat) (120 gsm) was effective to promote growth of the crop and resulted in higher sprouting percentage at 1 and 3 months after planting (86.10, 96.30% respectively), number of tillers per plant (4.88) and leaf area index (1.30) at 4 months after planting, significantly lower weed density (8.63) and dry weight of the weeds (2.95 g) per square meter. Weed flora noticed in the experimental field were: *Cyanodon dactylon* (L.) Pers. *Setaria glauca* (L.) Beauv., *Pennisetum polystachion* (L.) Schultes, *Pennisetum pedicellatum* Syn. *Cenchrus pedicellatus* (Trin.) Morrone, *Mimosa pudica* L., *Indoneesiella echioides* L., *Euphorbia hirta* L., *Alternanthera paronychioides* A. St. Hil., *Atylosia scarabaeoides* (L.) Benth. Among the weed management practices, weed control ground cover perforated mat produced significantly higher yield of corms (7.62 t ha^{-1}), cormels (19.86 t ha^{-1}), higher gross (₹ 5,58,990 ha^{-1}) and net returns (₹ 3,76,379 ha^{-1}) and B:C ratio (3.06).

Precision management of water and nutrients in tropical tuber crops

Water management studies in sweet potato

The field experiment to standardize a suitable irrigation schedule in sweet potato was conducted for the fourth season with eight treatments in RBD with three replications. The treatments comprised of drip irrigation @ 50 (T_1), 75 (T_2), 100 (T_3), 125 (T_4) and 150% cumulative pan evaporation (CPE) (T_5); sprinkler irrigation @ 5 mm (T_6); furrow irrigation @ 5 mm (T_7) and a rainfed control (T_8). The crop was planted during January 2023 and irrigation was given as per treatments. The tuber yield showed significant statistical variation among irrigation treatments. The highest tuber yield was recorded in T_3 (20.82 t ha^{-1}), followed by T_7 (16.87 t ha^{-1}) and T_4 (16.2 t ha^{-1}), which were on par. Pooled analysis of the data indicated that drip irrigation @ 100% CPE (T_3) was the optimum level of irrigation for sweet potato. Water productivity was worked out as 4.6 to 8.2 kg m^{-3} for different levels of drip irrigation (Fig. 13.). Water productivity computed for sprinkler and furrow irrigation was 2.4 and 2.9 kg m^{-3} respectively.

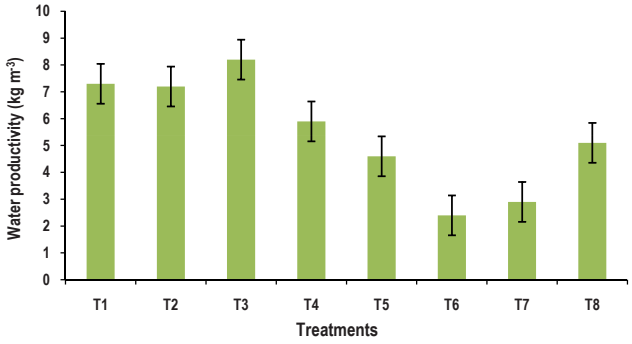


Fig. 13. Water productivity of sweet potato under different irrigation treatments

Water saving techniques in cassava

The field experiment was conducted for the second season with drip irrigation at 50% cumulative pan evaporation (CPE) along with eight water saving treatments viz., porous ground cover mulching (T_1), biomulching (T_2), application of coir pith (T_3), foliar application of antitranspirant (T_4), application of pusa hydrogel (T_5), organic gel Sujalam (T_6), Pusa hydrogel along with ground cover mulching (T_7), organic cultivation practices (T_8), along with drip irrigation

at 50% as control (T_9). Three more treatments viz., drip irrigation at 100% CPE (T_{10}), furrow irrigation (T_{11}) and a rainfed crop (T_{12}) were also included for working out the water use efficiencies. Porous ground cover mulching with drip irrigation at 50% CPE resulted in the highest tuber yield (64.84 t ha^{-1}), which was on par with pusa hydrogel along with ground cover mulching. Rainfed crop resulted in 9.40 t ha^{-1} of tuber yield. Ground cover mulching resulted in 34.20% increase in tuber yield and 50% saving in irrigation water compared to drip irrigation at 100% CPE (Fig. 14). Water saving techniques enabled 47 to 117% increase in tuber yield than the treatment with irrigation at 50% CPE without any water saving measures.

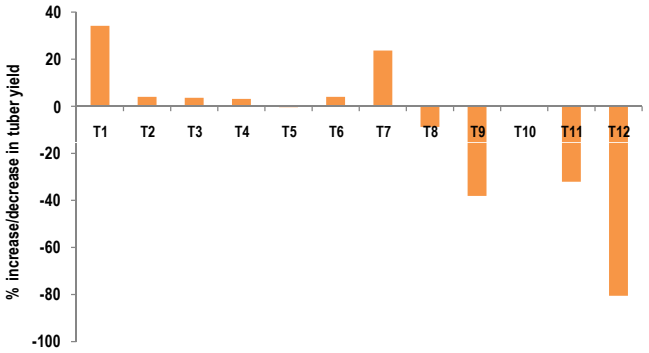


Fig. 14. Per cent increase/decrease in cassava tuber yield compared to irrigation at 100% CPE (T_{10})

Fertigation studies in elephant foot yam

The first season experiment on fertigation studies in elephant foot yam to standardize the fertigation schedule was completed. The experiment was laid out in split plot design with four levels of nutrients in main plots (M_1:75-50-100; M_2:100-50-100; M_3:100-50-125; M_4:100-50-150 kg N, P_2O_5 and K_2O per ha) and three schedules of fertilizer application in sub plots (S_1: 50% N and K< 90 DAP, 25% 90-120 DAP, 25% 120-180 DAP; S_2: 50% N and K< 120 DAP, 25% 120-150 DAP, 25% 150-180 DAP and S_3: 25% N and K< 90 DAP, 50% 90-150 DAP, 25% 150-180 DAP). The corm yield at harvest indicated no significant difference among the fertilizer doses and schedules of application (Fig. 15). The lowest dose, 75-50-100 kg N, P_2O_5 and K_2O per ha applied @ 50% before 120 DAP, 25% during 120-150 DAP and 25% during 150-180 DAP was beneficial for optimum yield (45.50 t ha^{-1}).

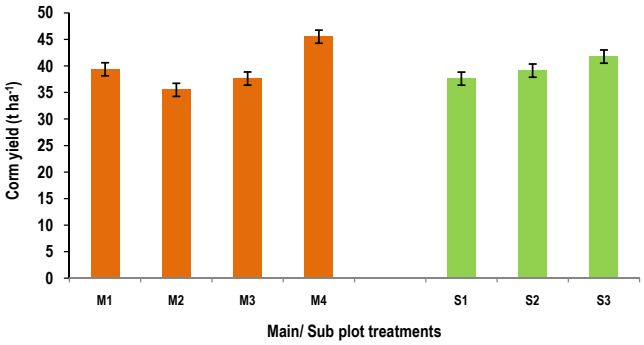


Fig. 15. Corm yield of elephant foot yam under fertigation treatments

Water management studies in Chinese potato

The field experiment to standardize a suitable irrigation schedule in Chinese potato was initiated with eight treatments in RBD with three replications. The treatments comprised of drip irrigation @ 50 (T_1), 75 (T_2), 100 (T_3), 125 (T_4) and 150% cumulative pan evaporation (CPE) (T_5); sprinkler irrigation @ 5 mm (T_6); furrow irrigation @ 5 mm (T_7) and a rainfed control (T_8). The crop was planted in November and the experiment is in progress.

Drip irrigation and fertigation management in greater yam

A field experiment was conducted for the third season to study the effect of levels of drip irrigation and fertigation on greater yam at Regional Station, Bhubaneswar, Odisha. The experiment was laid out in split plot design with three levels of irrigation in main plots [(60% CPE (I_1), 80% CPE (I_2) and 100% CPE (I_3)] and three fertigation levels in subplots [(NPK@ 60:60:60 kg ha^{-1} (F_1), NPK@ 80:60:80 kg ha^{-1} (F_2) and NPK@ 100:60:100 kg ha^{-1} (F_3)] and check: (surface irrigation IW/CPE: 1.0; P@ 60 kg ha^{-1} basal application; NK@ 80:80 kg ha^{-1} soil application at basal (40%), 30 (30%) and 60 (30%) days after planting) and control: (surface irrigation IW/CPE: 1.0; without fertilizer) were also included for comparison. The crop was harvested at 300 DAP on 21 February 2023.

Increasing the levels of irrigation increased the yield of greater yam (Fig. 16). The treatment I_3 resulted in the highest tuber yield of 38.20 t ha^{-1} and it was followed by I_2 with 36.00 t ha^{-1}. Among fertigation, the treatment F_3 resulted in significantly the highest tuber yield (36.70 t ha^{-1}) (Fig. 17).

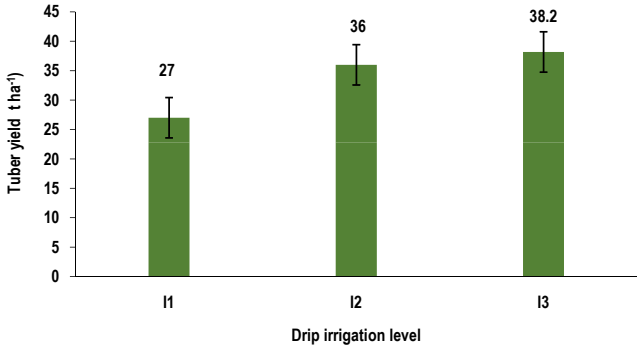


Fig. 16. Effect of levels of drip irrigation on the yield of greater yam

The treatment I_3F_3 resulted in higher tuber yield (40.40 t ha^{-1}), water use efficiency, gross return, net return (₹ 6,06,600 and 4,01,500 ha^{-1} respectively) and B:C ratio (2.95) on par with I_2F_3 and I_3F_2. The treatment I_3F_1 resulted in higher nutrient use efficiency (187 kg kg^{-1}), especially nitrogen and potassium (564 kg kg^{-1}). Higher phosphorus use efficiency was in the treatment I_3F_3 (630 kg kg^{-1}).

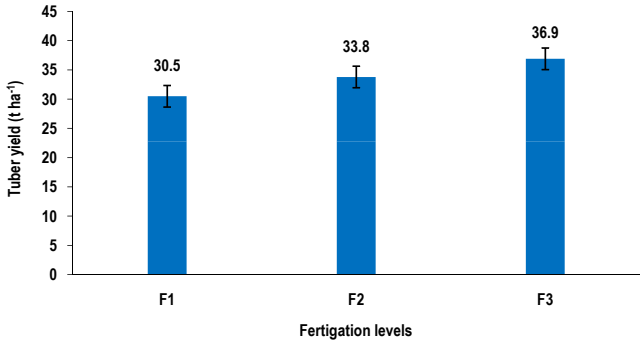


Fig. 17. Effect of levels of fertigation on the yield of greater yam

Studies on fertigation intervals and number of splits in greater yam

A field experiment was conducted for the first season to study the effect of fertigation intervals and number of splits on greater yam at Regional Station, Bhubaneswar, Odisha. The experiment was laid out in split plot design with fertigation intervals in main plots (2 days (I_1), 3 days (I_2) and 4 days (I_3)) and number of splits in sub plots (40 splits (S_1), 50 splits (S_2) and 60 splits (S_3)). A control treatment [soil application of N:P_2O_5:K_2O @ 100:60:100 kg ha^{-1} at NK basal (40%), 45 (30%) and 90 (30%) days after planting) and full P at basal] was also included. The treatments were replicated thrice. Drip irrigation was given at 80% CPE. Fertigation of N:P_2O_5:K_2O @ 100:60:100 kg ha^{-1} was adopted. The crop was harvested at 300 DAP on 23 February 2023. The treatments I_2 and S_3 resulted in higher tuber yield of 36.00 t ha^{-1} and 39.80 t ha^{-1} respectively (Fig. 18 and 19). The treatment I_2S_3 resulted in significantly higher tuber yield (39.80 t ha^{-1}), gross (₹ 5,96,500 ha^{-1}) and net returns (₹ 3,88,200 ha^{-1}) as well as B:C ratio (2.87).

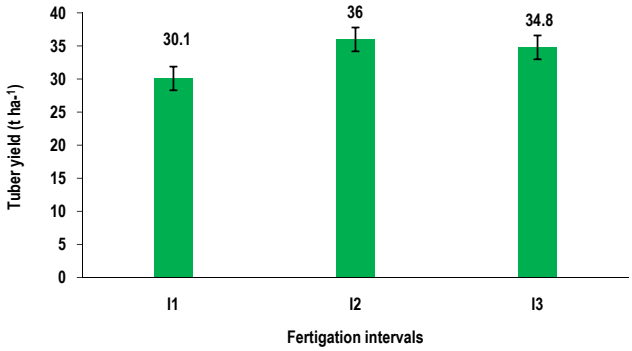


Fig. 18. Effect of number of splits of fertigation on the yield of greater yam

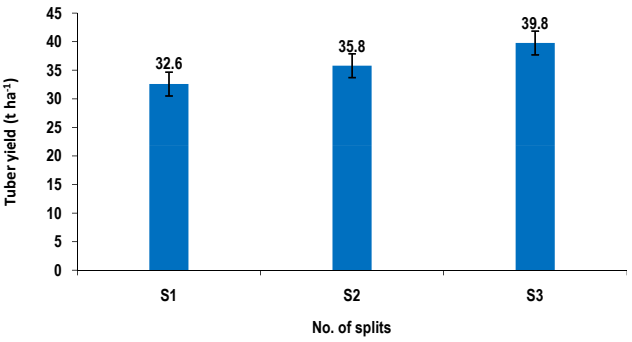


Fig. 19. Impact of drip fertigation intervals on the yield of greater yam

The second season field experiment laid out during 2023 to study the effect of fertigation intervals and number of splits on greater yam is in progress.

Sustainable nutrient management in tropical tuber crops

INM in greater yam + maize system and arrowroot

Effect of integrated use of inorganic and organic sources on yield, proximate composition and soil quality in greater yam + maize system: In the experiment conducted during kharif 2022-23, significantly highest tuber yield (29.10 t ha^{-1}) was obtained for integrated application of FYM @ 10 t ha^{-1} in combination with NPK @ 40:30:40 kg ha^{-1} with a yield response of 99.30% over control. Graded doses of N application showed a tuber yield response of 30, 57, 83 and 82% with the application of N @ 40, 80, 120 and 160 kg ha^{-1}, respectively

over control. An increase of 39, 60 and 55% tuber yield over control was noticed due to addition of 30, 60 and 90 kg P_2O_5 ha^{-1}, respectively and a tuber yield response of 39, 68 and 75% over control was observed due to application of 40, 80 and 120 kg K_2O ha^{-1}, respectively. Dual inoculation of *Azospirillum* and phosphorus solubilizing bacteria (PSB) along with 40 and 30 kg ha^{-1} of N and P_2O_5, respectively showed an increase of 88% tuber yield over control.

Integrated use of FYM @ 10 t ha^{-1} and NPK @ 40:30:40 kg ha^{-1} showed highest dehydrogenase activity (1.41 µg TPF h^{-1} g^{-1}) and fluorescein diacetate hydrolysis (FDA) (5.66 µg g^{-1} h^{-1}). Urease activity was the highest (395.8 µg NH_4-N g^{-1} h^{-1}) due to application of 120 kg N ha^{-1}. Highest activities of acid and alkaline phosphatase (56.32 and 45.79 µg PNP g^{-1} h^{-1}, respectively) were observed due to combined application of FYM and NPK @ 40:30:40 kg ha^{-1}, followed by N_{40} + P_{30} + *Azospirillum* + PSB. Count of bacteria in soil had significantly highest relationship with the activities of dehydrogenase, FDA, urease and acid phosphatase (with r values of 0.779**, 0.880**, 0.608**, and 0.734** respectively). Integrated use of organic manures and biofertilizers along with ½ NPK improved the soil health, thereby producing sustainable crop yields in greater yam.

Screening nutrient efficient genotypes of sweet potato

Screening of elite sweet potato genotypes for nitrogen use efficiency: Results of the field experiment conducted during kharif 2022-23 on nutrient use efficient genotypes of sweet potato evaluated with 90 elite genotypes revealed that Kishan resulted in significantly highest tuber yield (14.12 t ha^{-1}), followed by Kanjanghad (12.41 t ha^{-1}). Combined application of FYM + 50 kg N ha^{-1} resulted in significantly highest tuber yield (14.52 t ha^{-1}) with a yield response of 74% over control.

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

Nutrient management for naturally biofortified sweet potato varieties: A field experiment was conducted for the second consecutive rabi season during 2022-23 to study the effect of various nutrient management practices on yield and proximate composition of biofortified sweet potato varieties. The highest tuber yield (12.41 t ha^{-1}), starch content (21.14%), total sugars (3.08%) and dry matter content (26.21%) was recorded in Bhu Krishna.

Integrated application of FYM @ 5 t ha^{-1} along with NPK @ 75:25:75 kg ha^{-1} resulted in the highest tuber yield (12.49 t ha^{-1}), starch content (20.27%) and total sugars (2.98%). Among the fertility gradients, highest starch (20.27%), total sugar (2.98%) and dry matter contents (26.15%) were observed with FYM @ 5 t ha^{-1} along with NPK @ 50:25:50 kg ha^{-1}.

Highest soil organic C (0.388%), available N (216 kg ha^{-1}) and available K (275.1 kg ha^{-1}) was observed due to the application of FYM @ 5 t ha^{-1} along with NPK @ 75:25:75 kg ha^{-1}. Results suggested that Bhu Sona and Bhu Krishna performed better than Bhu Ja and Bhu Kanti. Integrated application of FYM @ 5 t ha^{-1} along with NPK @ 75:25:75 kg ha^{-1} of N, P_2O_5 and K_2O was the optimum dose for biofortified sweet potato in acid Alfisols.

Land configuration effects on biofortified sweet potato varieties: A field experiment was conducted for the second season at Regional Station, Bhubaneswar, Odisha, to study the effect of land configuration on biofortified sweet potato varieties. It was laid out in split plot design with land configuration in main plots [(30 cm ridge height (60 cm row to row spacing) (L_1), 45 cm ridge height (90 cm row to row spacing) (L_2) and 60 cm ridge height (120 cm row to row spacing with two lines of planting on each ridge) (L_3)] and varieties [(Bhu Krishna (V_1), Bhu Sona (V_2), Bhu Kanti (V_3) and Bhu Ja (V_4)] in sub plots with each treatment replicated thrice.

Varieties varied significantly for total tuber yield, harvest index and economics. The variety Bhu Krishna produced significantly higher marketable tuber yield (13 t ha^{-1}), gross (₹ 2,60,300 ha^{-1}) and net (₹ 1,81,300 ha^{-1}) returns as well as B:C ratio (3.29). The interaction effects revealed that planting Bhu Krishna at 45 cm ridge height (90 cm row to row spacing) (L_2V_1) resulted in significantly higher marketable tuber yield (13.70 t ha^{-1}), gross (₹ 2,73,000 ha^{-1}) and net (₹ 1,93,300 ha^{-1}) returns as well as B:C ratio (3.42). Among the land configurations, the β carotene content was higher (41.72 mg 100 g^{-1} fresh wt basis) in tubers of plants grown in ridges of 30 cm height (60 cm row to row spacing). Among orange-fleshed varieties, higher total β carotene content was noticed in Bhu Sona variety, irrespective of land configurations.

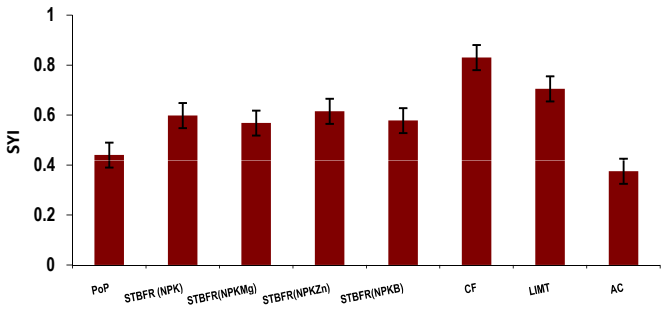
The third season field experiment during 2023 is in progress and the crop is yet be harvested.

Long term integrated nutrient management in tropical tuber crops

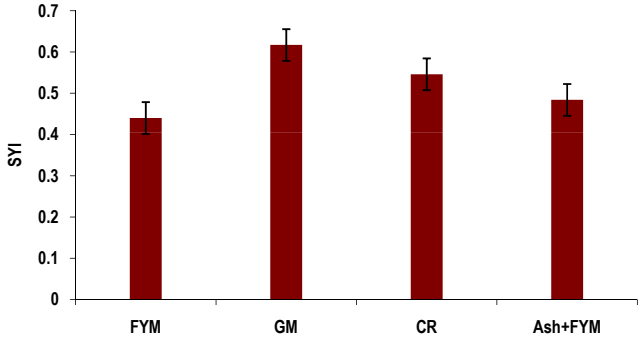
Long term effect of advanced integrated nutrient management (INM) practices on the sustainability of cassava

The fourth phase of the experiment was started in 2020, mainly with treatments to study the sustainability of recently evolved advanced nutrient management practices of cassava. Based on the tuber yield data of three years, the sustainable yield index was computed and the results are as follows:

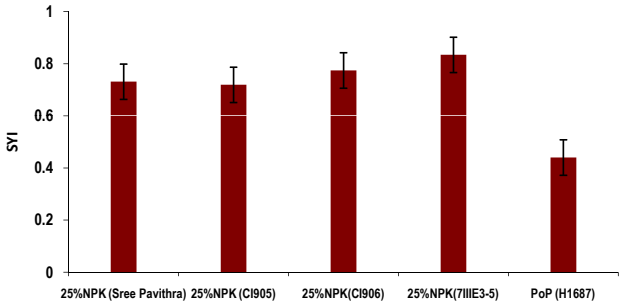
Among the different nutrient management approaches, application of customized fertilizers (CF) resulted in the highest sustainable yield index (SYI) during the three years (0.755, 0.659, 1.075 with mean a value of 0.830). Among the different organic manures tried, green manuring *insitu* with cowpea resulted in the highest SYI during the three years with values of 0.562, 0.491, 0.800 with a mean value of 0.617 (Fig. 20). Among the NUE genotypes at 25% recommended dose of PoP, the SYI was the highest under 7III E3-5 during the three years (0.759, 0.663, 1.081), followed by CI-906 (0.704, 0.615,1.003), Sree Pavithra (0.665, 0.581, 0.947) and CI-905 (0.654, 0.572, 0.932) with mean values of 0.834, 0.774, 0.731 and 0.719 respectively compared to 0.565, 0.493, 0.260 and 0.440 in the case of Sree Visakham under recommended PoP. As regards to the influence of nutrients (both soil and foliar application) on tuber yield, Zn resulted in the highest SYI of 0.705, 0.616, 1.004 during these years with mean value of 0.775 compared to soil test based application of NPK alone (0.544, 0.475, 0.774 and 0.598) respectively.



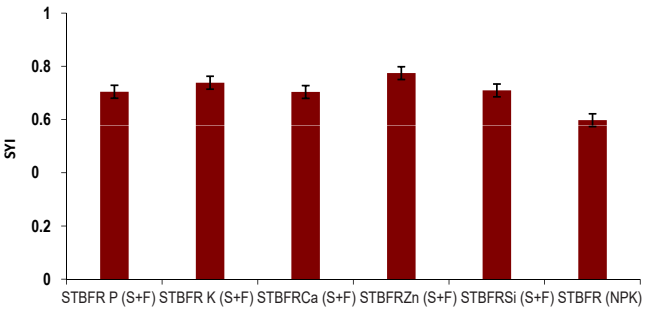
A. Nutrient management practices



B. Organic manures



C. Nutrient use efficient genotypes



D. Soil and foliar application of nutrients

Fig. 20. Sustainable yield index as affected by treatments

The tuber yield was higher under customized fertilizers (CF) (20.98 t ha^{-1}) on par with low input management strategy (LIMT) (19.24 t ha^{-1}). The tuber yield under PoP (12.73 t ha^{-1}) was on par with soil test-based application of NPK (STBFNPK) (13.49 t ha^{-1}) as well as STBFNPK along with independent application of Mg (12.28 t ha^{-1}), Zn (14.82 t ha^{-1}), B (13.85 t ha^{-1}). Tuber yield was not significantly different among the different sources of organic manures used as alternative to FYM (tuber yield of 12.73, 15.04, 13.26 and 11.19 t ha^{-1} for FYM, green manuring, crop residue and ash + FYM respectively). Among the NUE genotypes, 7III E3-5 under 25% of the recommended PoP produced higher tuber yield (27.30 t ha^{-1}) on par with CI-906 (24.06 t ha^{-1}) and

CI-905 (23.03 t ha^{-1}), compared to Sree Pavithra (15.92 t ha^{-1}) and Sree Visakham under PoP (12.73 t ha^{-1}). In the case of foliar application of nutrients to manage CMD, no significant effect was seen in tuber yield among the nutrients applied viz., P (19.10 t ha^{-1}), K (17.27 t ha^{-1}), Ca (20.08 t ha^{-1}), Zn (20.59 t ha^{-1}) and Si (16.21 t ha^{-1}). But these were significantly higher over STBFNPK alone (13.49 t ha^{-1}).

Low input management significantly influenced the soil bulk density with lower values (1.347± 0.047 Mg m^{-3}) as against absolute control (1.524± 0.032 Mg m^{-3}). This treatment also resulted in higher soil water holding capacity (42.03± 0.84 %) as against control (34.91± 0.625%) and other nutrient management and nutrient efficient cassava variety treatments.

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

The first season experiment was conducted with soil having very low B status ranging from 0.01-0.27 ppm. The tuber yield of cassava was good and there was no tuber cracking and the post-harvest soil had very low B content (beyond detectable limit). The correlation worked out between tuber yield and soil B status showed significant negative correlation (-0.6055). Hence there arise a need to study the influence of other nutrients contributing to better tuber yield under very low soil B status. The second season crop to confirm the effect of low soil B on the occurrence of tuber cracking is in progress.

Standardization of nano urea and nano DAP for cassava

Standardization of nano urea: The experiment was started in May 2023 with five treatments replicated four times in RBD. The variety used was Sree Reksha. The treatments included application of N @100 kg ha^{-1} through ordinary urea as per package of practices recommendation (PoP) (T_1), IFFCO nanourea as foliar spray @ 1250 ml ha^{-1} in two splits (T_2), application of 2% ordinary urea in two splits in place of nanourea (T_3), PoP (N @100 kg ha^{-1} through ordinary urea (Treat 1) + IFFCO nano urea as foliar spray @ 1250 ml ha^{-1} in two splits (Treat 2) (T_4) and PoP (N @100 kg ha^{-1} through ordinary urea (Treat 1) + 2% ordinary urea in two splits in place of nano urea (Treat 3) (T_5).

Standardization of nano DAP: The experiment was started in May 2023 with four treatments replicated five times in RBD. The variety used was Sree Reksha. The treatments included application of P @ 50 kg P_2O_5 ha^{-1} as basal (PoP) (T_1), IFFCO recommendation of sett treatment with 0.5% IFFCO nano DAP + foliar spray with IFFCO nano DAP @1000 ml ha^{-1}(T_2), 50% P as per PoP as basal + IFFCO recommendation (Treat 2) (T_3), 100% P as per PoP as basal + IFFCO recommendation (Treat 2) (T_4).

In both these experiments, apart from the analysis of initial soil samples for pH, organic carbon, available N, P, K, growth characters of the plant viz., plant height, stem girth, number of fallen and retained leaves as well as the total chlorophyll content of the leaves were estimated at 3 and 6 MAP. The crop will be harvested during early March 2024.

Soil carbon quality and conservation studies in tropical tuber crops

An incubation study was conducted for three months at ambient temperature and constant soil moisture conditions in laterite soil with 27 treatments consisting of three commonly available organic manures, three different levels of near neutral zeolites 4A (@ 0, 1 and 2 %, w/w) and fertilizer doses (@ 100% NPK, 75% NPK and 50% NPK). It was found that addition of NPK fertilizers from 75 to 100% significantly decreased the mean carbon mineralization activity (4.99 as against 6.20 g CO_2 kg^{-1} soil) and increasing levels of zeolites from 1% to 2% increased the carbon mineralization rates (3.39 as against 6.64 g CO_2 kg^{-1} soil). NPK @ 75% and zeolite @ 1% resulted in the highest acid phosphatase activity (1.26 µg pnp $g^{-1}h^{-1}$). NPK fertilizer additions from 50% to 100% increased the soil available nitrogen content (127.97 to 136.67 kg ha^{-1}). The above study indicated that zeolites at 1% level along with a fertilizer dose of 50% NPK had a favorable effect on soil microbiological activity with optimum carbon dioxide mineralization rate and improved availability of major soil nutrients.

A field experiment was initiated during August 2023 in cassava (variety Sree Vijaya) with two levels of organic manure (FYM) viz., 100 and 50% recommended dose (RD), three levels each of zeolite 4A (0, 0.5 and 1% w/w soil) and NPK fertilizers (0, 50 and 100% recommended dose of fertilizers (RDF)). Thus, a total of 18 treatment combinations

were replicated twice in factorial RBD design. Labile C changes in the soil samples (collected at one MAP) and the major available nutrients in the different treatments were estimated. Further, samples of DOM (dissolved organic matter) that was extracted from soil amended with and without zeolite (1%) and characterized for electrochemical parameters showed a significant change in current (in µA) corresponding to reduction peak, based on the cyclic voltammetry determinations, which was further confirmed with IR spectroscopic estimations (Fig. 21). The crop will be harvested during mid-March 2024.

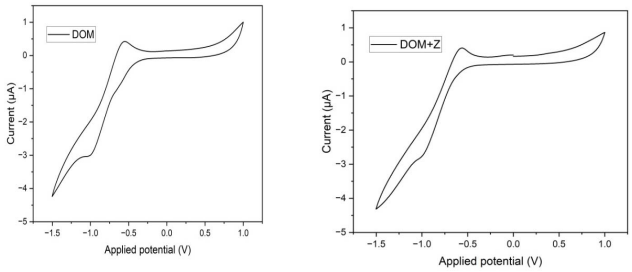


Fig. 21. Cyclic voltammetry estimations of DOM in zeolite amended soils

Climate change adaptation and mitigation in tropical tuber crops

Studies on drought tolerance in tropical tuber crops through mineral nutrition

A field experiment was conducted for the first season to find out the influence of mineral nutrients (potassium nitrate, magnesium sulphate and solubor, each at three different concentrations) in drought tolerance in cassava. The experiment was laid out in RBD with 10 treatments, including one control (NPK @ 100:50:100 kg ha^{-1}), each replicated thrice. The cassava crop (Sree Swarna) was harvested during October 2023. Mineral nutrition had significant but varying effect on storage root yield (Fig. 22). It was found that drought tolerance in cassava could be imparted with the aplication of recommended dose of fertilizer nutrients along with foliar application of potassium nitrate at 1%/solubor at 1%, four times at fortnightly intervals during 120-150 DAP, which resulted in the highest tuber yield of 22.05 and 22.48 t ha^{-1} respectively against control (13.86 t ha^{-1}).

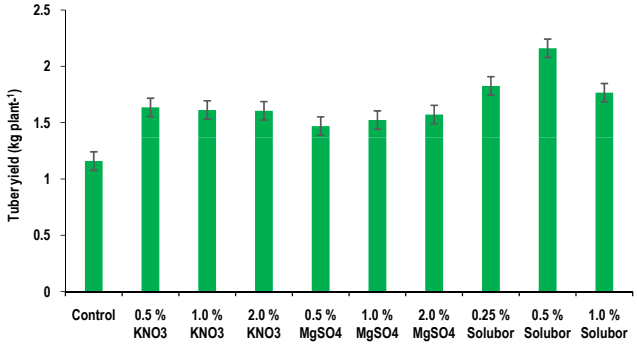


Fig. 22. Effect of different chemical treatments on cassava tuber yield

Studies on heat stress management in cassava

The study was conducted for the second season with the variety Sree Vijaya, which was planted during June 2023. Four chemical spray treatments viz., 0.2% salicylic acid, 0.2% calcium chloride, 1000 ppm benzyl adenine, and a control (water spray) were employed in open condition (OPEN), humidifying (HUM+) and without humidifying chamber conditions (HUM-). Observations on plant biometric characters, tuber yield and physiological parameters were taken during 4 MAP before the foliar spray treatments. The cassava plants in open condition produced an average tuber yield of 1.46 kg plant^{-1} as against 0.41 kg plant^{-1} under HUM+. The application of plant growth regulators and mineral solution as foliar spray treatments did not affect photosynthesis and respiration rates at 6 MAP. Leaf conductance and transpiration significantly varied among the treatments. The treatment, 0.2% $CaCl_2$ spray under Hum+(polychambers with humidifiers) showed significantly the highest leaf conductance (0.49 ± 0.024 mmol m^{-2} min^{-1}). Treatment with salicylic acid (SA) @ 0.2% under Hum- exhibited significantly the lowest leaf conductance (0.11 ± 0.027 mmol m^{-2} min^{-1}). The $CaCl_2$ spray in Hum+ treatment exhibited significantly the highest transpiration rate (9.1 ± 0.35 mm H_2O m^{-2} sec^{-1}). Conversely, SA showed significantly the lowest transpiration rate (2.9 ± 0.63 mm H_2O m^{-2} sec^{-1}), emphasizing the influence of chemical spray on cassava leaf conductance. The crop will be harvested during January 2024.

Physiological studies related to climate change in tropical tuber crops

Studies on the effect of drought stress on growth, biomass and yield of cassava

Results of field experiment on the impact of drought stress in 24 cassava genotypes indicated higher canopy temperature (27.4-32.6°C) for stressed plants,

suggesting reduced transpiration and stress onset (Fig. 23).

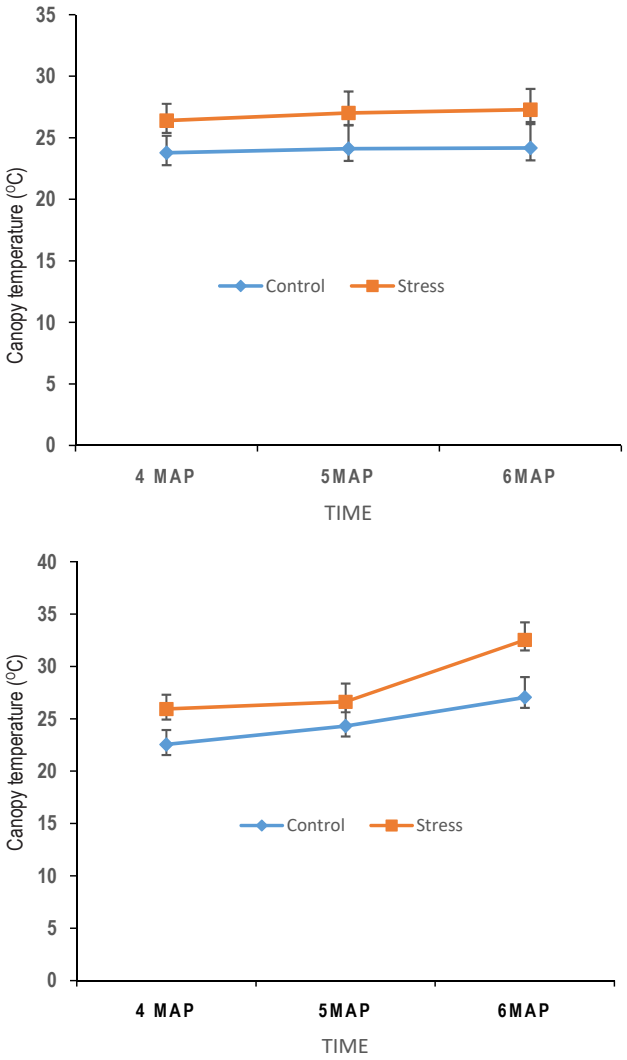


Fig. 23. Changes in the canopy temperature at different growth stages of cassava under control and drought stress

Like-wise, chlorophyll a decreased to 1.7 ± 0.09 mg g^{-1} FW from the control value of 2.0 ± 0.06 mg g^{-1} FW under stress conditions and chlorophyll b reduced to 0.41 ± 0.05 from 0.6 ± 0.01 mg g^{-1} FW in control. Total chlorophyll content decreased to 2.1 ± 0.13 under stress compared to 2.6 ± 0.071 mg g^{-1} FW in control. The carotenoid content also declined to 1.3 ± 0.09 mg g^{-1} FW under stress, as compared to the control value of 1.8 ± 0.092 mg g^{-1} FW. These differences suggest a negative impact of stress on cassava, leading to a reduction in both chlorophyll and carotenoid content. The osmolyte concentrations was higher in leaf tissue in stressed plants of all studied genotypes, except Sree Padmanabha, T-32, and S-4.

The net photosynthetic rate exhibited reduction under stress condition, measuring at 20 ± 1 µmol $m^{-2}s^{-1}$, in contrast to the value of 30 ± 1 µmol $m^{-2}s^{-1}$ observed in control conditions. Interestingly, stomatal conductance and leaf respiration did not demonstrate significant variations between control and stress treatments. Chlorophyll fluorescence kinetics parameters, including Fo, Fm, Fs, Fv Fm, PhiPS2, qP, qN, and NPQ, revealed noteworthy differences between control and stress treatments. These variations underscore the impact of drought stress on the intricate mechanisms governing the photosynthetic performance of cassava genotypes.

Greater number of leaves and higher leaf fresh weight was observed in control as compared to stressed plants. The leaf fresh weight (kg per plant) decreased significantly under stress (0.02 ± 0.004) as compared to control conditions (0.2 ± 0.04). Stem weight (kg per plant) also decreased under stress (0.4 ± 0.03) compared to control conditions (0.5 ± 0.06). Significant variation was observed in tuber weight (kg per plant) between control (0.8 ± 0.07) and stressed (0.4 ± 0.05) plants, indicating a notable impact on tuber development. Under drought, tuber yield was highest in Sree Vijaya. The number of tubers remained consistent between control and stress treatments at an average of 6 ± 0.4.

Studies on the effect of drought stress on growth, biomass and yield of sweet potato genotypes

Results pertaining to the second season studies on the impact of drought stress in sweet potato genotypes revealed a significantly highest net photosynthetic rate (Pn) of 48.86 µmol $m^{-2}s^{-1}$ in Sree Rethna under control. However, the highest Pn was observed for Sree Kanaka with a value of 18.96 µmol $m^{-2}s^{-1}$. Under control conditions, notably high respiratory rates were observed in Kalinga, Kamal Sunder, and S-819 with respiratory rates of 7.84, 7.77, and 7.39 µmol $m^{-2}s^{-1}$, respectively. Whereas, under stress conditions S-131 (5.18 µmol $m^{-2}s^{-1}$) and Sree Vardhini (5.09 µmol $m^{-2}s^{-1}$) showed significantly higher respiratory rates. High quantum yield (Fv/Fm) was observed for Bhu Sona and S-819, with Fv/Fm values of 0.82 and 0.83, respectively. Whereas, lower Fv/Fm was noticed in Bhu Swami and S-444, with Fv/Fm values of 0.53 and

0.68, respectively under control conditions. Drought-induced stress impacted the photosynthetic apparatus, leading to decreased photosynthetic efficiency and electron transport under stress conditions. The non photochemical quenching (qN) depicts the energy dissipation as heat and qN values for S-1461, S-1276, and S-14 were 1.49, 0.93, and 0.91, respectively. Whereas, low qN values were in Gouri, S-131, and Waynad L. These genotypes had qN values of 0.23, 0.63, and 0.38, respectively under stress conditions. Superior photosynthetic performance as well as growth under drought stress were observed in Kalinga, Bhu Swami, Sree Varun, Sree Vardhini and S-131. Overall, the study showed that sweet potato genotypes viz., Kalinga, Bhu Swami, Sree Varun, Sree Vardhini, and S-131 exhibited resilience and were adapted well to drought stress.

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. Establishment of seed villages programme in selected areas of Kerala, Tamil Nadu, Andhra Pradesh, Odisha and North Eastern India in a farmer participatory mode together with farmers training programmes for mass multiplication and popularization of disease free planting materials of improved varieties of tuber crops were done. Seed producers were identified for production of quality planting materials of tuber crops and area expansion of tropical tuber crops in non-traditional areas. The quality planting material production at ICAR-CTCRI, Thiruvananthapuram and Regional Station, Bhubaneswar, are given in Table 5.

Table 5. Quality planting material production of tuber crops during 2023

Sl. No.	Crop	Unit	Varieties	Quantity of planting material produced
1.	Cassava	No. of stems	Sree Vijaya	37000
			Sree Jaya	33000
			Sree Reksha	52000
			Sree Swarna	5000
			Sree Sakthi	5000
			Sree Pavithra	4000
			Local (M4, Quintel)	3500
			Total	**139500**
2.	Sweet potato	No. of vine cuttings	Bhu Sona	700000
			Bhu Krishna	650000
			Kisan	350000
			Sree Arun	15000
			Sree Kanaka	5000
			Kanjanghad	10000
			Total	**1730000**
3.	Elephant foot yam	Ton	Gajendra	14.00
			Sree Padma	15.00
			Total	**29.00**
4.	Greater yam	Ton	Sree Keerthi	8.00
			Sree Nidhi	3.00
			Orissa Elite	3.00
			Total	**14.00**
	White yam	Ton	Sree Priya	12.00
	Lesser yam	Ton	Sree Latha	3.00
			Total	**29.00**
5.	Taro	Ton	Telia	4.00
			Muktakeshi	3.00
			Total	**7.00**
6.	Chinese potato	No. of stem cuttings	Sree Dhara	50000
7.	Yam bean	kg	RM-1	150

Standardization of growth media and crop management in nursery: A field experiment was conducted for standardizing growth media and crop management for cassava (variety Sree Reksha) minisett nursery with two methods of stake cutting viz., minisetts with single node and minisetts with two node and four treatments of nursery growth media. The treatments comprised viz., potting mixture, soil: FYM (2:1) (T_1), coco peat + soil + FYM (2:1:1) (T_2), coco peat + soil (1:1) (T_3) and soil bed (T_4) with each treatment replicated thrice in a randomized block design (RBD). Three foliar spray treatments were followed in the nursery as urea (0.1%), 19:19:19 (0.1%) at 15 days and control. Results revealed that first sprouting took 3 days in potting mixture (T_1),

whereas it took 4 days in coco peat + soil + FYM (T_2), 5 days in coco peat + soil (1:1) (T_3) and soil bed (T_4). The 50% sprouting took 9 days in (T_1) potting mixture, whereas it took 10 days in (T_2) coco peat + soil + FYM, 11 days in (T_3) coco peat + soil (1:1) and 12 days in soil bed (T_4) in two node minisetts. It was observed that one shoot with plant height of 8 cm and 24 cm at 15 and 30 days were produced with (T_1) potting mixture, soil: FYM (2:1). It also produced higher plant establishment per cent (85%) in nursery in minisetts with two nodes as compared to 45% in single node treatments.

Evaluation of the performance of nursery raised minisett plants in the field: A field experiment was conducted with minisett seedling uprooted after one month in the nursery and transplanted to the main field. The treatments were replicated thrice. Among the different plant growth media treatments, field establishment of minisett seedling took 5 days in (T_1) potting mixture, whereas it took 7 days in (T_2) coco peat + soil + FYM and 8 days in (T_3) coco peat + soil (1:1) and sand. The plant height, number of leaves and stem girth were also favoured in this treatment. Among the two types of minisett, two node minisetts performed better than single node minisetts.

Determination of ideal stage of stem cutting for planting material production in cassava: A field experiment was initiated in cassava varieties, Sree Reksha and Sree Vijaya with five treatments and three replications in RBD. Treatments were, cuttings from stems taken 4 months before harvesting (T_1), cuttings from stems taken 3 months before harvesting (T_2), cuttings from stems taken 2 months before harvesting (T_3), cuttings from stems taken 1 month before harvesting (T_4) and cuttings from stems at the time harvesting (T_5). After cutting the stems were immediately planted in the field. It was found that first sprouting took 8 and 9 days in T_1, whereas it took 6 and 7 days in T_2 in Sree Reksha and Sree Vijaya respectively, However, it took 5 and 6 days in T_3 in Sree Reksha and Sree Vijaya respectively. Field establishment and plant growth were good in T_1, followed by T_2.

Establishment of seed villages for quality planting material production of tuber crops: A total of 35 seed villages were established in the states of Kerala, Tamil Nadu and Odisha covering an area of 180 acres for planting material production of tuber crops (Table 6), cassava (12), sweet potato (6), greater yam (6) Chinese potato (10) and elephant foot yam (1).

Table 6. Establishment of seed villages for quality planting material production of tuber crops

Sl. No.	Crop	Varieties	Seed villages and district	Area (Acre)
1.	Cassava	Sree Kaveri Sree Reksha Sree Athulya Sree Vijaya Sree Jaya	Koonavalayampatti, Rasipuram, Namakkal	5
		Sree Kaveri Sree Reksha Sree Athulya	Mettupatti, Naraikinanu, Namakkal	15
		Sree Athulya	Pillikalmedu, Tiruchenkode, Namagiripettai, Namakkal	8
		Sree Kaveri Sree Reksha Sree Athulya	Manmalai, Gangavalli, Attur, Goodamalai, Sentharapatti, Salem	15
		Sree Athulya	Veeradipatti, Pudukottai	10
		Sree Kaveri Sree Reksha Sree Athulya Sree Vijaya Sree Jaya	Kani kudiyeruppu, Karaiyar, Ambasamudram, Tirunelveli	4
		Sree Reksha	Eraniel, Kanyakumari	2
		Sree Reksha Sree Athulya Sree Jaya	Mekkarai, Tenkasi	4
		Sree Reksha Sree Athulya	Killimanoor, Manapuram, Karipur Thiruvananthapuram	10
		Sree Reksha Sree Pavithra	Kodumon, Erathu, Ezhamkulam Panthanamthitta	10
		Total		**83**
2.	Sweet potato	Sree Kanaka Sree Arun	Kilimanoor, Pothencode Thiruvananthapuram	5
		Sree Kanaka Sree Arun	Eraniel and Thuckalay Kanyakumari	5
		Bhu Sona Bhu Krishna	Gajapati, Kandhamal, Koraput & Jajpur	15
		Total		**25**
3.	Elephant foot yam	Gajendra	Erode, Tamil Nadu	2
4.	Yam	Sree Karthika	Gajapati, Kandhamal, Koraput Mayurbhanj & Jajpur	15

5.	Chinese potato	Sree Dhara	Mundur, Akathethara, Palakkad	10
			Varayoor, Thrissur	5
			Kadayam Kovindhaperi Rajankhapuram Kuthapanjan Velayuthasamykudiyiruppu Tenkasi	10 15
			Pallakal Pothukudi Mannarkovil, Tirunelveli	15
			Total	**55**
			Grand total	**180**

Decentralised Seed Multiplier (DSM) for quality planting material production of tuber crops: A total of 42 farmers from Kerala, Tamil Nadu and Odisha (covering 57.35 acres) have been registered as DSM for quality planting material production of tuber crops (Table 7).

Table 7. Decentralised Seed Multipliers for quality planting material production of tuber crops

Sl. No.	State	Crop	Varieties	Number of farmers	Area (Acre)
1.	Kerala	Cassava	Sree Reksha Sree Pavithra Sree Athulya	1	1.00
2.	Tamil Nadu	Cassava	Sree Reksha Sree Kaveri Sree Athulya	12	23.80
3.	Odisha	Cassava	Sree Athulya Sree Reksha	2	2.00
4.	Kerala	Sweet potato	Sree Arun Sree Kanaka Bhu Sona Bhu Krishna Kanjanghad Gouri	2	1.60
5.	Tamil Nadu	Sweet potato	Bhu Sona Bhu Krishna Sree Arun Sree Kanaka Kanjanghad Gouri	1	1.00
6.	Odisha	Sweet potato	Sree Arun Sree Kanaka Bhu Sona Bhu Krishna Kanjanghad Gouri	1	2.00
7.	Kerala	Elephant foot yam	Gajendra Sree Padma	3	7.15
8.	Kerala	Greater Yam	Sree Keerthi Sree Neelima Sree Shilpa Sree Swathy Sree Nidhi Da-340	3	2.00
9.	Odisha	Greater Yam	Orissa Elite Sree Keerthi	12	7.30
10.	Tamil Nadu	Chinese potato	Sree Dhara	4	9.00
11.	Odisha	Yam bean	RM1	1	0.50
			Total	**42**	**57.35**

Promotion of tuber crops in non-traditional areas: A total of 20 kg seed tubers of Chinese potato were distributed to KVK, Jeolikote, Nainital, Uttarakhand. Quality planting materials of improved variety of Chinese potato, Sree Dhara (10 kg) and elephant foot yam, Gajendra (25 kg), were distributed to KVK, Sonapur-Gadchiroli, Maharashtra.

Investigations on rapid multiplication of yams and aroids

Investigations on rapid multiplication of greater yam through vine cuttings: The experiment was conducted with three node sizes (single, double and three node cuttings) and six pre-treatments. The number of tubers varied from 2.08 in three node cuttings to 2.50 each in single and double node cuttings. The girth of tuber was maximum in single node cuttings (18.78 cm). The double node cuttings resulted in tuber length of 17.97 cm, which was on par with single node cuttings. Among the different node sizes used, highest tuber yield was obtained with two nodes (505 g), followed by single node (498.33 g), which were on par. Among the pre-treatments applied to improve rooting, highest tuber yield was obtained with NAA 100 ppm (593.33 g). The length and girth of tuber was greatest in PGPR Mix-1 (13.81 cm and 24.69 cm respectively). Hence the use of vine cuttings is a viable option for yam seed tuber production. Among the interaction effects, vine cuttings of all sizes treated with IBA 100 ppm was the best treatment with respect to yield parameters.

Establishment of seed villages and DSM programme: Four seed villages of elephant foot yam variety Sree Padma and four seed villages of yams (var. Sree Neelima and Sree Nidhi, 2 each) were established in Muttakkad, Panangodu, Venniyoor and Nellivila villages under Venganoor gram panchayat in Thiruvananthapuram district, Kerala, covering 8 acres.

Refinement of minisett propagation of elephant foot yam: An experiment was conducted in elephant foot yam with four sett sizes (50 g, 100 g, 150 g and

Scheme of *in vivo* rapid multiplication in greater yam through vine cuttings

Single yam mother plant

↓ (21 days)

500 two node cuttings (or 1000 single node cuttings)

↓ 7 months

180 kg seed tuber (450 plants x 400 g tubers)

↓ 45-60 days (excluding dormancy period of 60 days)

8100 nursery plants (20 g minisett in portray, assuming 90% efficiency)

↓ 7 months

6480 kg tuber sufficient to plant 2 ha (8100 x 800 g = 6480 kg)

200 g) and eight pretreatments replicated thrice in factorial CRD. The sprouting percent was the highest for 150 g sett (99.33), which was on par with 200 g size (98.94) (Fig. 24). The length (17.47 cm) and girth (6.92 cm) of sprout was superior in 200 g sett. The length of roots was the highest in 200 g. Sprout vigour index was the highest in 200 g sett and decreased with decrease in the sett size.

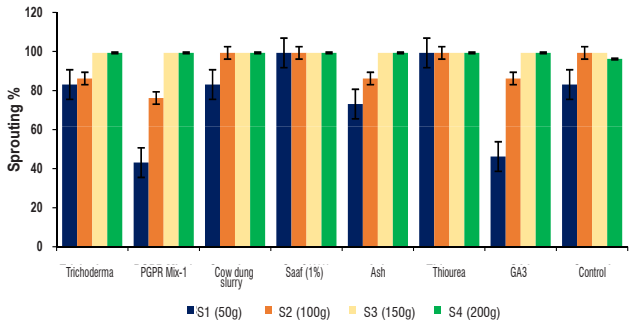


Fig. 24. Effect of sett size and pretreatments on sprouting per cent in elephant foot yam

Effect of pretreatments on sprouting behavior: Sprouting was highest (99.33%) in thiourea and 1% fungicide (carbendazim + mancozeb). The length of sprout was significantly superior in GA_3 (17.11 cm). The greatest number of roots were produced in thiourea (47.83). The least mean sprouting time (41.40 days) was observed in fungicide treatment. The longest time taken for sprouting (50.14 days) was observed in *Trichoderma*, followed by control (48.36 days). The sprout vigour index was the highest in GA_3 (1482.23), followed by 1% fungicide (carbendazim + mancozeb) (1467.75) (Fig. 25). GA_3 treatment showed flowering irrespective of the sett size. Thus, GA_3 treatment can be applied for inducing flowering in elephant foot yam. Interaction of pretreatments and sett size showed that with thiourea as well as 1% fungicide (carbendazim + mancozeb), all sett sizes resulted in cent percent sprouting.

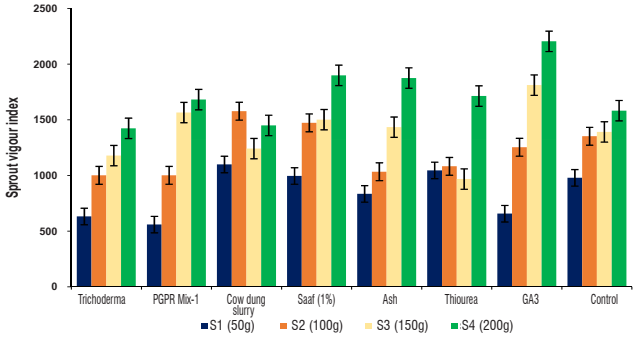


Fig. 25. Effect of sett size and pretreatments on sprout vigour index in elephant foot yam

Field establishment and growth of elephant foot yam minisetts subjected to pretreatments: The highest field establishment of 91.01% was observed in 200 g. The greatest canopy spread (0.566 m^2) was in 200 g, which was on par with 150 g (0.456 m^2). Among the pretreatments, the highest field establishment was in fungicide and *Trichoderma* treatments (85.60 and 85.44% respectively). Among the vegetative parameters, the plant height was greatest in PGPR Mix (158.83 cm). The canopy spread of PGPR Mix-1 (0.569 m^2), cow dung slurry (0.519 m^2), ash (0.498 m^2) and thiourea (0.423 m^2) were significantly higher than the rest of the treatments.

Crop Protection

Development of innovative technologies for the intensification of pest management in tuber crops through biorational approaches

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

Culturable endosymbionts from whiteflies

Endosymbiotic bacteria were isolated from the two most important whiteflies infesting tuber crops, *Bemisia tabaci*, *Aleurodicus dispersus*, after adding insecticides, imidacloprid and chlorpyrifos in the growth media. By observing the colony morphology, distinct bacterial colonies were sub-cultured and selected for further molecular identification procedures. PCR analysis was carried out for bacteria using 16S rRNA primer, with an annealing temperature of 49°C and yielded fragments at 1500 bp (Fig. 26). Based on the sequencing report, the culturable endosymbiont present in *B. tabaci* was identified as *Providencia,* which was resistant to chlorpyrifos. Similarly, *Paenibacillus alvei* present in *A. disperses* was resistant to imidacloprid and chlorpyrifos. *Clostridium senegalens* and *Acinetobacter* were found in control populations (grown in media without insecticides) of *Bemisia* and *Aleurodicus* respectively. The sequences were submitted to NCBI and the accession numbers obtained were OP303253, OP303256, OP303254 and OP295124.

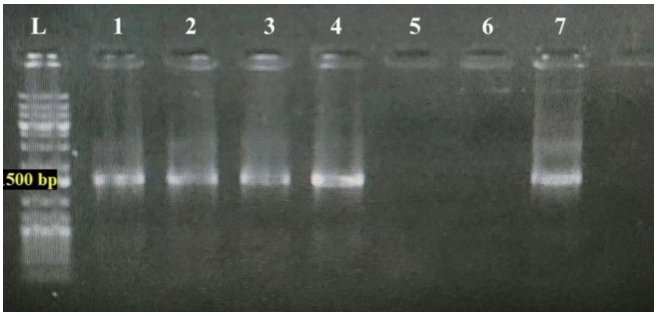


Fig. 26. PCR analysis of bacterial isolates using 16S rRNA primers (L: 1Kb plus ladder; Lanes 1–4 and 7: bacterial endosymbionts of whiteflies)

Detection of specific non-culturable bacterial endosymbionts in mealybugs using diagnostic PCR

Detection of non-culturable bacterial endosymbionts in mealybugs using diagnostic PCR with specific bacterial primers showed the presence of *Wolbachia* in mealybug *F. virgata* at a fragment length of 650 bp (Fig. 27).

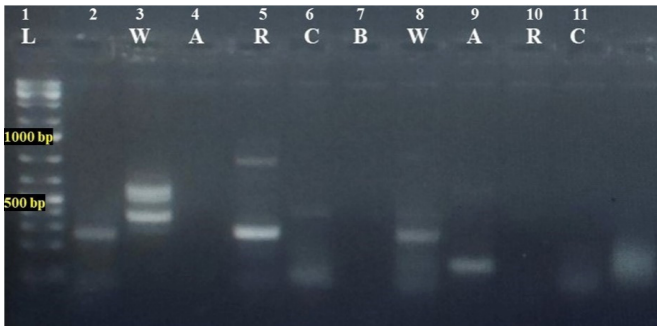


Fig. 27. Diagnostic PCR for the presence of secondary bacterial endosymbionts in mealybug samples
(Lane 3–6: bacterial endosymbionts of *F.virgata*; Lane 8–11: bacterial endosymbionts of *P. marginatus* (L-1Kb plus ladder, *W-Wolbachia, A-Arsenophonus, R-Rickettsia, C-Cardinium,* B-Blank)

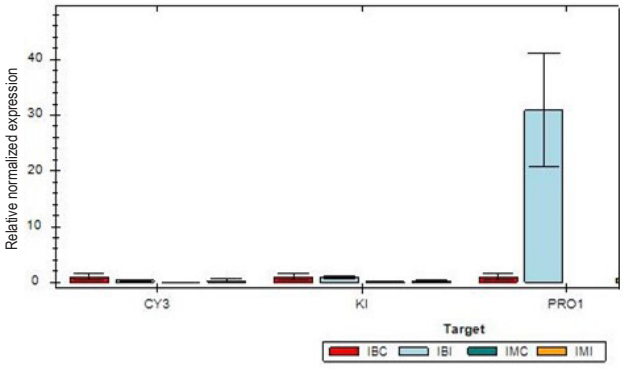
The study on diversity of microorganisms and microarthropods on tuber crop ecosystems: The diversity and abundance of microorganisms (bacteria and fungi) and microarthropods from rhizosphere soil of six different treatments viz., organic soil, inorganic soil, organic+inorganic (1:1), PoP (package of practice), chlorpyriphos applied soil and imidacloprid applied soil were studied. Four bacterial genera comprising 22 different species were obtained from six different fields. *Bacillus* and *Pseudomonas* genera were higher in number compared to the others. The bacterial species diversity was high in insecticide applied soil, mainly chlorpyriphos applied in comparison to imidacloprid applied soil. Based on morphological examination of fungal isolates, 13 distinct species were isolated.

The cosmopolitan distribution of soil microarthropods and their varying degrees of adaptation make

them suitable tools for assessing the health of soil ecosystems. Soil microarthropods observed in different treatments could be divided into six groups: Collembola, Coleoptera, Hymenoptera, Araneae, Acari and Diplopoda. Their number varied between 0 and 5 per 1000 cm^3. The abundance of these microarthropods was positively correlated with soil nutritional status and had a negative correlation with presence of insecticides. The study supports the scope of application of soil microarthropod indicator value in future studies on soil quality and in land management practices.

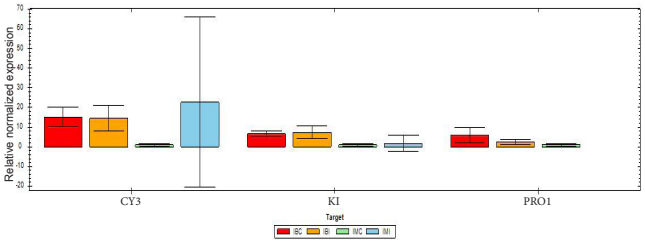
Characterization of insect resistance genes in sweet potato and related *Ipomoea* sp. against sweet potato weevil infestation

The identification of host plant resistance genes against sweet potato weevil is one of the alternatives in pest management strategy to develop plants resistant to weevil infestation. By screening wild *Ipomoea* spp., wild tuberous *Ipomoea mauritiana* was identified as source of resistant genes against sweet potato weevil. Various proteinase inhibitors related to sweet potato weevil infestation was studied. Specific target gene specific primers were designed and the gene expression of cysteine protease inhibitor, proteinase inhibitor, kunitz trypsin inhibitor was studied. One month old *I. batatas* and *I. mauritiana,* both healthy and weevil infested (leaf and tuber) samples were used for the study. The reference genes selected for the study were β-actin (ACT) ribosomal protein L (RPL), glyceraldehyde-3-phosphate dehydrogenase (GAP), cyclophilin (CYC), ADP-ribosylation factor (ARF), histone H2B (H2B), ubiquitin extension protein (UBI), cytochrome c oxidase subunit Vc (COX), phospholipase D1a (PLD). All the reference genes were validated using cDNA from both *I. batatas* and *I. mauritiana* plant samples. Histone H2B (H2B) was selected as stable reference gene in leaf samples and ADP-ribosylation factor (ARF) was selected as stable reference gene in root samples of *I. batatas* and *I. mauritiana.* The leaf and root samples from healthy and weevil infested plants were collected at two weeks interval for the study. The expression of protease inhibitor was upregulated in the sweet potato leaves (Fig. 28), whereas there was no change in expression of cysteine protease inhibitor and kunitz trypsin inhibitor. The expression of protease inhibitor genes was upregulated in the roots one week after infestation and the expression of cysteine protease inhibitor was upregulated in the roots three weeks after infestation (Fig. 29). From the study it was concluded that variation in protease inhibitor and cysteine protease inhibitor gene expression was observed in *I. batatas* due to sweet potato weevil infestation and wild species *I. mauritiana* will be utilized as a source of sweet potato weevil resistant genes for further studies.



CY3-Cysteine protease inhibitor; KI-Kunitz trypsin inhibitor; PRO1- Protease inhibitor; IBC- *I. batatas* control; IBI-*I. batatas* infested; IMC-*I. mauritiana* control; IMI-*I. muritiana* infested

Fig. 28. Gene expression in leaf samples one week after infestation (WAI)



CY3-Cysteine protease inhibitor; KI-Kunitz trypsin inhibitor; PRO1- Protease inhibitor; IBC-*I. batatas* control; IBI-*I. batatas* infested; IMC-*I. mauritiana* control; IMI-*I. mauritiana* infested

Fig. 29. Gene expression in tuber samples three weeks after infestation (WAI)

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

Field efficacy of nematicides against root-knot nematode in tuber crops

The effect of newer nematicides, Fluopyram 34.48% SL and Fluensulfone 2% GR was evaluated against *Meloidogyne incognita* in elephant foot yam (Sree Padma) under field conditions in Alappuzha, Kerala. Fluopyram (0.5 ml) treated plants had less damage (15%) than Fluensulfone (1g) treated (25%) and untreated control (50%) (Fig. 30). The yield was higher in Fluopyram treated plants (3.30 kg $plant^{-1}$) than Fluensulfone treated (2.80 kg $plant^{-1}$) and untreated control (1.7 kg $plant^{-1}$) (Fig. 31).

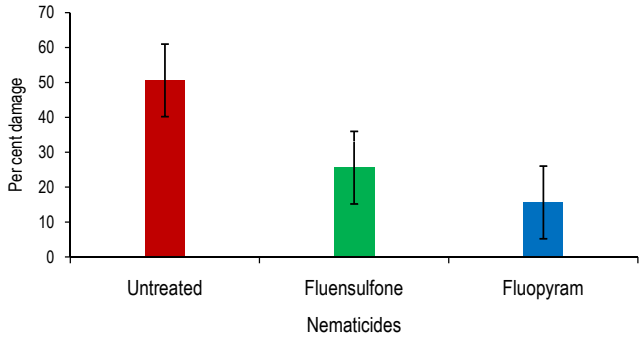


Fig. 30. Effect of nematicides on the infestation of nematodes in elephant foot yam

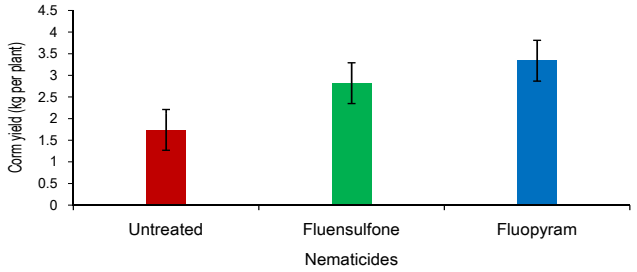


Fig. 31. Effect of nematicides on the yield of elephant foot yam

The effect of newer nematicides, Fluopyram 34.48% SL and Fluensulfone 2% GR was evaluated against *M. incognita* in Sree Dhara, Chinese potato variety under field conditions in Tirunelveli, Tamil Nadu. Fluopyram (0.5 ml) treated plants exhibited very less nematode damage (11%) as compared to Fluensulfone (1g) treated (21%) and untreated control (35%) (Fig. 32). The yield was higher in Fluopyram treated plants (2.20 kg plant^{-1}) than Fluensulfone treated (1.76 kg plant^{-1}) and untreated control (1.10 kg plant^{-1}) (Fig. 33).

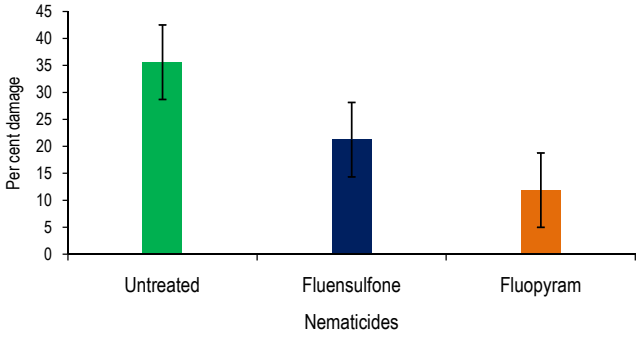


Fig. 32. Effect of nematicides on the infestation of nematodes in Chinese potato

Compatibility of nematicides with biocontrol agents

The compatibility of newer nematicides, Fluensulfone 34.48% SL and Fluopyram 2% GR were evaluated with fungal biocontrol agents, *Trichoderma harzianum* (Tr

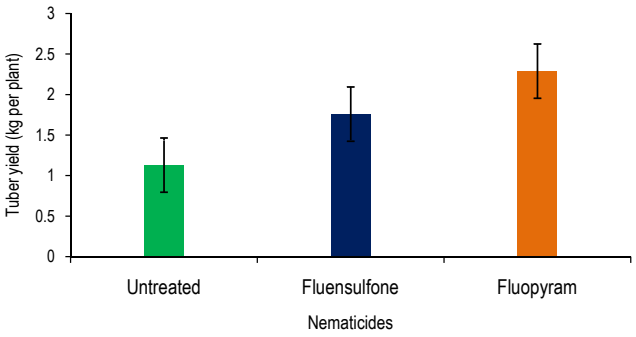


Fig. 33. Effect of nematicides on the yield of Chinese potato

9) and *T. asperellum* (Tr 15) and bacterial bioagents, *Bacillus subtilis* (S1T4) and *B. licheniformis* (EB-12) under *in vitro* conditions. The concentrations of the nematicides tested were 50, 100, 200, 400, 800 and 1000 ppm. Fluopyram was highly incompatible with fungal bioagents as it effected 45% and 50% radial growth inhibition in *T. harzianum* at 100 and 200 ppm, respectively and 45% reduction at both 100 and 200 ppm in *T. asperellum* after 96 hours (Fig. 34). Whereas, Fluensulfone was highly compatible with fungal bioagents as no growth reduction was observed even at the highest concentration of 1000

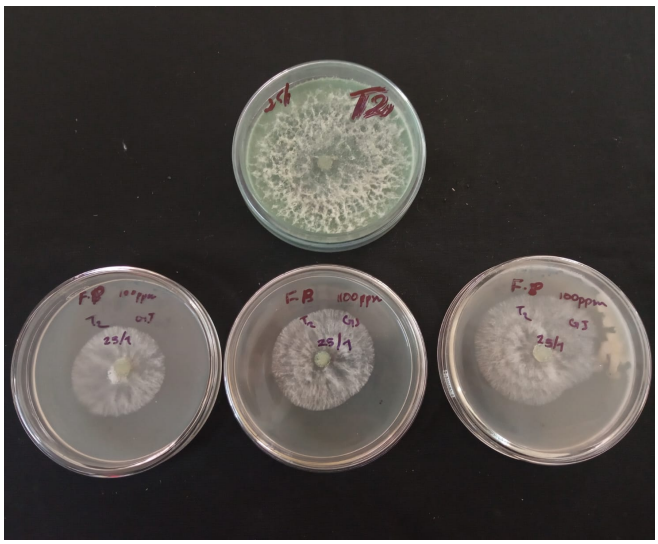


Fig. 34. Mycelial growth inhibition of *Trichoderma asperellum* by Fluopyram

ppm in both *T. harzianum* and *T. asperellum* after 96 hours (Fig. 35).

The bacterial bioagents, *Bacillus subtilis* and *B. licheniformis* were highly compatible with both Fluopyram and Fluensulfone as no growth reduction was observed even at higher concentrations of up to 1000 ppm after 96 hours.

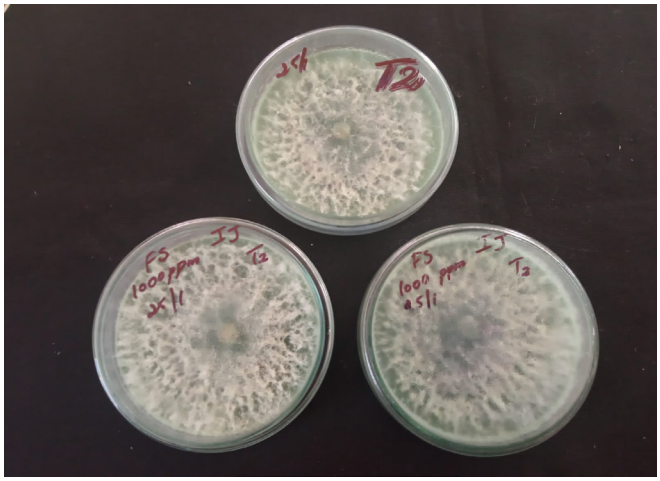


Fig. 35. Compatibility of Fluensulfone with *Trichoderma asperellum*

Isolation of entomopathogenic nematodes

An isolate of an entomopathogenic nematode CTCRIS2 *Steinernema* sp. has been identified from a soil sample collected from Thiruvananthapuram, Kerala. The nematode was isolated by soil baiting technique using last instar greater wax moth larvae (Fig. 36). The cadavers were brown in colour and all stages of the nematode had excretory pore anterior to the nerve ring. These characteristics confirm the generic status but the specific identity of the nematode is yet to be ascertained.

Fig. 36. Adults of isolate CTCRIS2, *Steinernema* sp. dissected out from the insect cadaver

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

Fifty samples of elephant foot yam plants, which showed distinct symptoms of leaf rot/blight and pseudostem rot were collected from various experimental fields of ICAR-CTCRI and farmers' fields of Thiruvananthapuram, Pathanamthitta and Malappuram districts of Kerala.

Seven major types of symptoms were observed from these samples collected from 12 locations. Minute rust like spots, spreading fast and becoming necrotic lesions were the most common symptoms in Thiruvananthapuram and Pathanamthitta districts of Kerala. Whereas, irregular shaped spots with light grey centre expanding and centers turning grey to brown in colour and dropping out, leaving holes was the most common symptom in samples collected from Malappuram district of Kerala.

Management of postharvest rot in elephant foot yam

Nine treatments were evaluated for their efficacy in managing postharvest rot in elephant foot yam (Fig. 37). The treatments were treating the corms with *Trichoderma* enriched cow dung slurry (T_1), carbendazim 12% + mancozeb 63% WP (0.2%) (T_2), turmeric powder 1% (T_3), crushed garlic 1% (T_4), *Nanma* 0.7% (T_5), turmeric powder 1% + *Nanma* 0.7% (T_6), crushed garlic 1% + *Nanma* 0.7% (T_7), *Jeevamrit* ($T_{8)}$ and control (T_9). The varieties tested were Gajendra, Sree Padma and Sree Athira. Among the varieties, highest postharvest rot was observed in the variety, Gajendra (62.60%) and the least incidence was in Sree Athira (52.60%). Six of the treatments could effectively check the pathogens causing postharvest rot (<10% incidence). Treating the corms in botanicals, turmeric powder 1% and crushed garlic 1% alone or in combination with *Nanma* (0.7%) was on par with the recommended strategies, treating the corms with *Trichoderma* enriched cow dung slurry or carbendazim 12% + mancozeb 63%WP (0.2%). Hence, prestorage treatment of corms in turmeric

powder 1% or crushed garlic 1% can be recommended for mitigation of postharvest rot in elephant foot yam corms meant for consumption.

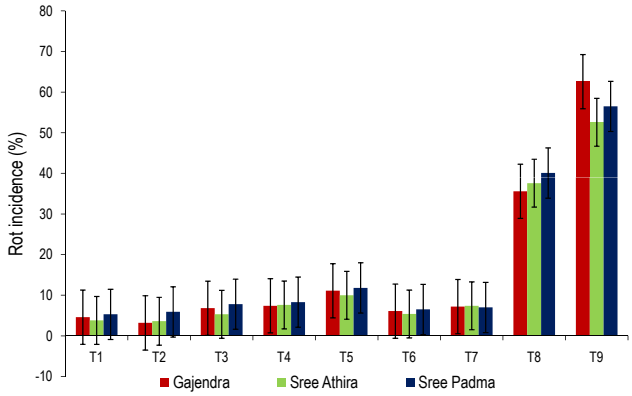


Fig. 37. Incidence of postharvest rot in elephant foot yam corms after imposition of treatments

Starch, sugar, fat, fibre, ash and moisture contents in corms before treatment and storage as well as after treatment and storage were analysed and compared using statistical tools. Except fibre, none of the contents showed any significant difference due to treatment in all three varieties used. Fibre content was significantly higher with the treatments, corm treatment with *Trichoderma* enriched cow dung slurry and carbendazim 12% + mancozeb 63% WP (0.2%).

Effect of oil cakes on pathogen suppression and mycelial growth of *Trichoderma asperellum*

Five oil cakes viz., coconut oil cake, groundnut oil cake, neem oil cake, mustard oil cake and sesame oil cake were evaluated in sterile and unsterile conditions for their ability to suppress *Sclerotium rolfsii,* the pathogen causing collar rot in elephant foot yam. All the oil cakes completely inhibited the growth of *S. rolfsii.* However, sesame oil cake completely lost the ability on sterilization (Fig. 38). When the concentration of oil cakes was reduced to 50% by diluting it with soil, sesame oil cake and groundnut oil cake could not arrest the mycelial growth. Except neem oil cake, all the other cakes showed reduced pathogen suppression potential upon sterilization. It varied from 39.53% (mustard oil cake) to 87.44% (sesame oil cake). The ability of the oil cakes to support the growth of *Trichoderma asperellum,* the bio-agent recommended for the management of collar rot was also studied. Under unsterile condition, mycelial growth of *Trichoderma* completely covered the substrates, neem oil cake and groundnut oil cakes

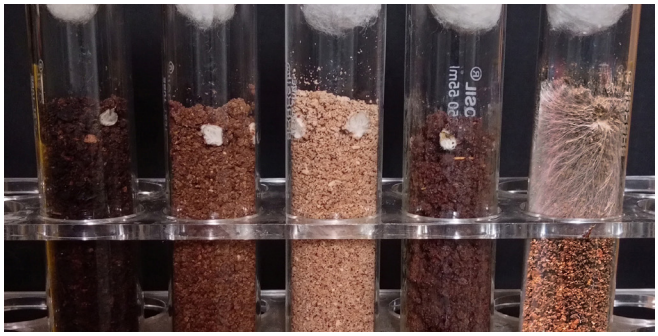


Fig. 38. Mycelial growth of *S.rolfsii* on sterile sesame cake and potting mixture

and turned the substrate to green due to sporulation. No growth was observed with coconut oil cake, while scanty growth without sporulation was noticed with mustard oil cake and sesame oil cakes. Upon sterilization, mycelial growth of *Trichoderma* completely covered the substrates, except coconut oil cake, and turned the substrate to green due to sporulation. Thus, neem cake is the ideal oil cake for the organic cultivation of elephant foot yam since it suppresses the pathogen as well as promotes the proliferation of bio-agent (Fig. 39).

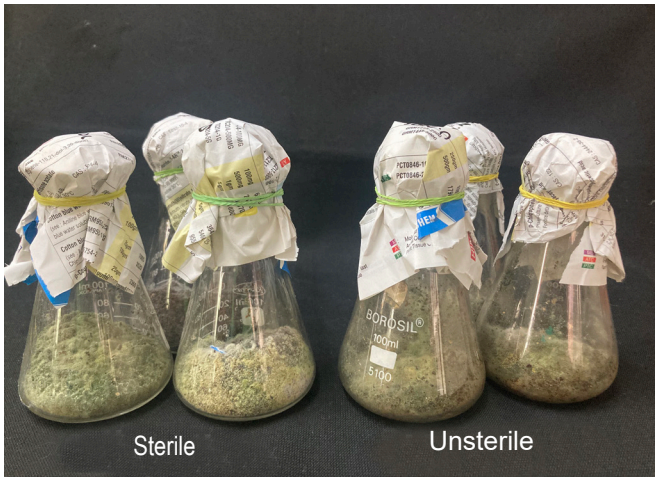


Fig. 39. Growth and sporulation of *T. asperellum* on neem oil cake

Screening of bacterial endophytes from taro plants against *Phytophthora colocasiae*

The five most potent bacterial endophytes isolated from taro, which showed greater antagonistic activity against *P. colocasiae* (KV9, KV10, PA3, KV6 and UL3) were identified as *Bacillus tequilensis, B. subtilis, B. safensis, B. subtilis* and *Bacillus* sp. respectively through 16S r DNA sequencing. All the five endophytes exhibited biofilm formation *in vitro*, variations were observed among strains and KV6

exhibited markedly higher biofilm formation with an optical density (OD) of 0.4 (Fig. 40). The biofilm helps in the survival of the bacteria by withstanding biotic and abiotic factors.

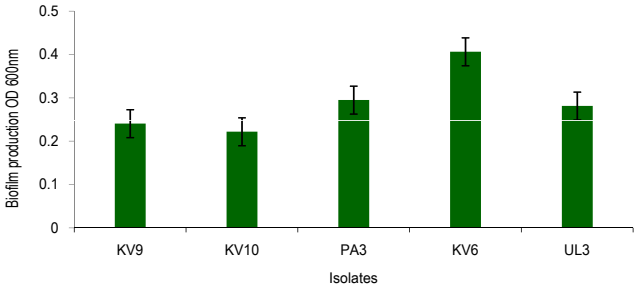


Fig. 40. Biofilm production shown by selected bacterial endophytes

Fungal pathogens and disease management in cassava and yams

Isolation of pathogens associated with cassava stem and root rot

More number of samples obtained from cassava, infected by cassava stem and root rot revealed the association of *Fusarium* spp. However, the samples collected from the same field exhibited diversity in their morphological characteristics. Consequently, additional samples were collected from the same fields, and the pathogens were isolated to identify variations at the species level using molecular approach.

Screening of bioagents against *Fusarium* isolates

Ten potent *Trichoderma* isolates and four bacterial isolates from ICAR-CTCRI microbial repository were evaluated for their effectiveness against various *Fusarium* isolates obtained from samples of cassava stem and root rot. All the *Trichoderma* isolates inhibited the pathogen isolates; however there was variation in the extent of inhibition against various pathogen isolates. A bacterium, SB Ko 4-6, was identified as highly effective against the *Fusarium* isolates (FKo 4-1, FKo 3-1 and FTh-1) (Fig. 41).

Field management of cassava stem and root rot

The effect of seven treatments viz., combination of lime + *Trichoderma* + carbendazim (adhoc recommendation), lime alone, dolomite, calcium nitrate, ash, phosphogypsum and customized fertilizers along with farmers practice as control was evaluated out in two onfarm trials on management of cassava stem and root rot at Parasuvaikkal, Thiruvananthapuram, Kerala. Application of phosphogypsum @ 120 g per

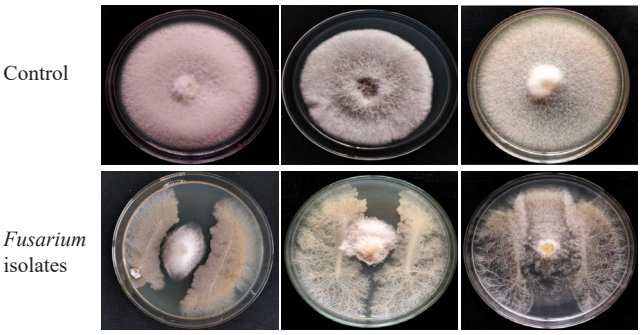


Fig. 41. Effect of soil bacteria SB Ko 4-6 on *Fusarium* isolates

plant showed lowest disease incidence (20%) after five months, followed by adhoc recommendation (28%) and customised fertilizer application (32%), compared to control (48%).

Management of greater yam anthracnose

In a field trial, different fungicides viz., carbendazim (50% WP), azoxystrobin (18.2%) + difenoconazole (11.4% SC) (Fossil), difenoconazole 25% EC (Score) and tebuconazole + trifloxystrobin (Nativo) were tried in greater yam plants (cv. Orissa Elite) to study the effect on anthracnose. All fungicides reduced anthracnose intensity. Highest reduction was by azoxystrobin + difenoconazole (88%) (1 ml^{-1}), which was followed by difenoconazole (1 ml^{-1}) and carbendazim (0.5 g per litre)

Virus and phytoplasma diseases of tropical tuber crops and their management

Management of cassava virus infection through microbial treatment

Microbial treatment with three isolates of *Trichoderma asperellum* (T4, T7 and T8) showed reduction in viral load as compared to control in H-226 plants. After the first month, plants treated with T4 had a viral load of 1.36 x 10^8 copies/10ng and T7 had 1.26 x 10^5 copies/10ng, while control had 10^5copies/10ng. After three months, plants treated with T4 had 53.20 copies/10ng, T7 had 58.50 copies/10ng and T8 had 68.50 copies/10ng, while control had 3.90 x 10^9 copies/10ng.

Similarly, two isolates (B3 and B8) of *Bacillus* sp. showed reduction in viral load in Sree Prakash variety. One month after planting, plants treated with B3 (*Bacillus subtilis*) had a viral load of 1.27 x 10^9 copies/10ng, while untreated control had 7.40 x 10^5 copies/10ng. After three months, plants treated with

B3 had a viral load of 1.74 x 10^4 copies/10ng and those treated with B8 had 8.10 x 10^3 copies/10ng, while control had 8.70 x 10^5 copies/10ng.

Development of artificial microRNA gene constructs for developing resistance against cassava mosaic virus

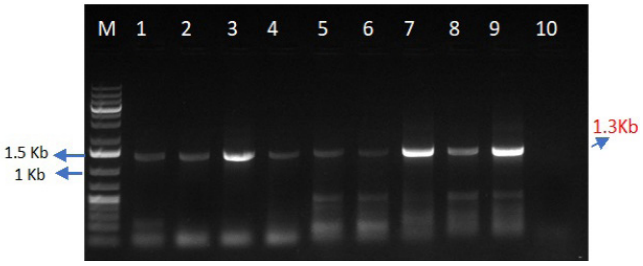
Cloned artificial microRNA precursor backbones, which target AC4 gene of *Sri Lankan cassava mosaic virus* (SLCMV), *Indian cassava mosaic virus* (ICMV) and SLCMV: ICMV (viz. (pRS300:SLCMV-AC4-1, pRS300:ICMV-AC4-1) were subsequently sub–cloned into pCAMBIA2301. (pRS300: SL-IC-MV-1:pCAM2301). Agrobacterium strain LBA4404 was transformed with the above construct via heat shock method. Empty pCAMBIA 2301 was also transformed into LBA4404 to be used as experimental control.

Editing of Geminiviral genome for developing resistance to cassava mosaic disease

Cloning of Coat protein (CP) specific gRNA transcription units in shuttle vectors was confirmed by sequencing. Binary vector (pDGE2) harbouring multiple sgRNA transcription units (TUs) comprising 2 and 4 gRNAs specific to *CP* region was constructed through golden gate cloning. *Nicotiana benthamiana* transformation with *Agrobacterium* harbouring gRNA TUs targeting *Rep* region was done with four different recombinant *Agrobacterium*, two strains with single gRNA and the other two with multiple gRNA transcription units. Total of 25 healthy rooted plants obtained are being maintained. These plants were transferred to soil for hardening and challenge inoculation.

Dasheen mosaic disease in elephant foot yam

Molecular variability analysis of DsMV in plant samples collected from different geographical locations : DsMV infected leaf samples were collected from four districts of Kerala viz., Thiruvananthapuram, Alappuzha, Kottayam and Wayanad. Total RNA was extracted from the leaf tissues using lithium chloride method. RT-PCR (Reverse Transcription Polymerase Chain Reaction) using P1 specific primers was performed (Fig. 42). The gel purified P1 amplicons were cloned into pTZ57R/T and sequenced. It showed 75.02-75.91% similarity at nucleotide level for P1 gene and 65.46 - 66.75% amino acid level similarity with isolates from difference in comparison with already published sequences.



Lane M: 1Kb ladder; lanes 1-8: leaf samples from Wayanad, Alapuzha, Thiruvananthapuram, Kottayam districts; lane 9: positive control

Fig. 42. Amplification of P1 gene from samples collected from different districts

Cloning and characterization of *Sweet Potato Leaf Curl Virus* (SPLCV)

Six full length clones of SPLCV were made in pUC18 and sequenced. The total length of the sequence varied from 2815 to 2840 nt and showed 92.18-93.41% sequence identity to the published sequences. In phylogenetic analysis, all the cloned SPFMV isolates (Fig. 43) clustered with the other reported SPLCV isolates. As revealed in the BLAST analysis, SPLCV-41, 52, 53, and 7 formed a group. SPLCV 65 and 63 formed a separate group. SPLCV-12, which

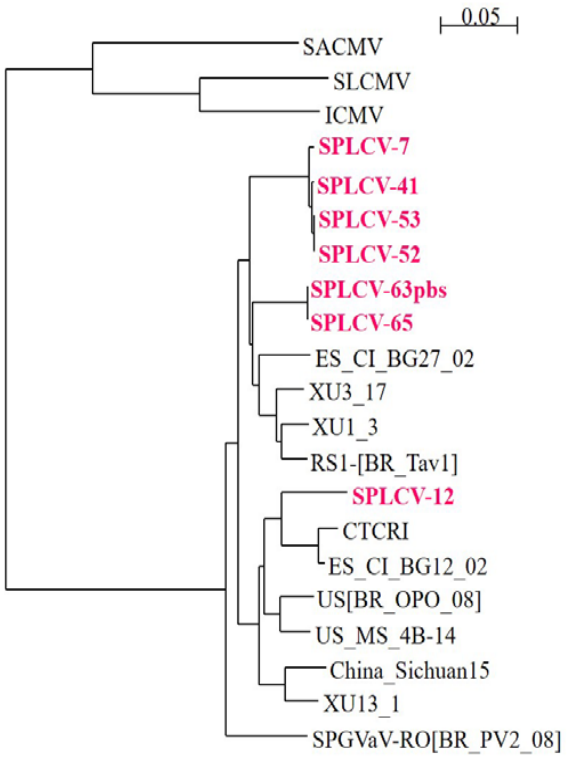


Fig. 43. Phylogenic analysis of cloned SPLCV isolates with published SPLCV genomes

showed a different pattern in restriction analysis formed a separate group.

Infectious clones were developed using SPLCV clones 7, 63 and 65 and they were mobilized into *Agrobacterium* strain Ach5 for studying their infectious nature in *Nicotiana benthamiana.*

CRISPR/Cas9 gene editing strategies to control SPLCV

Eight sets of individual gRNA spacer sequences were designed from the six cloned SPLCV genomes after multiple sequence alignment and cloned in pDGE vector (Addgene). The oligos cloned were C1C4 in pDGE5, CR2 in pDGE8, CR2 in pDGE7, V1V2 in pDGE9, CR1 in pDGE13, CR2 in pDGE10, V1 in pDGE12, C1C4 in pDGE14 and C1 in pDGE15. The clones were confirmed by sequencing. The single as well as multiplexed sgRNA constructs in pDGE62/ pDGE1 were mobilised in EHA105 by triparental mating and used for *N. benthamiana* transformation.

Mass production and effective utilization of bioagents to manage fungal diseases of tuber crops: Identification of potential bioagents from eastern regions of India

Standardization of the tuber crop-based agar media for *Trichoderma* growth

A total of 20 distinct dextrose agar media were prepared using tuber crops viz., cassava, yam bean, elephant foot yam, sweet potato, greater yam, Chinese potato, taro, potato, and arrowroot. These media were tested to assess the mycelial growth of *Trichoderma* at 24 h intervals. The results indicated that sweet potato was the most suitable media for *Trichoderma* mycelial growth, while greater yam was the least conducive for its growth. After 96 hours, mycelial growth in all media reached 85 mm, except in arrowroot agar, where it reached 74.30 mm.

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

Ten different tuber crops were evaluated to determine their shelf life and suitability for the mass multiplication of *Trichoderma* under *in vitro* conditions. The results obtained at 60 days after inoculation (DAI) highlighted that sweet potato was the most favourable substrate for the mass multiplication of *Trichoderma*, with a spore viability of 24.50 x 10^6 cfu g^{-1} (Fig. 44). The shelf life was assessed through conidial count using a haemocytometer on a weekly basis to understand the mass proliferation of *Trichoderma*. Results revealed that sweet potato exhibited the highest spore count after 60 days, whereas greater yam yielded the least favourable results.

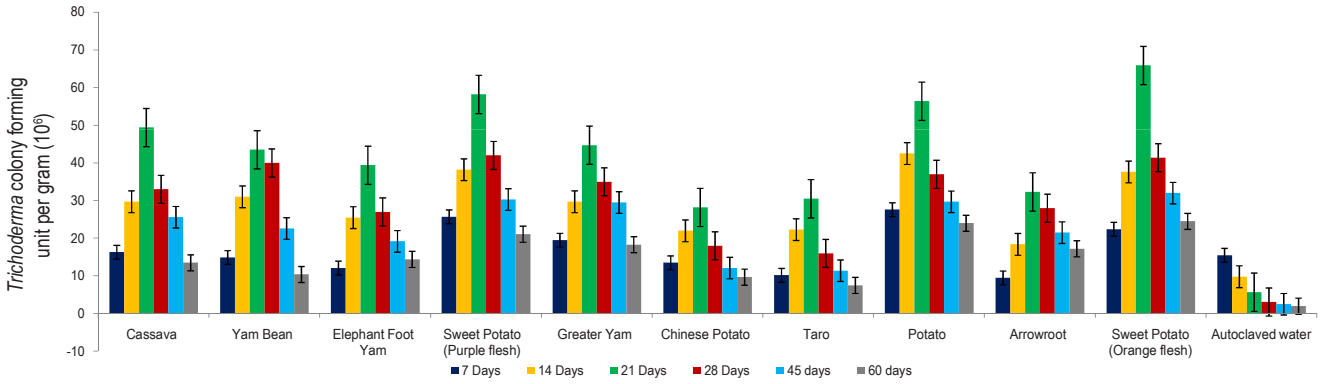


Fig. 44. Sporulaion of *Trichoderma* on various tuber crops substrates

Isolation and characterization of bacterial bioagents from eastern Indian rhizosphere soil

Eight bacterial isolates were isolated from the rhizosphere soil of Eastern regions of India (Tripura and Odisha states) using a modified serial dilution method. Soil samples from diverse agricultural fields were mixed to create a representative composite sample. The isolates include *Bacillus subtilis* (3 nos) and *Pseudomonas fluorescens* (5 nos), with incubation periods of 24-48 hours at 37°C and 25°C, respectively. Subsequent to the isolation, these bioagents underwent sequencing for further characterization.

Crop Utilization

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

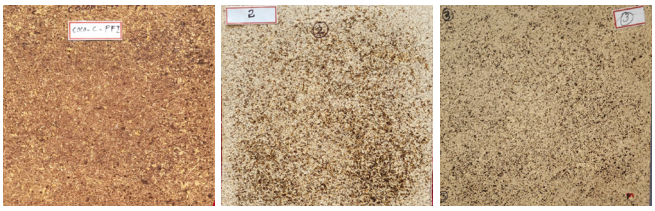
Non-conventional applications of cassava starch in construction and building materials

Particle board from cassava stem and agro-residues

Cassava stem-coir pith based particle boards were made by varying temperature (110, 120 and 130°C), concentration of resin (20, 30 and 40%), pressure of moulding (25, 35 and 45 bar) and coir pith content (50, 75 and 100%) using 150 g feed mix and 15 min press time (Fig. 45). The physical and functional properties of the boards were analysed. The density, thickness swelling, water absorption after 2 h of soaking and water absorption after 24 h of soaking were 1287-1865 kg m^{-3}, 6.72-18.46%, 5.32-37.43%, and 13.87-49.98%, respectively and the total colour difference varied from 56.75 to 72.30. The optimized conditions were as follows, pressure: 55 bar, temperature: 130℃, resin concentration: 30% and coir pith content: 50%.

Cassava stem-rice husk based particle boards were made at different conditions of temperature (100, 110 and 120°C), resin concentration (20, 30 and 40%), pressure of moulding (30, 40 and 50 bar) and rice husk content (25, 50 and 75%) with a 200 g feed mix and 15 min press time (Fig. 45). The density of the particle boards ranged from 1121 to 1545 kg m^{-3}, thickness swelling from 8.89 to 23.56% and total colour difference from 49.25 to 59.85.%. The water absorption after 2 h and 24 h of soaking were 6.5-44.5% and 18.8 to 52.3%, respectively. The optimized conditions for cassava stem-rice husk were pressure: 50 bar, temperature: 120℃, resin concentration: 40% and rice husk content: 25%.

Cassava stem was pretreated with hot water for different durations and particle boards were prepared using 150 and 200 g treated samples, pressed at 50 bar for 15 min by keeping the die temperature at 100°C. Urea formaldehyde was used as resin (Fig. 45). The density and total colour difference of the boards ranged from 913 to 1291 kg m^{-3} and 36.83 to 44.58, respectively. The water absorption after 2 h and 24 h were 13.95-34.67% and 27.50-52.97%, respectively and the hygroscopicity at 95% relative humidity was in the range of 2.35-3.32%.



A: Cassava stem-coir pith; B: Cassava stem-rice husk; C: Pretreated cassava stem
Fig. 45. Cassava stem based particle boards

Development of cassava and sweet potato based animal feed

A field experiment was conducted to study the effects of staggered leaf harvesting in year-round fodder production in cassava with three varieties (Sree Reksha, Sree Jaya and Sree Vijaya). There were two treatments for leaf harvesting: 7 times (3, 4.5, 6, 7.5, 9, 10.5 and 12 MAP) and 4 times (3, 6, 9, and 12 MAP). Leaf yields up to 6 months revealed that the variety Sree Jaya had higher leaf yield (19.00 t ha^{-1}), followed by Sree Reksha (14.10 t ha^{-1}). Among the number of leaf harvest treatments, seven times of harvest of leaves resulted in higher leaf yield (18.00 t ha^{-1}).

A field experiment was laid out in factorial randomized block design with five replications to study the year-round fodder production in sweet potato. The experiment consisted of four varieties (Local, Elite line, Sree Bhadra and Kishan) and two numbers of vine cuttings (5 occasions of vine cuttings (at 85, 155, 225, 295 and 365 DAP) and 6 occasions of vine cuttings (at 75, 133, 191, 249, 307 and 365 DAP). The

study up to 5 months revealed that the variety Kishan produced higher vine yield (20.70 t ha^{-1}), followed by Sree Bhadra (15.2 t ha^{-1}). Cutting of the vines six times produced higher vine yield (19.00 t ha^{-1}).

Variation in the biochemical and micronutrient properties of the leaves of different varieties of cassava viz., Sree Suvarna, Sree Vijaya, Sree Sakthi, Sree Reksha, Sree Jaya and M4 were analyzed. The starch content ranged from 11.54 to 14.52%, crude protein from 10.05 to 13.56%, and fibre from 14.66 to 25.13%. The iron content ranged from 133.20 to 336.80 ppm, zinc from 2125 to 2189 ppm, copper from 81 to 86.4 ppm, calcium from 2168 to 3502 ppm, magnesium from 1120 to 1780 ppm (Table 8).

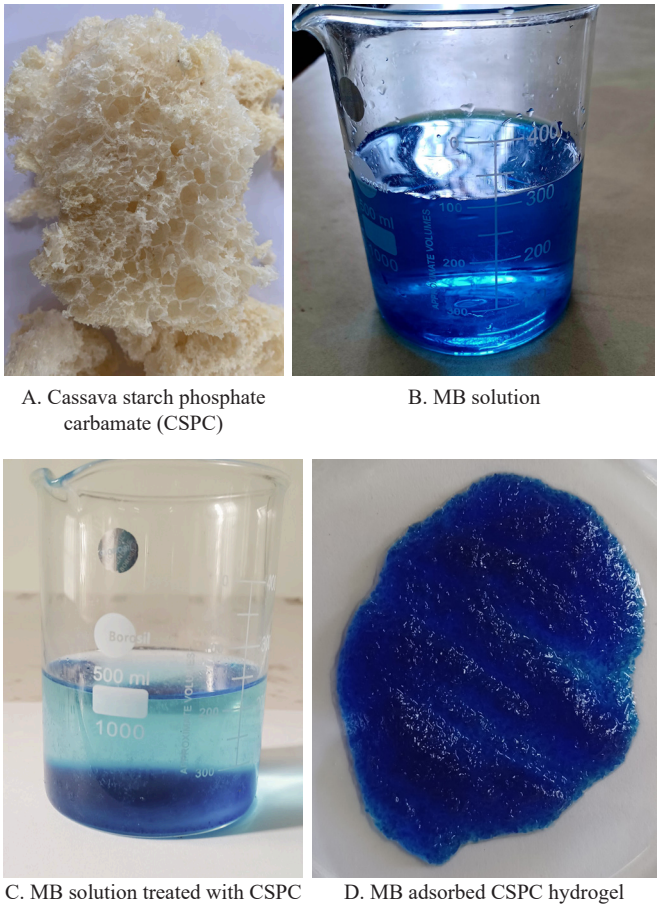
Table 8. Proximate and mineral composition of cassava leaves from different varieties (on dry weight basis)

Variety	Moisture content	Starch	Sugar	Protein	Fibre	Ash	Fe	Zn	Ca	Cu	Mg
	(%)						(ppm)				
Sree Suvarna	73.35	11.55	2.47	11.37	16.28	9.53	133.2	2178.2	3060	82.8	1780
Sree Vijaya	76.89	13.33	4.66	10.06	14.66	9.07	333.4	2189	3502	86.4	1355
Sree Sakthi	74.37	13.14	3.23	11.81	16.89	11.14	336.8	2156.6	3060	82.6	1210
Sree Reksha	75.63	14.52	3.08	10.93	25.13	10.74	202	2148.4	2168	81.6	1505
Sree Jaya	72.01	13.88	3.13	13.56	16.62	10.45	275.6	2124.8	2526	82	1330
M4	73.29	12.90	3.16	10.50	20.42	8.87	324.6	2163	2488	81	1120

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

Evaluation of cassava starch phosphate carbamate as dye adsorbent

Cassava starch phosphate carbamates (CSPC) with high water absorption capacity, synthesized by the reaction of starch with urea and phosphoric acid were evaluated for dye removal from water using methylene blue (Fig. 46). The dye adsorption capacity of the hydrogel was studied at different conditions that included initial solution pH, temperature, adsorbent dosage, contact time, and initial concentration of methylene blue (MB). The removal ratio and adsorption capacity were determined at 20 min intervals after CSPC treatment. It was found very effective in removing methylene blue from aqueous solution. With increase in the initial concentration of the dye from 10 ppm to 30 ppm, the adsorption amount by the SPCS also increased. The amount of dye adsorbed by the hydrogel with respect to dye concentration was in the order of 10 ppm < 20 ppm < 30 ppm. The dye removal percentage by the hydrogel at the equilibrium state, i.e., after 100-120 min of treatment was about 98.30-99.20% with 10 and 20 ppm of the dye concentrations, but it was 76.20% at 30 ppm. The dye adsorption capacity as well as the percentage dye removal were determined at different concentrations of the hydrogel, viz., 5, 10, 20, 30, 40 and 50 mg. The percentage removal of dye was maximum (99.60%) at 20 and 30 mg of the adsorbent concentrations.



A. Cassava starch phosphate carbamate (CSPC)

B. MB solution

C. MB solution treated with CSPC

D. MB adsorbed CSPC hydrogel

Fig. 46. Dye adsorption by cassava starch phosphate carbamate

Soil moisture retention studies with cassava starch phosphate carbamate hydrogels

An experiment was conducted to study the soil moisture retention properties of cassava starch phosphate carbamate hydrogels by pot experiment. From the prepared hydrogels, two samples with maximum swelling (95.90 and 98.50 g g^{-1}) were selected for the study at different application rates in the range of 0.25-1.00% (based on soil weight). The moisture content of the soil was recorded every alternate day. The physical properties viz., pH, electrical conductivity, soil moisture, bulk density, and porosity as well as chemical properties viz., nutrient levels and organic carbon content were determined for the control and hydrogel amended soils. About 30-43% moisture was retained 14 days after watering in the soil treated with 0.75% and 1% hydrogel, while the untreated soil showed only 17.50% moisture retention after the same period. There was a significant increase in the porosity as well as nutrient status of the conditioned soil samples. The nitrogen and phosphorus contents were 78.2±3.92 ppm and 41.4±1.48 ppm in the control soil, whereas 233.0±3.98 ppm and 174.1±6.94 ppm, respectively for the soil amended with 1% hydrogel. There was an increase in water holding capacity from 28.30±0.30% for the control soil to 40.70±0.10% after treatment.

Modulation of cassava starch properties by complexation with proteins

The effect of complexation of cassava starch with different proteins from plant and animal sources (pea protein, soy protein, egg protein and fish protein) on the physico-chemical, pasting, and digestive properties was studied. The source of protein significantly affected the properties of the modified starches. There was a reduction in the peak viscosity from 2409.50 cP for the native starch to 262.0-1973.5 cP for different modified starches and swelling volume from 25 ml g^{-1} for the native starch to 10-15 ml g^{-1} for the modified starches. The water binding capacity increased significantly after complexation from 96.40% for the native starch to 110-260% for the complexed starches. In contrast to the starch-plant protein complexes, the aqueous solubility of starch tremendously increased after complexation with proteins from animal sources. Interaction with proteins resulted in reduced *in vitro* digestibility of starch (30-35%) when compared to the native cassava starch (42.30%).

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

Sorghum incorporated sweet potato thin cookies

Sweet potato-based bakery foods are becoming increasingly popular among consumers worldwide due to the presence of nutritional attributes like dietary fibre, minerals and bioactive compounds. Maida-free sweet potato and sorghum-based thin cookies were developed (Fig. 47), and a completely randomized design (CRD) was used to optimize the levels of sweet potato, sorghum and wheat flour in the products. The nutritional characteristics of thin cookies which included protein, fibre, starch, minerals, fat and sugar contents were determined. The protein content ranged from 3.06 to 1.75 mg $100g^{-1}$ dry weight (dw), starch 36.59 to 24.58 mg $100g^{-1}$ dw, fibre 1.45 to 2.78 mg $100g^{-1}$ dw and ash 2.98 to 2.45 mg $100g^{-1}$ dw for the eight thin cookie formulations. Micronutrient analysis revealed the presence of good amounts of calcium (0.771 to 3.478 ppm), iron (0.587 to 1.956 ppm), magnesium (0.189 to 0.314 ppm), zinc (0.153 to 0.253 ppm) and copper (0.039 to 0.099 ppm). The treatment containing 40% of sweet potato flour, 40% of sorghum flour and 20% of wheat flour showed comparatively higher nutritional attributes than other formulations. Moreover, 9-point Hedonic scale sensory analysis revealed good overall acceptability.

Fig. 47. Sweet potato-sorghum thin cookies

Pearl millet incorporated sweet potato choco-filled cookies

The nutritional characteristics such as protein, fibre, starch, minerals, fat and sugar contents were studied in the sweet potato, pearl millet and wheat flour based

choco-filled cookies (Fig. 48). The protein content ranged from 2.61 to 4.75 mg $100g^{-1}$ dw, starch from 39.59 to 45.58 mg $100g^{-1}$ dw, fiber from 0.21 to 0.51 mg $100g^{-1}$ dw and ash from 3.52 to 6.48 mg $100g^{-1}$ dw. The micronutrient composition was as follows: calcium - 0.99 to 3.40 ppm, iron - 1.05 to 1.67 ppm, magnesium - 0.27 to 0.34 ppm, zinc - 0.16 to 0.27 ppm and copper - 0.04 to 0.09 ppm. The treatment containing 40% of sweet potato flour, 40% of pearl millet flour and 20% of wheat flour was superior in nutritional and sensory attributes compared to the other formulations in the experiment.

Fig. 48. Pearl millet incorporated sweet potato choco-filled cookies

Sweet potato-sorghum low-calorie cookies using natural sweeteners

Natural sweetener (stevia) derived from *Stevia rebaudiana* was used for the development of sweet potato-sorghum low-calorie cookies (Fig. 49). The effect of sweet potato, sorghum and wheat flour concentrations on the nutritional and sensory characteristics of the cookies was studied. Significantly lower sugar content of 1.50-1.78% was found in the low-calorie cookies compared to 15.21% of total sugar content in control cookies made with table sugar. The combination of 45 g each of sweet potato and sorghum, and 10 g of wheat flour was the best in terms of nutritional and sensory attributes.

Fig. 49. Sweet potato-sorghum low-calorie cookies

Cassava-millet based rice analogue

Rice analogues were prepared from cassava-pearl millet-guar gum based composite flour with different proportions of cassava flour (40-50%), pearl millet flour (25-35%) and guar gum (0.5 and 1.0%). Biochemical, physical and cooking properties were analyzed. Moisture content of the rice analogue varied from 3.53 to 4.57%, starch from 27.96 to 41.72%, sugar from 4.72 to 6.76%, fibre content from 0.21 to 0.52%, ash content from 1.69 to 2.29%, protein content from 2.63 to 3.94%, fat from 4.44 to 8.18% , magnesium content from 133.4 to 154.8 ppm, calcium from 23.02 to 138.62 ppm, iron content from 61.0 to 593.6 ppm, zinc content from 15.4 from 78.2 ppm, cooking time from 5:05 to 8:00 minute, swelling index from 1.54 to 4.21, cooking loss from 22.18 to 37.45%, total colour difference from 25.79 from 77.68, whiteness index from 22.13 to 73.68, yellowness index from 21.40 to 30.03, length from 0.619 to 0.656 cm, width from 0.232 to 0.250 cm, thickness from 0.168 to 0.190 cm, weight of the grain from 0.017 to 0.022 g, geometric mean diameter from 0.296 to 0.309 cm, sphericity from 0.459 to 0.492, surface area from 0.272 to 0.299 cm^2, seed volume from 0.0079 to 0.0092 cm^3, aspect ratio from 36.14 to 40.10, true density from 890 to 1500 kg m^{-3} and bulk density from 813 to 929 kg m^{-3}.

Rice analogues were developed from the composite flour containing cassava flour (40-50%), barnyard millet flour (25-35%) and flaxseed (2 and 3%). Biochemical, cooking and physical characteristics of rice analogue were analyzed. Moisture content varied from 2.63 to 6.95%, starch from 38.88 to 53.03%, sugar from 4.67 to 5.99%, fibre from 0.10 to 1.62 %, ash from 1.23 to 1.71%, protein from 3 to 5.25%, fat from 11.98 to 15.62%, cooking time from 6:35 to 8:07 minute, swelling index from 1.84 to 3.51, cooking loss from 10.42 to 25.10%, total colour difference from 24.51 to 37.28, whiteness index from 62.12 to 74.95, yellowness index from 20.91 to 26.29, length from 0.610 to 0.693 cm, width from 0.193 to 0.262 cm, thickness from 0.166 to 0.184 cm, sphericity from 0.459 to 0.492, surface area from 0.017 to 0.293 cm^2, seed volume from 0.0056 to 0.0078 cm^3, aspect ratio from 37.14 to 41.33, true density from 890 to 1540 kg m^{-3}, bulk density from 810 to 900 kg m^{-3}, tapped density from 1020 to 1240 kg m^{-3}, weight of the grain from 0.016 to 0.022 g, geometric mean

diameter from 0.277 to 0.310 cm, porosity from 33.70 to 46 and water activity from 0.390 to 0.588.

Cassava-pearl millet-soy flour based pasta

Pasta was developed from cassava-pearl millet-soy flour based composite flour (Fig. 50) with different proportions of cassava flour (40-60%), pearl millet flour (40-60%) and soy (5 and 15%). The physico-chemical, cooking and digestibility characteristics of pasta were analyzed. The starch, sugar, fibre, ash, crude protein and fat contents were 48.08-54.35%, 4.06-5.81%, 0.21-0.40%, 1.77-2.40%, 3.68-4.29% and 4.10-10.47%, respectively. The nutrients viz., magnesium, calcium, iron and zinc contents were 144.6-157.0 ppm, 338.2-1480.6 ppm, 259.6-437.8 ppm, and 25.2-43 ppm, respectively. The cooking time ranged from 8.19 to 8.55 min, swelling index from 1.06 to 2.31, cooking loss from 12.64 to 22.59%, and total colour difference from 20.37 to 24.13. The water absorption index and water solubility index were in the range of 11.62-21.48 and 0.69-1.23, respectively. The optimized parameters for the production of pasta from cassava, pearl millet and soybean based composite flour by the response surface methodology were: cassava-40%, pearl millet-58.38% and soy flour-15%.

A: Cassava flour-pearl millet; B: Cassava flour-barnyard millet; C: Cassava-pearl millet-soy flour based pasta

Fig. 50. Cassava-millet based rice analogues and pasta

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

Design and development of a tractor operated Chinese potato harvester

An average of 100 female labourers and 20 male labourers are needed to harvest one acre of Chinese potato tubers. Thus to mitigate labour shortages and to reduce harvesting costs, a tractor operated prototype Chinese potato harvester has been designed and developed to harvest Chinese potato tubers grown in ridge and furrow system (Fig. 51). The developed Chinese potato harvester comprises of a main frame, digging system, discharge system, power transmission system and transport system. It can cover three ridges with a spacing of 30 cm and a depth of operation of 15 cm. The performance of the two different digging blade types; the straight and V-type blades in the harvester was examined. The V blade had the highest digging efficiency of 92.83 per cent, while the straight blade displayed the lowest digging efficiency of 78.36 per cent. Straight blades required a maximum draft of 3475.12 N, whereas V blades required a minimum draft of 2315.67 N. V blades were found to consume 4.72 l h^{-1} of fuel less than straight blades, which consumed 6.04 l h^{-1}. The actual field capacity and field efficiency of the developed prototype Chinese potato harvester were determined to be 0.13 ha h^{-1} and 81.15 per cent, respectively. The cost per hectare of harvesting using the developed harvester was determined to be ₹ 18,400 per hectare compared to ₹ 1,12,500 for harvesting manually. The cost savings per hectare while harvesting with the mechanical harvester is ₹ 94,100.

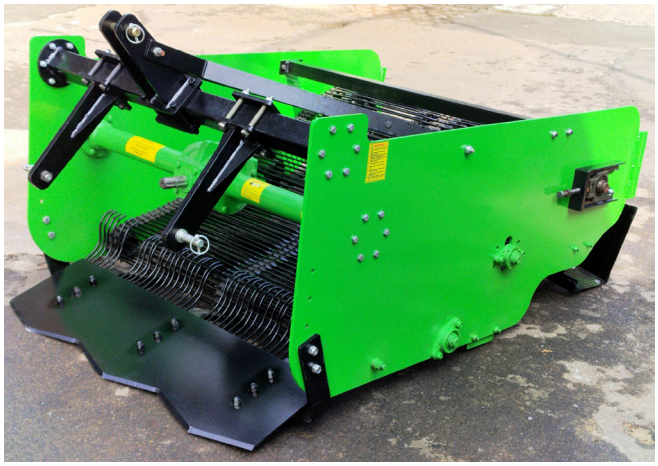


Fig. 51. Tractor operated Chinese potato harvester

Design and development of a sweet potato grader based on size and length for quality chips production using machine vision system

Sweet potato is a major tuber crop cultivated widely for different food applications. The grading of sweet potato tubers is done according to size, shape, weight, the presence of defects and the surface uniformity. For quality chips production, sweet potato tubers are graded based on size and length. In India, processors prefer to use sweet potato tubers with an overall diameter not more than 2.5 inches and a length not less than 4 inches for producing quality chips. Thus, to design and develop a sweet potato grader based

on size and length, engineering properties such as proximal diameter, middle diameter, distal diameter, weight and length for different varieties of sweet potato tubers namely Bhu Sona, Sree Kanti and Kanjanghad were measured. The proximal, middle and distal diameter of the varieties ranged from 18.87-58.76 mm, 26.54-58.32 mm and 17.34-47.43 mm, respectively. The length and weight of the varieties varied from 75-200 mm and 31.52-201.50 g, respectively.

The variation in size, length and weight of sweet potato tubers within cultivars can significantly affect the effectiveness of the grading machine. Currently, grading of sweet potato tubers for chips production is performed manually in India. In addition to incurring high labour costs, manual grading is subjective and prone to human assessment error. Thus, this study was aimed to develop a sweet potato grader based on size and length using machine vision system to reduce labour dependence and costs and enhance the quality for sweet potato chips production. The fabricated system consisted of a custom-designed, motorized roller conveyor for sweet potato transportation, singulation unit and a computer vision module with a camera to measure the size and length of sweet potato tubers. A customized computer vision was developed with algorithm to segment and track each sweet potato travelling on the conveyor and analyze the required quality parameters in real-time. The final grade of individual tuber will be determined from a sequence of multi-view images against predefined grading standards in terms of size and length. The grader based on machine vision system is fabricated and its performance evaluation is in progress.

Portable self propelled tapioca sett cutter

Mechanized planting of tapioca requires the use of stem cuttings that are uniform in length with an adequate number of undamaged buds. Also, when cutting tapioca stems into pieces for planting, each cutting should be 15 cm length and have about 6 to 8 nodes. The interval between cutting of the stems and planting in the ground should be as short as possible to facilitate better growth. In order to get the best growth of tapioca, it is important to cut the setts properly. The manual tapioca sett cutting for cultivation demands human labour, and it is a time-consuming job. Tapioca sett cutting is mainly carried out in the field itself to facilitate the tapioca planting easier. Therefore, a portable self propelled tapioca sett cutter was developed for producing quality tapioca setts in the field itself. The developed portable self propelled tapioca stem cutter consisted of petrol engine (1.6 HP), rotary cutting blade (12 inch diameter), frame, pulleys, platform, inlet and outlet assembly and stopper (Fig. 52). The machine can be operated by hand or pedal. The adjustable feature on the stopper can be used to produce the required length of tapioca setts. Rotary cutting blades attached to the prime mower that rotate at 1000 RPM will produce uniform and round cutting of tapioca setts for high quality tapioca sett production. The machine was tested for performance in terms of cutting efficiency, percentage of damaged setts and output capacity. The results showed that cutting efficiency, percentage of damaged setts and output capacity were 98%, 0.45% and 3600 setts per hour, respectively.

Fig. 52. Portable self propelled tapioca sett cutter

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

Demonstrations on improved varieties of cassava and OFTs on site specific nutrient management (SSNM) in Chinese potato were conducted in Tamil Nadu in 36 farmer's fields for proving the technical feasibility and economic viability of the improved technologies. Farmers were trained to adopt scientific crop management practices. Pests and diseases viz., mealybug, spiraling white fly and cassava mosaic disease in cassava and sucking pests and nematode in Chinese potato were managed with integrated pest, disease and nematode management practices.

Improved varieties of cassava

Data from 10 FLDs conducted during April 2022-January 2023 at Manmalai and Sentharapatti villages in Salem district revealed that yield of Sree Athulya (38.77 t ha^{-1}) was higher (9.42%) than the yield of local varieties (35.43 t ha^{-1}). The net income realized from Sree Athulya was ₹ 2, 29,199 ha^{-1} (B:C ratio: 2.74), while for local varieties it was ₹ 1,82,004 ha^{-1} (B:C ratio: 2.40) (Fig. 53). Technology gap, extension gap and technology index of Sree Athulya was estimated as 31.23, 3.34 and 44.61 respectively. Similarly, data from 10 FLDs conducted at Mettupatti and Naraikinaru villages in Namakkal district revealed that the yield of Sree Athulya (30.92 t ha^{-1}) was higher (11.91%) than the yield of local varieties (27.63 t ha^{-1}). The net income realized from Sree Athulya was ₹ 1, 49,787 ha^{-1} (B:C ratio: 2.41), while for local varieties, it was ₹ 1,08,446 ha^{-1} (B:C ratio: 2.07) (Fig. 54). Technology gap, extension gap and technology index of Sree Athulya was estimated as 39.08, 3.29 and 55.83 respectively.

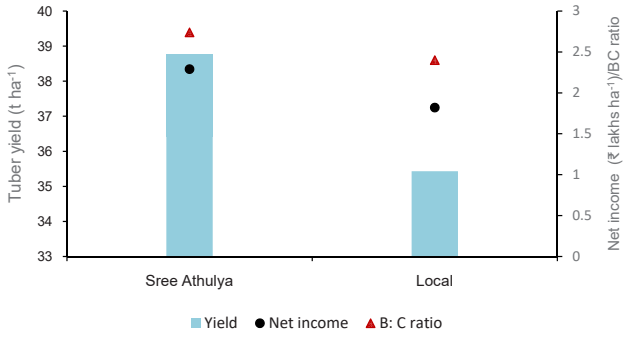


Fig. 53. Performance of Sree Athulya in Salem district

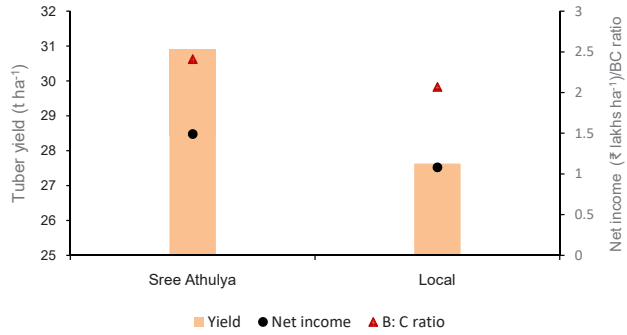


Fig. 54. Performance of Sree Athulya in Namakkal district

Six OFTs on high yielding cassava mosaic disease (CMD) resistant variety of cassava, Sree Kaveri (8S-501) conducted at Vazhapadi in Salem and at Mettupatti in Namakkal district of Tamil Nadu revealed that the average yield of Sree Kaveri under irrigated conditions was 40.21 t ha^{-1}, which was (9.80%) higher than the yield of local varieties (36.62 t ha^{-1}). The net income realized from Sree Kaveri under irrigated conditions was ₹ 2, 33,566 ha^{-1} (B: C ratio: 2.78), while for local varieties it was ₹ 1, 76,813 ha^{-1} (B: C ratio: 2.37) (Fig. 55). Under rainfed conditions, the average yield of Sree Kaveri was 28.69 t ha^{-1}, which was higher (7.97 %) than the yield of local varieties (26.49 t ha^{-1}). The net income from Sree Kaveri was ₹ 1, 71,626 ha^{-1} (B:C ratio: 2.60) and ₹ 1,17,831 ha^{-1} (B:C ratio: 2.13) from local varieties (Fig. 56).

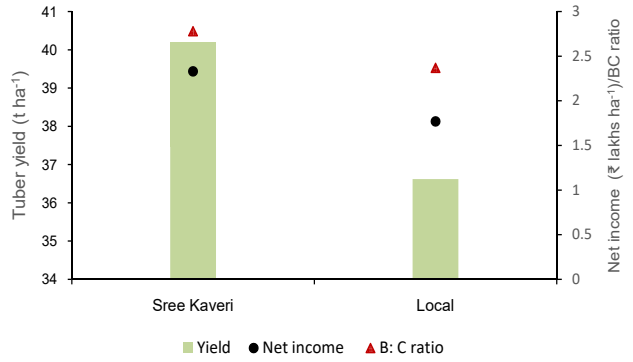


Fig. 55. Performance of Sree Kaveri in Salem district under irrigated conditions

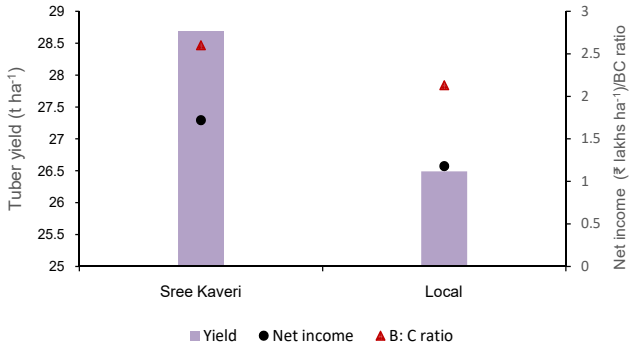


Fig. 56. Performance of Sree Kaveri in Namakkal district under rainfed conditions

Site specific nutrient management (SSNM) in Chinese potato

Ten farmers (with 50 cents plot each) from Tenkasi and Tirunelveli districts of Tamil Nadu were selected for the OFTs on SSNM in Chinese potato during October 2022 to February 2023. Improved variety of Chinese potato 'Sree Dhara' and inputs such as customized fertilizers and micronol were supplied to the farmers as per the recommendations. Soil, plant and tuber samples were collected and analyzed for estimating the nutrient uptake and standardizing the nutrient recommendations.

Five FLDs conducted on SSNM in Chinese potato in Tenkasi district revealed that the yield of SSNM treated plot of Sree Dhara (19.75 t ha^{-1}) was 12.15% higher than the yield obtained from farmer's practice (17.61 t ha^{-1}). The net income realized from SSNM treated plot of Sree Dhara was ₹ 2, 47,950 ha^{-1} (B: C ratio: 2.95), when compared to farmer's practice, which was ₹ 2, 12,440 ha^{-1} (B: C ratio: 2.74) (Fig. 57). Similarly, five FLDs on SSNM in Chinese potato in Tirunelveli district revealed that the yield of SSNM treated plot of Sree Dhara (20.99 t ha^{-1}) was 9.78% higher than the yield obtained from farmer's practice (19.12 t ha^{-1}). The net income realized from SSNM treated plot was ₹ 2,33,078 ha^{-1} (B: C ratio: 2.81) when compared to farmer's practice, which was ₹ 2, 08,540 ha^{-1} (B: C ratio: 2.72) (Fig. 58).

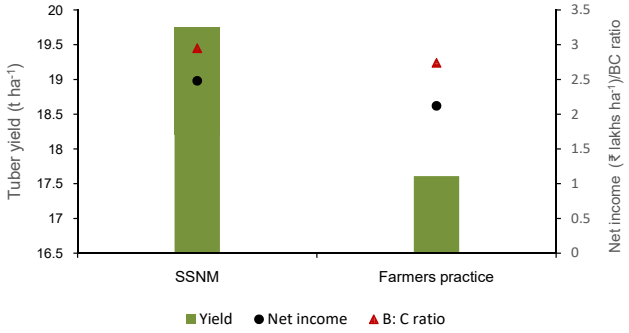


Fig. 57. Performance of SSNM in Chinese potato in Tenkasi district of Tamil Nadu

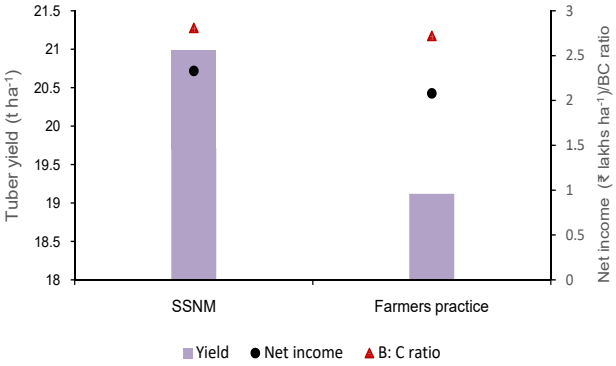


Fig. 58. Performance of SSNM in Chinese potato in Tirunelveli district of Tamil Nadu

Technological interventions through FPGs

Two Farmer Producer Groups (FPGs) on cassava were formed viz., 'Pasumai FPG' at Mettupatti village of Namakkal and 'Vidiyal FPG' at Manmalai village of Salem, Tamil Nadu for enhancing the farmers' income by adoption of improved varieties and technologies of cassava under the technical guidance of the scientists of ICAR-CTCRI.

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 90 tuber crops growers in major districts viz., Tenkasi (15) and Tirunelveli (15) in Tamil Nadu, Ganjam (15)

in Odisha and Uttara Kannada (15) and Belagavi (30) in Karnataka.

Upscaling tuber crops technologies for promoting food and nutritional security

Monitoring sweet potato FLDs

For promoting biofortified sweet potato varieties among farmers in Attapadi, three FLDs (0.16 ha per FLD) were conducted at Gonjiyur, Attapadi, Palakkad in Kerala.

Table 9. Results of ANOVA analysis of tuber yield of biofortified sweet potato varieties at Gonjiyur, Attapadi, Kerala

Variety	Tuber yield (t ha^{-1})*	F	p
Bhu Kanti	20.27^{a}	21.906	0.002
Bhu Sona	19.03^{a}		
Bhu Ja	6.67^{b}		

* Means in column followed by the same letter under each variable are not significantly different by ANOVA (p = 0.05; Tukey HSD).

In the FLDs, Bhu Kanti produced highest tuber yield (20.27 t ha^{-1}), followed by Bhu Sona (19.03 t ha^{-1}) and Bhu Ja (6.67 t ha^{-1}). A one-way ANOVA was performed to compare the varietial differences in the tuber yield. Results indicated that there was statistically significant difference in the tuber yield of three biofortified sweet potato varieties [F (2,6) = 21.906; p=0.002] (Table 9). Tukey's HSD Test for multiple comparisons found that the tuber yield of Bhu Kanti and Bhu Sona were significantly higher than Bhu Ja (p<0.01; Tukeys HSD). The benefit: cost ratio of these varieties ranged from 4.25 to 4.53.

In the FLD of Bhu Krishna variety (0.16 ha per FLD) laid out in three locations in Kallakurichi, Tamil Nadu, an average yield of 22.50 t ha^{-1} was obtained. The ANOVA results showed no significant difference in the mean tuber yield across these locations.

Consumer acceptability of millet porridge

The consumer acceptability of two versions of orange-fleshed sweet potato-millet porridge developed at KIIT University, Bhubaneswar was evaluated for their consumer acceptance among students in Kerala. A semi-trained women student panel of 15 members evaluated the sensory quality of these porridge samples in terms of their appearance, colour, taste, aroma and mouth feel on a 5 point Likert scale (1= Very poor; 5=Very good).

Table 10. Mean differences in the liking scores of two millet porridge samples

Sl. No	Sample	Mean value		Mean difference	t
		Malted ragi	Folate enriched ragi		
1	Appearance	3.9	2.6	1.30	3.38*
2	Colour	3.6	3.1	0.50	0.983^{NS}
3	Taste	3.8	2.9	0.90	2.24*
4	Aroma/smell	3.5	2.7	0.80	1.986^{NS}
5	Mouth feel	4.2	2.8	1.40	3.202*

*Significant at 5% level (p<0.05); NS – Not significant

The results indicated that both the samples were moderately accepted by the respondents (Mean<4). While the malted ragi sample rated significantly higher than the folate enriched ragi for its appearance (t=3.38; p<0.05), taste (t=2.24; p<0.05) and mouth feel (t=3.202; p<0.05), the colour and aroma/smell were rated similarly (Table 10).

To understand the reasons for moderate sensory scores of both samples as well as for poor acceptability of folate enriched sample, an informal interview was conducted among participants. The results revealed the following aspects:

The respondents were familiar with consuming health drinks with milk. When the samples were served as porridge made with hot water, the respondents were unfamiliar in this form of consumption. They preferred a millet drink mixed with hot milk. The folate enriched porridge is suitable for consumption like a paste, like Chyawanprash and served with moderate level of sugar (half tea spoon for 10 g millet powder). The folate enriched porridge has coarse texture which needs to be ground till it gets fine texture. Most of the respondents felt bitterness in their mouth after swallowing the folate millet porridge.

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

A study was conducted to document the empowerment index of women involved in sweet potato cultivation. By using simple random sampling method, 60 farmers and 60 farm women were selected from two taluks in Belgaum district, as this district ranks first in sweet potato production in Karnataka. The selected respondents were interviewed with an interview schedule and the data collected were tabulated and analysed.

Socio-economic profile of the respondents

Majority of men (71.67%) and women (81.67%) were middle aged. All the men and women were literates. Agriculture was the main occupation for 96.67% of men and 98.33% of women, as agriculture predominates in these areas. Fifty six per cent of the respondents had nuclear family and only 16.67% had more than six members in their family. Men's mean farming experience in agriculture was 36.51 years, while women's was 25.06 years; however, in the cultivation of sweet potato, men's mean farming experience was 30 years and women's was 20.45 years. Farm size indicated that 38.33% were marginal and small farmers respectively. Sixty five per cent were cultivating sweet potato in less than 2.5 acres. Livestock was possessed only by 18.33%. Majority (70%) had access to credit. Majority of the men (73.33%) and women (68.33%) had medium level of aspirations and the innovativeness was medium for 61.67% of men and 63.33% of women.

Extent of participation in sweet potato cultivation

In sweet potato cultivation, medium level of participation was observed among 68.33% of men and 60.00% of women with a mean score of 2.0 for men and 1.5 for women (Fig. 59). Mean participation score of women was more in practices like selection/ planting of vine cuttings (1.97) and intercultural operations (2.42). In land preparation, participation of men was more (2.58) and for women the score was 1.72. In selection of variety (2.22), application of fertilisers (2.30), identification of pests and their management (2.00) and in grading and marketing (2.30) men had prominent role than women. Even though, participation of men was more in most of the activities, there was only marginal difference. The overall participation score of men was 2.01, whereas it was 1.59 for women.

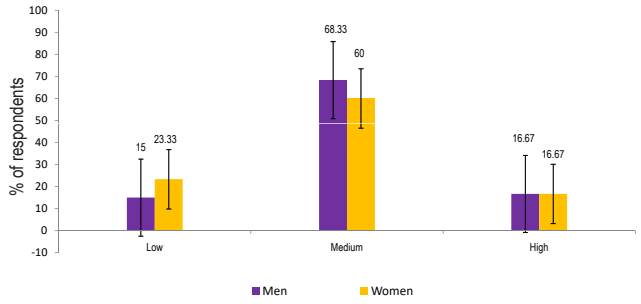


Fig. 59. Level of participation of respondents in sweet potato cultivation

Extent of participation of men and women in sweet potato cultivation

The Women's Empowerment Index in Agriculture developed by International Food Policy Research Institute (IFPRI) and USAID's 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. Differences were observed in the indicators such as input in productive decision (men 2.62; women 2.02), autonomy in production (men 2.65; women 1.73), ownership of asset (men 2.77; and women 1.28), purchase/sale of assets (men 2.70; women 1.22) control over use of income (men 2.57; women 1.83) and speaking in public (men 2.15; women 1.68). The overall empowerment of men was 0.82 and women was 0.58 (Fig. 60).

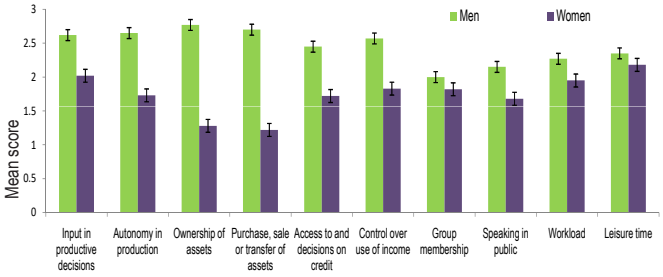


Fig. 60. Empowerment indicators of respondents in sweet potato cultivation

The analysis of the needs of women indicated that first rank was assigned to demonstrations on improved varieties/technology (mean score 2.70), followed by quality planting materials of improved varieties of sweet potato (2.62), training on improved technologies of sweet potato cultivation (2.56), and subsidies/inputs for sweet potato cultivation (1.61) (Fig. 61). They preferred high yielding varieties

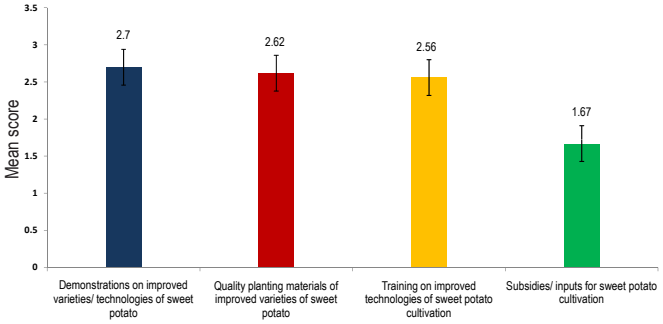


Fig. 61. Needs of farm women in sweet potato cultivation

(1 rank), pest and disease resistant varieties (II rank), good size and shape tubers (III rank), good keeping quality (IV rank) and good cooking quality (V rank) (Fig. 62).

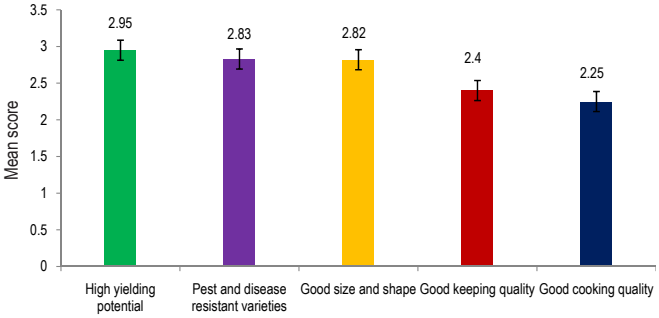


Fig. 62. Preferences of farm women in sweet potato cultivation

Opportunities in sweet potato cultivation

The opportunities as perceived by women were enhancing yield by adoption of new technologies (2.55), short duration and women friendly crop (2.40), suitable for their cropping system (2.37), suitable for their local agro-ecosystem (2.15) and scope for post harvest processing (1.77) (Fig. 63).

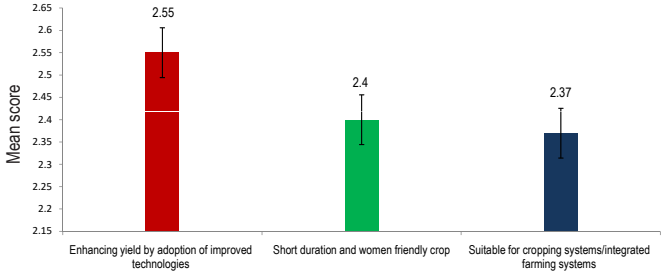


Fig. 63. Opportunities in sweet potato cultivation as perceived by farm women

Constraints in sweet potato cultivation

The constraints reported were price fluctuation (I), pest and disease (II), less access to extension services (III) weather aberrations (IV), non availability of quality planting materials (V), lack of knowledge and access to crop loans and subsidies (VI), high labour cost (VII) and wild animal attack (VIII) (Fig.64).

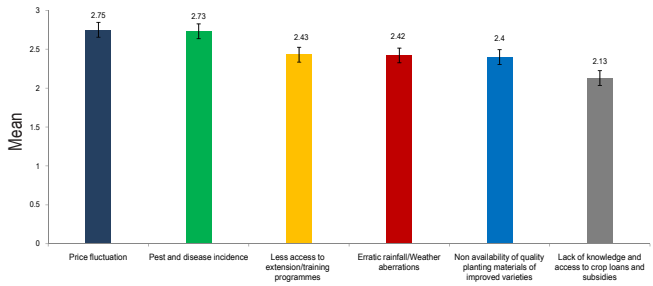


Fig. 64. Constraints in sweet potato cultivation as perceived by farm women

Impact assessment of technologies of tropical tuber crops

Impact assessment of improved varieties of cassava was conducted among 300 farmers in Salem, Tiruchirappalli, Namakkal, Cuddalore, Dharmapuri and Pudukottai districts of Tamil Nadu. These districts were purposefully selected as field demonstrations were conducted in these districts with improved varieties. These districts have more than 65% of the area under cassava cultivation. Four stage sampling procedure was used for selection of districts from the state, followed by the selection of blocks, identification of villages and finally, the selection of individual farmers from the villages. In total, 300 respondents were collected, drawing samples from 30 villages situated in 14 blocks across the six aforementioned districts of Tamil Nadu. A logistic regression model was used to identify factors determining adoption of improved varieties and the Propensity Score Matching method was used to estimate the impact of improved varieties and these were estimated using STATA Software V. 15.1.

Diffusion of cassava varieties

Farmers were cultivating 17 varieties of cassava. Improved varieties viz., H-165, H-226, Sree Athulya, Sree Jaya, Sree Kaveri, Sree Reksha, YTP I and II and Mulluvadi covered 47.31% of the total area. The remaining area of 52.69% was covered by local varieties. Among the improved varieties, H-226 and Sree Athulya were the leading varieties, which covered 29% of the area in the districts. *White Thailand and Kunkumarose* were the most (44%) widely adopted local varieties. Local varieties were highly popular because of its availability, high yield, starch content and demand among traders (Kunkumarose). Varieties H-226 and Sree Athulya were the best suited for industrial requirements as they have high starch content and ability to withstand drought (H-226).

Cost of cultivation and profitability

The total cost for cultivating cassava between adopters of improved varieties and non-adopters varied. Adopters incurred ₹ 0.79 lakh ha^{-1}, while it was ₹ 0.71 lakh ha^{-1} for non-adopters, as the harvesting and transportation cost were not included in the total cost. The adopters showed significant yield gains compared to the local varieties (10.13%). Higher yield of adopters had reduced the unit cost

of production and therefore increased profitability. Gross and net returns for adopters were 14% and 16% higher than that of non-adopters. The unit cost of production due to the adoption of improved varieties over local varieties declined by 1.11% (₹ 63 per tonnes). The adopters fetched a higher price (4%) than local varieties. The estimated benefit:cost ratio was high for adopters (3.16) than for the non-adopters (3.08).

Impact of improved varieties

Difference among adopters and non-adopters of improved varieties of cassava were compared using t test in terms of input costs, yield, price and net income earned in cassava cultivation. Results clearly indicated the advantages in adopting the varieties. Per ha increase in input cost is ₹ 8083 for adopters. Moreover, adopters had yield and income advantages of 2.57 t ha^{-1} and ₹ 25,713 ha^{-1} respectively than non-adopters (Table 11). While t test clearly indicated the differences due to adoption, the estimated impact might be less precise as the test accommodates no factors that control adoption decision. Hence, we attempt to estimate direct causal effect of technology using counterfactual framework. Farmers, who adopted the improved varieties, their input cost, yield and net income more than that of non-adopters. Estimates obtained in matching procedure are more reliable as it controls the different factor responsible for adoption.

Table 11. Impact of improved varieties: PSM results

Treatment-effects estimation		Number of observations = 299	
Estimator : propensity-score matching		Matches: Requested = 1	
Outcome model : matching		Minimum =1	
Treatment model: logit		Maximum =2	
Particulars	Average Treatment Effect on Treated (Impact)	Standard error	P value
Input cost (₹ ha^{-1})	9963.16***	2440.12	0.000
Yield (t ha^{-1})	3.29***	1.28	0.010
Price (₹ t^{-1})	78.63	228.48	0.731
Net income (₹ ha^{-1})	26182.07**	11071.84	0.018

Variables such as yield, access to technical advice, district and irrigation dummies were significant factors for the adoption of improved varieties (Table 12). All other variables included in the model were found non-significant. Marginal effects of yield suggest that one ton increase in yield will increase the likelihood of adopting improved varieties by 2%. Marginal effects of dummy variable showed that the accessibility of technical advice increased the probability of adoption of improved varieties by 18.80%. District dummies were significant which suggested that the adoption decision was influenced by soil types, rainfall, and cropping pattern. Irrigation dummies showed that the availability of irrigation facilities will increase likelihood of adoption of improved varieties.

Table 12. Determinants of technology adoption: Logit estimates

Explanatory variables	Coefficient	Standard errors	P value
Age (years)	0.0004	(0.002)	0.873
Education (years)	-0.003	(0.006)	0.655
Family size (no)	-0.019	(0.019)	0.320
Ln_farm size (ha)	0.060	(0.043)	0.164
Yield (t ha^{-1})	0.025***	(0.010)	0.008
Access to technical advice (1/0)	0.188***	(0.049)	0.000
District 1 (1=Salem, 0=otherwise)	-0.032	(0.074)	0.669
District 2 (1=Namakkal, 0=otherwise)	0.417***	(0.097)	0.000
District 4 (1=Pudukkottai, 0=otherwise)	0.105	(0.174)	0.548
District 5 (1=Tiruchirappalli, 0=otherwise)	0.593***	(0.076)	0.000
Irrigation 1 (1=Drip, 0=otherwise)	0.193***	(0.073)	0.008
Irrigation 2 (1=Flood, 0=otherwise)	0.394***	(0.075)	0.000

*** indicates significance of z statistics at 1% level.

Trait preferences

It is important to understand the field level trait preferences of farmers for prioritizing varietal and seed system development. The most preferred traits in Tamil Nadu are high tuber yield, resistance to pests and diseases, mainly mealybug and red spider mite. Other high valued traits include high starch content, short duration varieties, drought resistance

and easy to harvest. Farmers did not give importance to characteristics like storability of planting material and tubers.

Generation and application of statistical and bioinformatics tools for tuber crops research and development

Interactive database of genomic variations in cassava, CasGVD

A comprehensive database of cassava genomic variations was developed, currently, CasGVD includes large sets of data on genomic variations (SNPs and INDELs) compiled from whole genome analysis of two genotypes, Sree Kaveri and 9S-127. Analysis of the draft genome assembly revealed the presence of 7,789,154 and 7,130,986 SNPs in, respectively. Comparative analysis showed the presence of 11, 04,776 and 9, 43,104 InDels in Sree Kaveri and 9S-127 respectively. Currently, CasGVD includes large sets of data on genomic variations (SNPs and INDELs) compiled from Sree Kaveri and 9S-127, which can be utilized for genome wide association studies and molecular marker studies in cassava. The construction of CasGVD was a multistep process, the integrative genome viewer (IGV) was integrated with the genomic variant database developed using the predicted genomic variations from Sree Kaveri and 9S-127. This CasGVD helps in chromosome and location wise retrieval of genomic variants (Fig. 65).

Web based statistical analysis software: AgriAnalytics@R

Developed AgriAnalytics@R (AgriAnalytics@R Ver. 3.10 (shinyapps.io)), a web based statistical

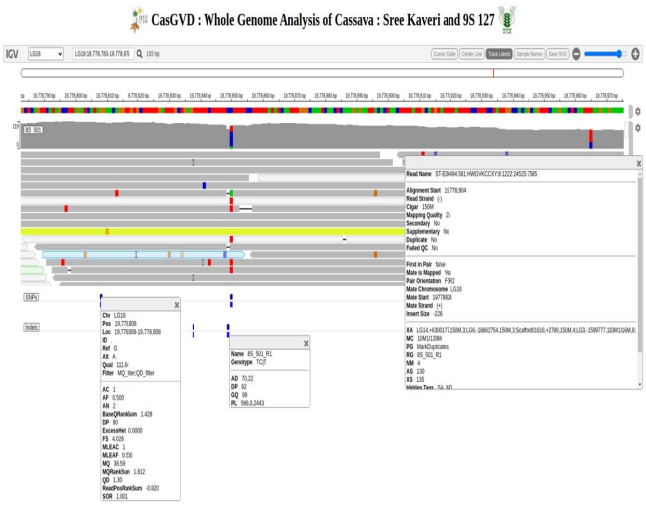


Fig. 65. CasGVD, the interactive database on genomic variants in cassava

package using R Shiny, which provides statistical analysis and data visualization specifically tailored for Agricultural Research. The features includes importing data directly from excel formats, descriptive statistics with plots for visualization, ANOVA (CRD and RBD), correlation matrix with p-value and correlogram. Easy to use interface with one click download options for results is given. The tool can be accessed at

https://sreejyothi.shinyapps.io/agrianalyticsr/ (Fig. 66).

Accession Number	Starch	Drymatter	Total Sugar	Crude fiber	Ash
CI-144	18.35	28.58	2.30	1.10	1.80
CI-3	25.09	39.05	2.40	1.00	1.60
CI-4	20.44	27.36	2.60	1.00	1.80
CI-5	19.01	28.55	2.20	1.30	3.00

Fig. 66. AgriAnalytics@R, the web based statistical data analysis software

R Packages developed

An R package named 'baseq', Basic Sequence Processing Tool for Biological Data was created and submitted to CRAN repository. The various functions created can be used for bioinformatics application like data cleaning of DNA file and sequence, data cleaning of RNA file and sequence, counting of base, sequence pattern, transcription of DNA sequence, converting fastq file to fasta file, reading of fasta and fastaq files to list and data frames, generating reverse complement, translation of RNA to protein etc.

Another package namely 'fixr' submitted CRAN repository contains a set of functions that facilitate basic data manipulation and cleaning for statistical analysis including functions for finding and fixing duplicate rows and columns, missing values, outliers, and special characters in column and row names and functions for checking data consistency, distribution, quality, reliability, and structure.

Developmental Projects

1. ICAR-CTCRI-Tribal Sub Plan: Livelihood improvement of tribal farmers through tuber crops technologies (ICAR, TSP; PI: M. Nedunchezhiyan; Co-PIs: Kalidas Pati, V.B.S. Chauhan, K. Hanume Gowda and R. Arutselvan)

During the year 2023, 310 tribal farmers were adopted from Gajapati, Kandhamal and Koraput districts of Odisha and Manyam district of Andhra Pradesh and tuber crops technologies were demonstrated. Planting material of 10,000 kg of greater yam, 1000 kg of elephant foot yam, 400 kg of taro, 100 kg of yam bean, 10,00,000 cuttings of sweet potato and 6000 stems of cassava were distributed to the tribal farmers. Vegetable seeds (125 kg) containing French bean (Arka Arjun and Arka Mangala) were distributed. Besides, four types of small tools (each 300 nos.) were distributed to the tribal farmers. For capacity building of the tribal farmers on crop diversification with tuber crops and value addition, 10 on-farm trainings were organized. In tribal farmers field, sweet potato, yam bean, taro, elephant foot yam, greater yam and maize were harvested and yields of 12.20, 20.40, 13.20, 21.40, 25.60 and 2.90 t ha^{-1} respectively were produced. Tuber crops day was celebrated on 18 January 2023.

2. ICAR-CTCRI-SCSP: Empowerment of tuber crops farmers through sustainable use of resources and tuber crops technologies (ICAR, SCSP; PI: V. Ramesh; Co-PIs: M.N. Sheela, M.S. Sajeev, S.S. Veena, D. Jaganathan, H. Kesava Kumar, J. Suresh Kumar and T. Krishnakumar)

The farmer beneficiaries under this scheme were selected from one block of Pathanamthitta district of Kerala, two blocks of Karur district, one block each in Salem, Mayiladuthurai and Nagapattinam districts of Tamil Nadu. A total of 100 farmers were identified from six blocks to improve their livelihood through judicious use of resources and latest tuber crops technologies, including varieties. A total of 120 field demonstrations were established to showcase the ICAR-CTCRI technologies, including latest varieties of tuber crops and production technologies in cassava and nutrient management trials in elephant foot yam.

A total of 15,000 cassava stems of Sree Athulya and Sree Kaveri were distributed in S. Naraiyur, Arasankudi, Eluthoor villages in Mangalur block, Cuddalore district Tamil Nadu during February 2023 and 10,000 stems of Sree Reksha and Sree Pavithra were distributed to farmers in Adoor, Kadampanadu and Enadimangalam panchayats of Kerala State during October 2023. Inputs like neem cake, straight and water-soluble fertilizers, gypsum, nano urea, liquid micronutrient solutions like micronol, effective microorganism solution, *Trichoderma* capsules, Pusagel were distributed in addition to PP chemicals, farm tools like spade, pick axe, battery type sprayer (15 L) to farmer beneficiaries, thus covering a total of 140 farmers at the end of the reporting period. The nutrient management trial in two villages of Karur district (Nanjakalakurichi in Paramathi block and Pallapalayam in Thanthoni block) in 50 farmer's field aimed at providing a best fertilizer package for obtaining higher yield in elephant foot yam as against the present low yield of 10-12 t $acre^{-1}$ realized by farmers. Various inputs were distributed considering the poor soil quality (low soil organic carbon, available N, available K). A total of 17 farmer stake holder training programs/farmer interface cum meetings were conducted benefitting 717 farmers.

3. ICAR-CTCRI NEH Programme: Scaling up of biofortified tuber crops through 'Rainbow diet approach' in the north eastern hill region (PI: P. Sethuraman Sivakumar; Co-PIs: K. Laxminarayana H. Kesava Kumar, P. Prakash, T. Krishnakumar, R. Arutselvan, V.B.S. Chauhan, R. Muthuraj, C. Mohan, E.R. Harish, Mahesh Tengli (CAUCI, Umiam), Ashok Chhetri (CAU, Imphal), R Sasikumar (NEHU, Tura))

Eri silk worm rearing on cassava: An experiment conducted by Eri Basic Seed Farm, Muga Eri Silkworm Seed Organization, Central Silk Board at Assam indicated that Eri silk worm rearing on cassava variety Sree Reksha was a remunerative enterprise in Assam. From one acre of cassava, 6000 kg leaves are produced in a year, which is adequate for rearing of 400 dfls. A net profit of ₹ 60,000 was realised through Eri silk worm rearing using ICAR-CTCRI variety Sree Reksha.

Conducting FLDs of biofortified sweet potato Bhu Sona and Bhu Krishna in Meghalaya and Tripura: A total of 43 FLDs with biofortified sweet potato varieties viz., Bhu Sona and Bhu Krishna were established in two districts of Meghalaya and one district of Tripura (one cent per FLD). The village and district-wise details of FLDs (i) Tripura-Gandhacherra village-10 nos.; Bolkhali village-10 nos.; Karnamaipara village-3 nos. and Meghalaya-10 each in Wahkhen village, East Khasi Hills and Wadagokgre village, Garo Hills districts. Among the FLDs conducted in four locations in Tripura, biofortified sweet potato variety, Bhu Krishna had higher tuber yield of 10.94 t ha^{-1}, which was significantly higher than Bhu Sona (8.78 t ha^{-1}) ($t=2.467$; $p<0.01$) (Fig. 67).

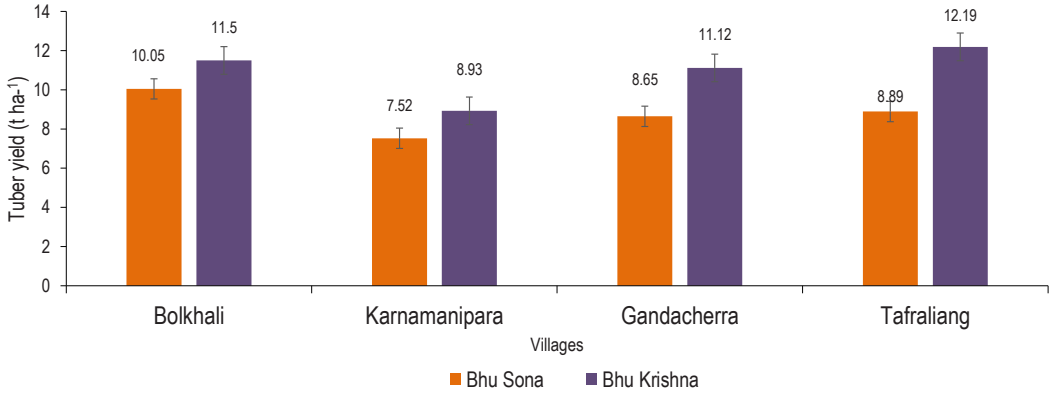


Fig. 67. Tuber yield of biofortified sweet potato varieties in Tripura

Establishment of nutriseed villages: Five nutriseed villages of biofortified sweet potato varieties viz., Bhu Sona and Bhu Krishna were established – Tripura-3 (Gandhacherra, Bolkhali and Karnamanipara villages in Dhalai district); Meghalaya-2 (Wahkhen village, East Khasi Hills and Wadagokgre village, Garo Hills districts); Assam-1 (Hajongbari village, Kamrup district). Area under sweet potato under these FLDs–0.6 acre per village under the homestead-based system. From these villages, 10 farmers were identified as nutriseed farmers and enrolled into DSM seed scheme of ICAR-CTCRI.

Externally Aided Projects

Crop Improvement

1. **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 (PPV&FRA), New Delhi; Lead Centre PI: Kalidas Pati)

Twentyone taro and 18 elephant foot yam reference lines were planted in the field gene bank at Regional Station, ICAR-CTCRI, Bhubaneswar, Odisha. Test report of two candidate varieties of taro (Guchedar and Narendra Ghuiya) has been submitted to the PPV&FRA, New Delhi. Newly received two candidate varieties of taro from PPV&FRA (Giddi Mudli and Phoola Mudli) were planted for testing. Pre-harvest unique characteristics of each reference line for taro and elephant foot yam have been identified and recorded. For taro, characters like plant height and type, leaf shape and colour and petiole colour, tuber shape and colour etc. were considered for updating the DUS data. In the case of elephant foot yam, characters like plant height, leaflet shape and size, petiole texture, rachis pattern, corm shape and weight, cormel shape, etc. were considered for updating the DUS data. The progress report was reviewed by Dr. Trilochan Mohapatra, Chairman, PPV&FRA, New Delhi during the Regional Workshop on PPV&FRA Act, 2001 and Exhibition of Agro-biodiversity on 12 May 2023 at ICAR-National Rice Research Institute, Cuttack, Odisha. During the exhibition, different DUS characters of both taro and elephant foot yam were showcased.

2. **Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in yam bean and greater yam** (PPV&FRA, New Delhi; Lead Centre PI: M.N. Sheela; Co-PI: J. Sreekumar)

The field gene bank of reference varieties of greater yam (461) and yam bean (4) are being conserved in the field. The DUS testing guidelines have been developed and published in the PPV&FRA website. For the DUS testing of greater yam, 20 characteristics were selected, of which five characteristics, viz., petiole colour, leaf shape, tuber shape, tuber cortex colour and tuber flesh colour, were identified as grouping traits. The database of the reference/released varieties of greater yam was prepared based on DUS test guidelines. Two greater yam varieties and one lesser yam variety received from farmers were multiplied and evaluated to facilitate registration.

3. **Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in yam bean and greater yam** (PPV&FRA, New Delhi; Collaborating Centre PI: Kalidas Pati)

The field gene bank with 14 varieties of greater yam including seven reference lines and seven lines received from ICAR-Central Island Agricultural Research Institute, Port Blair and 10 yam bean reference lines are being maintained at the Regional Station, ICAR-CTCRI, Bhubaneswar, Odisha. The pre-harvest characteristics of each reference line for greater yam and yam bean have been identified and recorded. Progress report was reviewed by Dr. Trilochan Mohapatra, Chairman, PPV&FRA, New Delhi during the Regional Workshop on PPV&FRA Act, 2001 and Exhibition of Agro-biodiversity on 12 May 2023 at ICAR-National Rice Research Institute, Cuttack, Odisha. Different DUS characters of both the crops were showcased during the exhibition.

4. **Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in sweet potato and cassava** (PPV&FRA, New Delhi; Lead Centre PI: M.N. Sheela; 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.

The database of the reference/released varieties of cassava was prepared based on DUS test guidelines. The applications for registration of eight extant cassava varieties and two sweet potato varieties were prepared. DUS trials were conducted with two farmer's varieties each of cassava and sweet potato.

5. **Establishment of varietal gene bank and development of standards of DUS testing for varietal gene bank in sweet potato and cassava** (PPV&FRA, New Delhi; Collaborating Centre PI: Kalidas Pati)

The field gene bank with 43 reference lines of sweet potato and 17 lines of cassava are being maintained at the Regional Station, ICAR-CTCRI, Bhubaneswar, Odisha. All the pre-harvest characters like vine pigmentation, vine length of internode, leaf shape and colour for sweet potato and all the pre-harvest characters of cassava like leaf colour, plant height, type and canopy were recorded for updating the DUS data reference varieties. Progress report was reviewed by Dr. Trilochan Mohapatra, Chairman, PPV&FRA, New Delhi during Regional Workshop on PPV&FRA Act, 2001 and Exhibition of Agro-biodiversity on 12 May 2023 at ICAR-National Rice Research Institute, Cuttack, Odisha. Different DUS characters of sweet potato and cassava were showcased during the exhibition.

6. **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)

A total of 18188 hybrid seeds from controlled crosses were received from CIP, Peru through ICAR-NBPGR in June 2018. Germinated ones from these 18188 seeds were evaluated in five batches. A total of 105 hybrids were selected based on flesh colour (orange) and dry matter. Preliminary yield trials of 119 selected hybrids from last batch of seeds were done during kharif 2023. The experiment was laid out in augmented design in the upland with two controls, Sree Kanaka and Bhu Sona. The yield ranged between 25 g and 500 g plant^{-1} with 678/36 having dark orange flesh producing the highest yield of 500 g plant^{-1}. Anthocyanin and total carotenoids were estimated in tubers of 25 selected lines and carotene content ranged between 0.1 and 20 mg 100g^{-1} FW. The dark orange-fleshed sweet potato hybrid H-43/31 had H-value of 21^{o} and carotenoid content of 20.43 mg100g^{-1} FW. An android mobile app 'Colorgrab', was used to measure the carotenoid content of tubers in the orange-fleshed hybrids based on the HSV (Hue, saturation and value) provided by the app, which is indicative of the flesh colour and could be correlated with the biochemically determined carotenoid content. The H component between 20-25^{o} indicated dark orange flesh with carotenoid content between 20-10 mg 100g^{-1} FW. Increase in H component indicated a reduction of orange colour, which can be correlated with decreasing carotenoid values, provided V component is kept constant between 80-90%. The S component decreases with increase in H.

7. **ICAR-Bioversity International & 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, S. Sunitha and T. Makeshkumar; Co-PIs: G. Byju, K.I. Asha, K.M. Senthilkumar, P. Murugesan and R. Muthuraj)

Five elite cassava varieties viz., Sree Reksha, Sree Sakthi, Sree Suvarna, PDP-CMR-1 and 8S-501(Sree Kaveri) with resistance to cassava mosaic disease caused by ICMV and SLCMV were established *in vitro*, multiplied through micropropagation and 397 virus free cultures were developed.

A field experiment was laid out with seven CMD-resistant varieties to evaluate the early bulking nature. All the varieties were superior to the standard check, short-duration variety Vellayani Hraswa. D-48 produced the highest yield (60.49 t ha^{-1}), followed by D-143 and D-174, and was resistant to CMD. Another experiment was conducted with 16 genotypes, including short duration (6 months) varieties (Vellayani Hraswa, Sree Jaya and Sree Vijaya) as check varieties. The agronomic traits were recorded at monthly intervals from the fifth month onwards. The genotype 19S 6-4 indicated good tuber bulking even at five months with a tuber yield of 11.89 kg plant^{-1} in the sixth month.

A field experiment was laid out at ICAR-CTCRI, Thiruvananthapuram during August 2022 to June 2023, to evaluate the drought tolerance of cassava varieties and to work out the water use efficiency under two production systems viz., rainfed and irrigated. Eight CMD resistant genotypes of cassava viz., Sree Reksha (V_1), Sree Sakthi (V_2), PDP-CMR-1 (V_3), CTS-247 (V_4), KBH-18 (V_5), CTS-17 (19S-6-4) (V_6), 8S501-2 (V_7), and CTS-48 (V_8) were included in the study as main plot treatments in split plot design and two production systems as subplots. The drip system provided supplemental irrigation at the rate of 100% crop evapotranspiration. Periodical growth observations and biomass partitioning were recorded at two-month intervals. At six months, the leaf retention percentage was higher in all cassava varieties under irrigated conditions than under rainfed conditions, except V_3, which showed 14% more leaf retention under rainfed cultivation. V_3, V_5 and V_8 showed comparable or more leaf retention, indicating its drought tolerance at six months. At harvest, tuber yield ranged from 44.18 (KBH-18) to 85.29 t ha^{-1} (CTS-17) under irrigated conditions and 24.90 (Sree Sakthi) to 70.88 t ha^{-1} (PDP-CMR-1) under rainfed conditions. The tuber yield was comparable for V_3, V_4, V_5, and V_8 under both irrigated and rainfed conditions, indicating its drought tolerance and greater water use efficiency. All the varieties were resistant to cassava mosaic disease. PDP-CMR-1 had the highest water use efficiency and drought tolerance among the varieties tested.

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

A rapid and reliable method for total RNA extraction from sweet potato leaves was standardized. RNA isolation and cDNA synthesis was done for five genotypes of sweet potato, Bhu Sona, H-526/7, Kanjanghad local, Sree Kanaka and SD-11 at 10-days interval for two seasons. Fourteen primers for photoresponsive tuberization gene including housekeeping gene were validated in all the cDNA using RT PCR. Field trial was done with all the above genotypes during kharif season and observations were recorded on vegetative as well as tuber characters at 10-days interval during this year. The tuberization was initiated between 14-20th day and 526/7, SD-11 and Sree Kanaka tuberized in all seasons. Bhu Sona showed poor tuberization and Kanjanghad local produced pencil roots. Primer designing, DNA isolation and wet-lab validation for allele mining of photoresponsive tuberization gene was done. For *in vitro* tuberization, nodal explants were inoculated in ten media combination with ABA and BAP (2 mg l^{-1}) along with IAA (0.02-0.08 mg l^{-1}) with different sucrose concentration (3-8%) and different photoperiods (13-16 hours).

9. *In vitro* quality planting material production of tuber crops to meet the demand of Odisha (RKVY, Dept. of Agriculture & Farmers' Welfare, Govt. of Odisha; PI: V.B.S. Chauhan; Co-PIs: K. Kalidas Pati, K. Hanume Gowda and M. Nedunchezhiyan)

Production of quality planting material and farmers training: Tissue cultured disease free plants of sweet potato varieties, Bhu Krishna, Bhu Sona; taro variety, Muktakeshi; yam variety, Orissa elite and cassava variety, Sree Jaya were maintained in net house and further planted in field for multiplication. Tissue culture plantlets of sweet potato (Generation-0) varieties, Bhu Krishna and Bhu Sona were produced (1000+1000) and maintained in the net house. In field nursery (Generation-1), 5 lakhs vines were produced and given to the farmers. Two hundred kg of tubers of greater yam (Orissa Elite) and 100 kg tubers of taro (Muktakeshi) were produced in net house from tissue culture plantlets (G-0). In field nursery (G-1), 500 kg yam (Orissa Elite) and 200 kg taro (Muktakeshi) were produced.

Skill oriented training to farmers: Training programme on 'Agro-techniques and production of quality planting material of tuber crops' was conducted at Tikabali and Raikia in Kandhamal district of Odisha. Planting materials of tuber crops were also distributed to the farmers. A total of 228 numbers of farmers participated in the training programme.

10. Collection and database creation of important named landraces of tuber crops from southern districts of Kerala (Kerala State Biodiversity Board, Thiruvananthapuram, Kerala; PI: K.I. Asha; Co-PIs: M.N. Sheela, A. Asha Devi, Shirly Raichal Anil and N. Krishna Radhika)

Twelve collection trips were carried out in the selected districts viz., Thiruvananthapuram, Kollam and Pathanamthitta and 131 accessions of important landraces comprising cassava (106), sweet potato (5), greater yam (6), taro (9) and elephant foot yam (5) were collected.

The important landraces collected includes *Arumasakkappa*, *Pannivella*, *Kantharippadappan*, *Kochangamuttan*, *Njarukku, Noorumuttan, Velichadi, Singapore vella, Chuvappan, Vella ethakka, Padachi, Karutha Singapore, Vellakkambu, Manjacheeni, Manjamutta, Kaavikkambu, Njarukkupacha, Manguzhathan, Block kappa, Vella noorumuttan, Pardappunoorumuttan, Karuppan, Vella kaliyan, Karutha kaliyan, Singapore karuppu, Kanjirappally kappa, Kozhivalan, Plavella, Block vella, Block chuvappu, Ethakkavella, Ummancheeni, Ethan kappa, Karutha malayan, Vella malayan, Malayan, Manjavariyan, Arumasachuvappan, Pacha malayan, Arumasakaruppan, Manja anakkomban, Chuvalathandan, Karutha kashaladi, Kariyilaporiyan, Malavella, Chuvappan, Kashalachadi, Mananthavadi, Kariyan, Manja noorumuttan, Ullichuvala, Golden pachi, Palavella, Pachakkambu, Karinjarukku, Ettumasachuvappan, Thanduchuvappan, Njarukkuvella, Konnikkambu, Chuvappan, Ummanvella, Karutha Malabar, Pulladukappa* and *Arumasachuvalathandan* in cassava; *Chuvappunadan, Bhadrakali chuvala* and *Kochuvattayilayan* in sweet potato; *Amakkachil, Neelakkachil, Injikkachil, Pulingodankachil* and *Cheruvallikachil* in greater yam; *Thamarakkananchembu, Karimchembu, Chuttichembu* and *Nadan chembu* in taro as well as *Neyychena* and *Nadanchena* in elephant foot yam.

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 major objectives were to evaluate organic, inorganic and integrated management practices in cropping systems involving tuber crops, to evaluate the response of greater yam varieties to organic production system, to develop integrated organic farming system involving tuber crops and to conduct geo-referenced on-farm characterization of natural farmers. Besides cluster-based demonstration of organic package under SCSP and on-station and farmer participatory evaluation of natural farming in cassava-based cropping systems are ongoing.

Evaluation of organic, inorganic and integrated management practices in cropping systems involving tuber crops: The results of the seventh season experiment indicated that among the systems, cassava-vegetable cowpea and cassava-groundnut under 100% organic were productive (tuber equivalent yield of 28.39 t ha^{-1} and 24.97 t ha^{-1}, respectively) and remunerative (net income of ₹ 4,55,313 ha^{-1} and ₹ 454,756 $ha^{-1}$and B:C ratio of 2.15 and 2.55, respectively). The production efficiency and energy equivalent of these systems were also highest under 100% organic (Table 13).

Evaluation of response of different varieties of greater yam to organic farming: The first year results indicated that the four varieties of greater yam evaluated viz., Sree Keerthi, Sree Karthika, Da-340, Orissa Elite, did not vary significantly under organic mode. Of these, Orissa Elite (8.62 t ha^{-1}) and Da-340 (8.40 t ha^{-1}) yielded higher with higher net returns of ₹ 124,395 and ₹ 113,416 per ha respectively.

Geo-referenced on-farm characterization of organic growers: Geo-referenced survey of 30 champion farmers practising natural farming in Thiruvananthapuram district, Kerala was conducted. Most of the surveyed farmers (80%) are members of Bharatiya Prakrithi Krishi Padhati (BPKP) and produce different bioformulations in their farm itself (50%) and sell these inputs through eco-shops and Krishi Bhavans (40%). There was no yield gap in cassava and tuber yield was higher in farmers fields than on-station, as the farmers used other organic manures in addition to natural farming manures.

Development of integrated organic farming system (IOFS) model: Tuber equivalent yield of 41.78 tons and net returns of ₹ 3,27,108 could be obtained from tuber crops based integrated farming system from an area of 75 cents.

Table 13. Productivity and economics of cropping systems under various management options

Crop/ Management options	Cassava-Vegetable cowpea			Cassava-Groundnut		
	TEY (t ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio	TEY (t ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
100% Organic (without premium)	28.39	455313	2.15	24.97	454756	2.55
100% Organic (with premium)	28.39	604112	2.52	24.97	579591	2.97
50% Organic + Innovative practice (without premium)	18.32	178450	1.48	16.71	208695	1.71
50% Organic + Innovative practice (with premium)	18.32	276244	1.74	16.71	292247	2.00
100% Inorganic	16.58	246579	1.98	11.13	89191	1.36
State (PoP)	14.45	171680	1.66	11.53	101886	1.42
50% Organic + 50% Inorganic	20.51	292629	1.91	17.99	238388	1.79
25% Organic + 25% Inorganic + Innovative practice	21.40	240247	1.60	15.51	138001	1.42

TEY : Tuber equivalent yield

Evaluation of natural farming in cassava (on-station): The field experiment to evaluate natural farming practices (NF) in cassava+vegetable cowpea-green gram system was continued for the second season with nine treatments replicated thrice in RBD. The treatments were T_1: control, T_2: complete NF (application of *Bheejamrit*, *Ghanajeevamrit* and *Jeevamrit* (BGJ) + crop residue mulching (CR) + intercropping (IC) + whapasa), T_3: NF-1 (without BGJ), T_4: NF-2 (without CR), T_5: NF-3 (without IC), $T_{6:}$ NF-4 (without whapsa), $T_{7:}$ AINPOF Package, T_8: Integrated crop management (ICM-1), T_9: ICM-2. In the second season of NF experimentation, in cassava, both the integrated crop management (ICM) practices produced significantly higher yield (44.25 t ha^{-1} and 43.69 t ha^{-1} respectively), followed by organic (AINPOF) package (31.91 t ha^{-1}) (Table 14). The natural farming practices were inferior. The yield of the intercrop vegetable cowpea (bushy type) was highest in natural farming without whapasa (2541.23 kg ha^{-1}) and that of green gram in ICM-1 (160.84 kg ha^{-1}). Significantly highest tuber equivalent yield (44.92 t ha^{-1}and 44.26 t ha^{-1}) and production efficiency (124.78 and 122.94 kg ha^{-1}) were also obtained in ICM practices. The experiment is ongoing for the third season for conclusive results and confirmation.

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: K. Laxminarayana; Co-PIs: M. Nedunchezhiyan, R. Arutselvan, M.S. Sajeev and B.B. Das)

The project is implemented in 100 farmer's fields each in two districts of Odisha (Kuliana (53 nos.), Bangriposi (47 nos.) blocks of Mayurbhanj district and Kolnara (34 nos.), Rayagada (12 nos.) Bissamcuttack (43 nos.) and Muniguda blocks (11

Table 14. 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	15590		90.02	15970	44.36
T_2	Complete NF	17660	2180.35	120.03	25420	70.62
T_3	NF-1 (Without BGJ)	18640	2121.75	125.33	26240	72.89
T_4	NF-2 (Without CR)	17690	2287.37	151.23	25950	72.08
T_5	NF-3 (Without IC)	28940		143.63	29540	82.06
T_6	NF-4 (Without whapasa)	23170	2541.23	98.82	32050	89.03
T_7	AINPOF Package	31910		91.22	32290	89.70
T_8	Integrated-1	44250		160.84	44920	124.78
T_9	Integrated-2	43690		136.83	44260	122.94
	CD (0.05)	11613		NS	10322	28.672

nos.) of Rayagada district for the second year during 2023-24 with the tuber crops (cassava, yam, elephant foot yam, yam bean and taro). Eight capacity building training programmes on production and value addition of biofortified tuber crops in different villages of Rayagada and Mayurbhanj districts were organised during 01-07 February and 08-15 June 2023, respectively. Pesticides (Imidacloprid and SAAF) were distributed to individual farmers and sprayed. Monitored the intercultural activities. Selected three farmers representing Kuliana and Bangriposi blocks of Mayurbhanj district and four farmers from Muniguda, Bissamcuttack, Rayagada and Kolnara blocks of Rayagada district, Odisha as Decentralized Seed Multipliers.

13. Establishment of Biotech-KISAN hub at DBT-ILS, Bhubaneswar for carrying out activities in tribal districts of Odisha (DBT-ILS, Govt. of India; PI: Rajeeb K. Swain, DBT-ILS, Co-PIs: M. Nedunchezhiyan, G.C. Acharya, ICAR-IIHR (CHES) and J.K. Sundaray, ICAR-CIFA

A five-day 'Capacity building training programme on production and post-harvest technology in horticultural and tuber crops' was organized during 16-20 January 2023 to the farmers of Koraput and Nabarangpur at the Regional Centre of ICAR-CTCRI, Bhubaneswar. Dr. N.K. Krishna Kumar, Chairman, RAC & Former DDG (Hort.) was the Chief Guest and Dr. Archana Mukherjee, former Director, ICAR-CTCRI was the Guest of Honour for the programme One day training programme on 'Production and value addition of biofortified tuber crops' was organized at Nabarangpur on 20 February 2023 and at Borigumma, Koraput on 21 February 2023. A five-day 'Value addition and entrepreneurship development in tuber crops' was organized during 20-24 March 2023 to the farmers of Koraput and Nabarangpur at the Regional Centre of ICAR-CTCRI, Bhubaneswar. About 1.5 lakh vine cuttings of biofortified sweet potato varieties (Bhu Sona 75000 cuttings and Bhu Krishna 75000 cuttings) and 5000 stems of cassava var. Sree Jaya were distributed to 20 farmers in Koraput district and 20 farmers in Nabarangpur district during 2023.

14. Rural bioresource complex for tubers and millets in Kandhamal, Odisha: (DBT-KIIT, Govt. of India; PI: Vishakha Raina, School of Biotechnology, KIIT DU; Co-PIs: M. Nedunchezhiyan, (Sandeep Kumar Panda and Mrutunjay Suar, KIIT DU)

A three-day training programme on 'Value addition in tuber crops' was organized during 18-20 December 2023 at Raikia, Kandhamal district in Odisha. Sixty women farmers of SHG groups participated in the training programme.

Crop Protection

15. ICAR-CRP on vaccines and diagnostics: Development and application of diagnostics to viruses infecting tropical tuber crops (ICAR-CRP on Vaccines and Diagnostics; PI: T. Makeshkumar; Co-PIs: M.L.Jeeva, R. Arutselvan and R. Muthuraj)

Validation of SLCMV LAMP PCR: The efficiency of the LAMP primers in detecting SLCMV from infected cassava leaf samples was validated. All the tested samples and positive control showed a ladder like amplicon pattern, which is characteristic to LAMP PCR, indicating the presence of SLCMV. The negative control did not show any amplicons. The sensitivity of the primers was also checked. The primers had a detection limit of 10 ng of viral DNA. The efficiency of the LAMP primers in detecting SLCMV from asymptomatic samples needs to be evaluated further.

Evaluation of DsMV DAC-ELISA and counter confirmation by PCR: The DsMV DAC – ELISA kit developed was evaluated for its efficiency in detecting infected samples from field. In ELISA, a total of 51 samples were evaluated, out of which 41 were positive and 10 were negative. The results were cross checked by PCR using DsMV specific primer sets DsMV 9F/9R and RPA 1F/1R. It was found that out of 51 samples, 44 were positive and 7 were negative. The three samples that were negative in ELISA was positive in PCR. However, the band intensity was too low for those samples, indicating lower viral load, which could be the reason for negative result in ELISA. The developed kit was released during the National Symposium on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR) held during 28-29 November 2023 at ICAR–CTCRI and was send for further evaluation at different laboratories.

Analyzing efficiency of newly synthesized GNP for lateral flow immune-assay based detection of DsMV: Gold nanoparticles (GNPs) were synthesized as per Turkevich method by reduction of

tetrachloroauric acid using trisodium citrate dihydrate.The gold nanoparticles (GNPs) synthesized were send for TEM analysis at ICAR-Indian Institute of Horticultural Research, Bangalore, for size confirmation and uniformity (Fig. 68). The images showed that the developed gold nanoparticles were of almost uniform size (20 – 30 nm size). The synthesized GNPs were conjugated to the antibody raised against DsMV coat protein. The GNP – antibody conjugate was used for developing lateral flow dipsticks. The efficiency of the strip was checked using diluted sap from infected plant. Both the test and control lines lit up for positive sample, whereas only test line lit up for negative sample. The sensitivity of the developed strip was further assessed using infected plant sap dilutions ranging from 1:10 to 1:40. It was found that the detection limit of the strip was 1:30 sap dilutions.

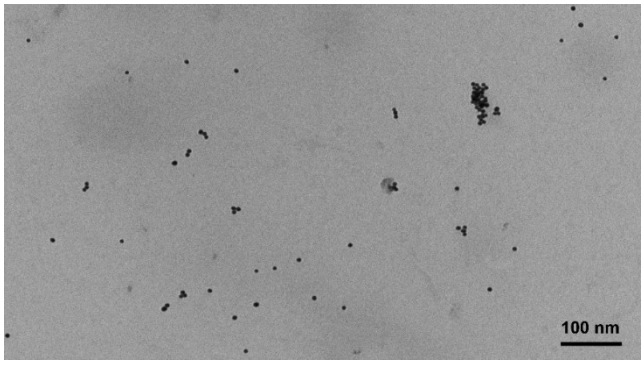


Fig. 68. TEM image of gold nano particles

16. Establishment of Plant Health Clinic (PHC) at ICAR-CTCRI, Regional Station, Odisha (National Horticulture Mission (NHM), Directorate of Horticulture, Govt. of Odisha; PI: R. Arutselvan; Co-PIs: Kalidas Pati and V.B.S. Chauhan)

New disease report on *Lasiodiplodia theobromae* causing leaf blight in sweet potato: The fungal pathogen *Lasiodiplodia theobromae* was isolated successfully from sweet potato leaf blight affected plants. Following the successful isolation of the pathogen, two distinct fungal isolates were obtained and designated as SP-LS-1 and SP-LS-4. To further characterize these isolates, partial sequences of their internal transcribed spacer 1 (ITS-1 and ITS-4) were obtained. These ITS-1 and ITS-4 sequences were then submitted to the National Centre for Biotechnology Information (NCBI), and the GenBank accession numbers OQ955288 and OR069483 were assigned, respectively.

New disease report on bacterial storage rot affecting elephant foot yam: The bacterium causing soft rot in elephant foot yam was isolated from the bacterial ooze using nutrient agar medium, at 27°C. The colony characteristics, including size, pigmentation, form, margin, and elevation of the isolate was studied. Morphological attributes, such as cell shape and arrangement, were identified through gram staining. Biochemical test kit (KB001) identified the soft rot bacteria as *Pectobacterium* spp. DNA samples were tested with *Pectobacterium*-specific primers, producing the expected amplicon (~1500 bp). NCBI blast analysis showed a 100% similarity to *Pectobacterium carotovora*. The 16S ribosomal RNA gene of *Pectobacterium carotovorum* isolate PC1 is documented in NCBI under accession number OR675420.

Crop Utilization

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: C. Pradeepika)

Postharvest wound and heat stress experiments were carried out in sweet potato using three different wounding patterns (shredded and circular cut) at different temperatures (30, 35, and 40°C) at constant relative humidity of 95%. The effect of sequential application of wound and heat stress on total soluble phenolics as well as antioxidant activities (DPPH and ABTS based antioxidant activities) of sweet potato was evaluated. Wound and heat stress increased total soluble phenolic content and antioxidant activity due to upregulation of pentose phosphate pathway.

18. Development of smart foods, biocomposites, green packaging, and bioenergy from agro-residues (NASF, ICAR, Govt. of India, PI: M.S. Sajeev; Co-PIs: T. Krishnakumar, A.N. Jyothi and S.S. Veena)

Starch was extracted from cassava stems (with/without pith (WP/WOP)) of different varieties viz., Sree Reksha, Sree Pavithra, Vellayani Hraswa and M-4. The starch was analysed for purity, biochemical, functional, rheological, viscometric and colour characteristics. Hydrophobic modification of starch through octenyl succinylation and hydroxypropylation by using octenyl succinic anhydride and propylene

oxide, respectively was carried out and viscometric properties of the modified starches were analysed. The properties of the modified starches were studied. The modified starches were granulated with plasticisers and polybutylene terephthalate (PBT) and compounding were done to use it for the production of biodegradable films. The hygroscopic properties of the native starch-PBT based films were studied.

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

Modification of a prototype of the current continuous type cassava peeler was made to enhance the feeding mechanism and include a high-pressure water supply above the peeling knife to prevent the knife from choking while peeling. A compact design was achieved by redesigning the continuous cassava peeler (Fig. 69). The peeling process of cassava tubers is facilitated by a complex system of flexible, self-adjusting circular blades. The developed continuous type cassava peeler has the capacity of peeling completely 500 to 750 cassava tubers per hour. It is easy and safe to operate and requires less power (1HP). The overall dimensions of the developed cassava peeler are 0.95 (H) × 0.69 (W) × 0.65 (L) m and total weight of the unit is 75 kg and requires an operating area of 3 m^2.

Fig. 69. Continuous type cassava peeler

20. 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 and P. Prakash)

The water, starch and sago samples collected from six sago factories were analyzed for quality parameters including microbial analysis and residual chloride, sulphate and phosphate contents. An experiment was conducted in the factory site on the wet storage of cassava starch without the use of chemicals and the samples collected at different intervals were analyzed for the quality parameters set by FSSAI. The critical control points and their levels were identified in the starch and sago production process and the first draft of the Hazard Analysis and Critical Control Point (HACCP) and Standard Operating Procedure (SOP) were prepared and submitted to SAGOSERVE.

21. Cassava custard (Contract Research Project, KCM Agri Clinic, Tirunelveli, Tamil Nadu; PI: C. Pradeepika; Co-PIs: A.N. Jyothi and M.S. Sajeev)

The project was aimed at developing cassava starch-based custard powder and optimize the ingredient levels, formulations and processing conditions. A comparative study has been planned to use starch from selected cassava varieties to understand the consistency in product quality and to analyze the product for physicochemical, cooking and functional properties. The project was initiated in November 2023 and the preliminary studies on custard formulation using cassava starch and studying the rheology along with proximate and functional properties are in progress with control samples.

22. 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 and C. Pradeepika).

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

Extension and Social Sciences

23. IP & TM scheme: National Agricultural Innovation Fund (NAIF) component I: Innovation Fund (ICAR, New Delhi; PI: P. Sethuraman Sivakumar; Co-PIs: Sheela Immanuel, R. Muthuraj and P. Prakash)

IP Portfolio management

Patent activities include the filing of one patent titled 'An apparatus for peeling an agricultural product' with the patent application number 202341088486, filed on 23 December 2023. Additionally, progress is underway for the e-Crop Based Smart Fertigation System (eCBSFS), and a hearing is scheduled for the Electronic Crop patent application number 1388/CHE/2014 filed on 17 September 2014.

Technology commercialization

Revenue from technology commercialization comprised ₹796,500 from licensing five technologies, ₹1,330,894 from two contract research agreements, and one consultancy service.

Technology promotion programmes

Participated in or organized three technology promotion events for startups/MSME (i) One day 'Technology Conclave & Technology Expo' organized by the Kerala Startup Mission at KMEA Engineering College, Aluva on 10 May 2023, where 450 students participated (ii) 'Bio-Connect 2023'-Kerala Industrial Conclave on Life Sciences during 25-26 May 2023, where 560 startups, academics, MSME and students participated (iii) ICAR Foundation Day exhibition on 16-17 July 2023 and (iv) G-20 spouses visit IARI campus on 09 September 2023.

An IP awareness programme was conducted during the World Intellectual Property Day at ICAR-CTCRI, Thiruvananthapuram on the topic 'Women and IP: Accelerating Innovation and Creativity' on 26 April 2023. Sixty scientists and students participated in the event.

24. IP & TM scheme: National Agricultural Innovation Fund (NAIF) component II: Incubation Fund (ICAR, New Delhi; PI: P. Sethuraman Sivakumar; Co-PIs: Sheela Immanuel, M. Nedunchezhiyan, M.S. Sajeev, Saravanan Raju, R. Muthuraj, P. Prakash and T. Krishnakumar)

Incubatee enrolment

A. Startups

During this year, three new startups were entrolled as incubatees in ICAR-CTCRI-Agri-Business Incubator (Table 15)

Table 15. Details of startups enrolled

Sl. No.	Startups	Date of enrollment	Details
1.	M/s Micro Nutrich Private Limited	22 June 2023	1/88, Palayakarar Street, Panapakkam, Tiruvallur, Tamil Nadu
2.	M/s Cropnrich Agri Private Ltd.	17 November 2023	MP-III-126/A, Cheruvanasseri Building, Pariyaram PO, Kalpetta, Wayanad, Kerala
3.	M/s J.J. Agencies	03 December 2023	15/454 Kunnanvila, Vattavila PO, Neyyattinkara, Thiruvananthapuram, Kerala

B. Agripreneurs enrolled

Under the Nutriseed Village Scheme, 43 farmers were included as seed entrepreneurs, hailing from various regions: Kallakurichi, Tamil Nadu (15); Attapadi, Kerala (5); Dhalai, Tripura (13); and Kamrup, Assam (10). These farmers are actively involved in the production of quality planting material of biofortified sweet potato varieties (Bhu Sona, Bhu Krishna, Bhu Ja, Bhu Kanti) and industrial varieties of cassava (Sree Athulya, Sree Reksha, and Sree Kaveri). They received technical and business mentoring from the ICAR-CTCRI ABI or the Satellite Incubation Centre including market facilitation (three farmers) through DSM scheme of ICAR-CTCRI.

Collaborations established

A Memorandum of Agreement was signed with M/s Micronutrich, Chennai on 18 December 2023 for value chain mentoring of biofortified tuber crops. Under this agreement, ICAR-CTCRI will extend knowledge sharing on biofortified sweet potato, credit and market facilitation and business mentoring for M/s Micronutrich Ltd. on mutually agreed terms and conditions for a period of five years.

EDP programmes organised

During this year, four EDPs were organized and a total of 890 aspiring entrepreneurs, startups participated (Table 16)

Table 16. Details of EDPs organized

Sl. No.	Name of programme	Date of programme	No.of partici-pants	Type of participants
1	Stakeholders Meeting - Scaling up Biofortified Tuber Crops	16 June 2023	172	Agripreneurs, Development workers
2	Webinar - Business Opportunities in Tuber Crop Processing in Odisha under Mukhyamantri Krushi Udyoga Yojana	04 October 2023	200	Startups and MSMEs
3	Product Launch-cum-Stakeholders Workshop on Strategies for Commercialization of Biofortified Crops	18 December 2023	95	Startups, Policy makers, International agencies
4	EDP on Biofortified Sweet potato (Four no in Meghalaya and Tripura)	December 2023	423	Agripreneurs and Development professionals

Business mentoring services were provided for the development of Detailed Project Reports (DPRs) focused on Tuber Crops based Value Chain and Entrepreneurship Development during the FPPP Masters training Phase II at SAMETI, Thiruvananthapuram (02.06.2023), KVK, Wayanad (15.06.2023), and KVK, Thiruvalla (20.06.2023).

Incubated startups/agripreneurs collectively generated a revenue of ₹ 148,800, with startups contributing ₹ 66,500 and agripreneurs contributing ₹ 82,300. Additionally, the ICAR-CTCRI generated revenue amounting to ₹ 82,750 through product sales and ABI enrolment fees.

25. **Development of smart solutions for managing biotic and abiotic stresses in cassava, sweet potato and taro through artificial intelligence** (DST-agrotech; PI: V.S. Santhosh Mithra; Co-PIs: G. Byju, T. Makeshkumar, M.S. Sajeev and E.R. Harish)

About 516062 images of cassava, 1565555 images of taro, and 1410540 images of sweet potato were collected (Table 17). Subsequently, convolutional neural network (CNN) models were devised to forecast soil nutrient levels using leaf images from cassava, sweet potato and taro plants.

Table 17. Images collected in tuber crops for smart solutions

a. Cassava

Attributes	No. of images trained	Accuracy	No. of classes
N	2072	97.03	3
P	2768	96.67	4
K	4584	75.33	7
Ca	3472	66.00	4
Mg	4361	78.17	5
S	2251	97.17	3
Fe	6544	67.33	7
Zn	3156	91.5	4
Cu	5623	74.0	8
B	2816	98.0	5
Cassava mosaic disease	1833	95.5	2

b. Taro

Attributes	No. of images trained	Accuracy	No. of classes
N	1986	94.33	3
P	2759	72.33	4
K	7343	76.00	7
TLB	3955	95.83	2

c. Sweet potato

Attributes	No. of images trained	Accuracy	No. of classes
N	1774	99.50	3
P	2613	66.83	4
K	2599	86.50	7

Artificial Intelligence (AI) models to predict biotic and abiotic stresses: CNN models using deep learning technology were developed to predict levels of nutrients in soil/diseases from leaf images of cassava, sweet potato and taro.

A deep learning CNN model was created to predict cassava yield based on leaf images captured at various stages of growth (months) (Table 18). The model was trained using 5659 images and could successfully predict 15 yield classes (t ha^{-1}) with an accuracy of 48%. Additionally, a taro leaf blight (TLB) forecasting model was developed utilizing predictive analysis techniques and the XGBoost algorithm. This model takes inputs such as months after planting, minimum

Table 18. CNN models developed using deep learning technology

Sl. No.	Name of the model	Input	Attribute predicted
1.	Cs_N	Cassava leaf image	Soil N (kg ha^{-1})
2.	Cs_P	Cassava leaf image	Soil P (kg ha^{-1})
3.	Cs_K	Cassava leaf image	Soil K (kg ha^{-1})
4.	Cs_Ca	Cassava leaf image	Soil Ca (kg ha^{-1})
5.	Cs_Mg	Cassava leaf image	Soil Mg (kg ha^{-1})
6.	Cs_S	Cassava leaf image	Soil S (kg ha^{-1})
7.	Cs_Fe	Cassava leaf image	Soil Fe (kg ha^{-1})
8.	Cs_Zn	Cassava leaf image	Soil Zn (kg ha^{-1})
9	Cs_Cu	Cassava leaf image	Soil Cu (kg ha^{-1})
10.	Cs_B	Cassava leaf image	Soil B (kg ha^{-1})
11.	T_N	Taro leaf image	Soil N (kg ha^{-1})
12.	T_P	Taro leaf image	Soil P (kg ha^{-1})
13.	T_K	Taro leaf image	Soil K (kg ha^{-1})
14.	Sp_N	Sweetpotato leaf image	Soil N (kg ha^{-1})
15	Sp_P	Sweetpotato leaf image	Soil P (kg ha^{-1})
16	Sp_K	Sweetpotato leaf image	Soil K (kg ha^{-1})
17.	Cs_CMD	Cassava leaf image	Cassava mosaic disease
18.	T_TLB	Taro leaf image	Taro leaf blight

temperature (°C), mean temperature (°C), relative humidity (%), and wind speed (m s^{-1}). It forecasts the percentage disease index (PDI) of TLB with an accuracy of 53%.

26. 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)

On-farm validation of Site-Specific Nutrient Management (SSNM) involving customized fertilizers and micronol and organic farming technologies were conducted in 10 coconut gardens of 50 cents each in cassava and elephant foot yam in Pollachi taluk, Coimbatore, Tamil Nadu. Farmers were supplied with elite and quality planting materials of improved varieties of tuber crops viz., Sree Pavithra in cassava and Gajendra in elephant foot yam for planting in coconut gardens and critical inputs as per the recommendations. A training programme, on 'Intercropping of tuber crops in coconut gardens' was organized on 17 August 2023 at the office of Department of Agriculture, Pollachi, for the benefit of 60 farmers. Farmers were trained on SSNM and organic farming technologies for profitable cultivation of tuber crops in coconut gardens.

Data on growth parameters, pests and disease incidence and yield of tuber crops viz., cassava and elephant foot yam were recorded. Soil samples were collected from all the selected coconut gardens and the chemical properties were analyzed for SSNM and organic farming demonstrations. The effect of different treatments on tuber yield of cassava and elephant foot yam (Fig. 70) under SSNM vs package of practices (PoP) vs farmer's practice (FP) revealed that SSNM resulted in higher yield over FP (by 36.54%) and PoP (by 28.39%). In elephant foot yam, SSNM performed better than FP by yielding 25.56% higher and PoP by 9.80% more.

The effect of different treatments on tuber yield of cassava and elephant foot yam under organic farming (OF) vs package of practices (PoP) vs farmer's practice (FP) is given in Fig. 70. In cassava, OF yielded higher over FP by 33.86% and PoP by 11.64%. In elephant foot yam, OF yielded higher over FP by 12.73% and PoP by 13.80% (Fig. 71).

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

Under this initiative, the Institute acquired two AGRIBOT – DUO spray drones from India. Two Institute staff members obtained certification from the Directorate General of Civil Aviation (DGCA) approved training agency, "Garuda Aerospace" located in Thalambur, OMR, Chennai, for piloting small category rotorcraft/RPAS drones. A total of 370 demonstrations were conducted across various locations in Kerala and Tamil Nadu. Seminars were organized to educate the farmers about the advantages of smart farming and drone utilization. Spraying operations were conducted in the fields of rice, banana, Chinese potato, cassava, taro, and maize. Specifically, nano urea, 19:19:10; Micronol: Tapioca special; Micronol: Chinese potato special; and Micronol: Taro special, were applied over an area of 149, 17, 172, 30, and 2.0 hectares respectively.

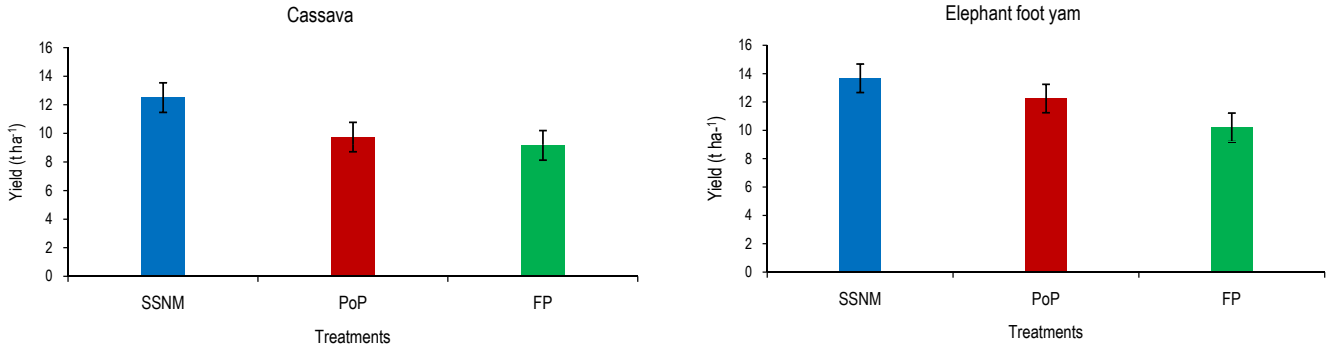


Fig. 70. Productivity of tuber crops under SSNM vs PoP vs FP

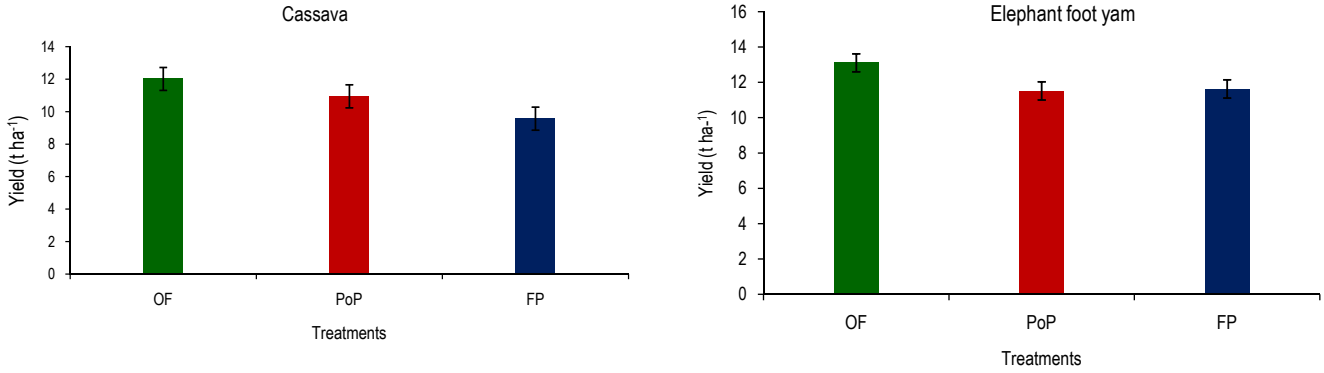


Fig. 71. Productivity of tuber crops under OF vs PoP vs FP

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

The All India Coordinated Research Project on Tuber crops (AICRP TC) functioning since 1968 has twenty one centres spread over 18 states and one union territory covering north-eastern, eastern, western and southern parts of India (Fig.72).The main aim of the project is generating region specific value added varieties, agronomic and production system technologies, pest and disease management strategies and popularisation of tuber crops varieties and technologies for improving the productivity.

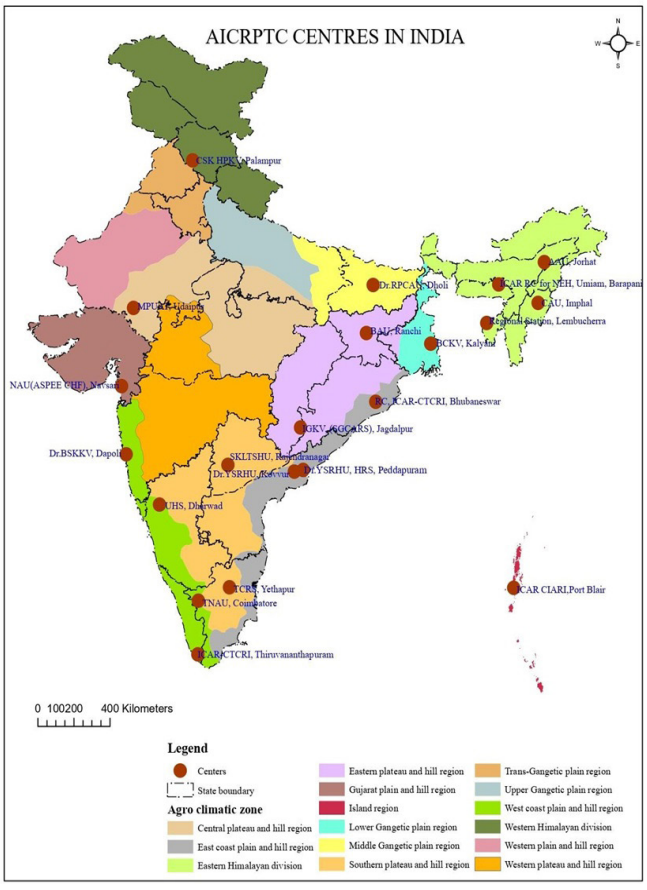


Fig. 72. AICRP TC centres at different agro-climatic zones

Varieties recommended for release

Three varieties of cassava, four varieties each of greater yam and taro, one variety of elephant foot yam and three varieties of dasheen taro were recommended for release in different states for higher yield. The important traits of the 15 varieties recommended for release is given in Table 19.

Table 19. Important traits of varieties of tuber crops recommended for release

Sl. No.	Crop and code number	Traits	Recommended states
Cassava			
1.	MNS 41 (TCa 16-5)	Resistant to cassava mosaic disease. Average yield of 40 t ha^{-1} and potential yield of 80 t ha^{-1}	Chhattisgarh, Manipur, Tamil Nadu and Andhra Pradesh
2.	MNS 135 (TCa 16-4)	Tolerance to anthracnose disease. Average yield is 42 t ha^{-1}	Maharashtra
3.	MNS 255 (TCa 16-3)	Resistant to cassava mosaic disease. Average yield of 45 t ha^{-1}	Kerala
Greater yam			
4.	TGy 17-6	Average yield of 18-22 t ha^{-1}	Assam and West Bengal
5.	Da 67 (TGy 17-8)	Average yield of 40 t ha^{-1}	Chhattisgarh and Kerala
6.	IKDIO-04-59 (TGy 17-4)	Tolerant to anthracnose disease. Average yield of 28.64 t ha^{-1}	Rajasthan
7.	TGy 17-3	Tolerant to anthracnose disease. Average yield of 28.64 t ha^{-1}	Kerala
Taro			
8.	Tamitin (TTr 17-12)	Moderately resistant to taro leaf blight and taro corm borer. Average yield of 25-28 t ha^{-1}	Bihar, Maharashtra, Jharkhand, Kerala, Tamil Nadu and Tripura
9.	BCC-38	Average yield of 21.50 t ha^{-1}	Assam and Meghalaya
10.	TTr 17-8	Moderately resistant to taro leaf blight and tolerant to water stagnation. Average yield of 20 t ha^{-1}	Assam
11.	C 149 (TTr 17-3)	Tolerant to water logging and moderately resistant to taro leaf blight	Rajasthan

Dasheen taro			
12.	C 4 (TBd 17-4)	Moderately resistant to taro leaf blight and tolerant to water logging.Average yield of 33 t ha^{-1}	Bihar and Jharkhand
13.	C 8 (TBd 17-2)	Moderately resistant to taro leaf blight. Average yield of 26 t ha^{-1}	Chhattisgarh, Assam and Meghalaya
14.	C 7 (TBd 17-3)	Tolerant to water logging and moderately resistant to taro leaf blight	Bihar
Elephant foot yam			
15.	C3	Tolerant to collar rot and moderately tolerant to high moisture stress. Average yield of 45.60 t ha^{-1}	Bihar

Production technologies

- **Customized fertilizers in taro:** Secondary and micronutrient-inclusive customized fertilizers developed for taro are recommended for adoption in the package of practices for Eastern Himalayan region (Assam), Eastern Plateau and Hills Region (West Bengal, Odisha), Middle Gangetic Plains Region (Bihar), and Southern Plateau and Hills Region (Telangana). Keeping in view the availability of secondary and micronutrients from the customized fertilizers and considering its advantage to improve the soil fertility and soil health, the customized fertilizers in taro is also recommended for East Coast Plains and Hills Region (Andhra Pradesh).
- **Customized fertilizers in cassava:** Secondary and micronutrient inclusive customized fertilizers developed for cassava are recommended for adoption in the package of practices for Southern Plateau and Hills Region (Andhra Pradesh and Tamil Nadu).
- **Water saving techniques in cassava:** The treatments (i) drip irrigation at 50% CPE + ground cover sheet (120 gsm) and (ii) drip irrigation at 50% CPE + mulching with crop residues were on par with respect to yield and B:C ratio at Yethapur centre. Hence both are recommended for adoption in the package of practices for Southern Plateau and Hills Region (Tamil Nadu).
- **Organic production technology in cassava:** Considering tuber quality as well as soil quality improvements, organic production technology in cassava is recommended for adoption in the package of practices for Southern Plateau and Hills Region (Andhra Pradesh and Tamil Nadu), and Central Plateau and Hills Region (Chhattisgarh). Farmyard manure (FYM) @ 12.5 t ha^{-1}, *in situ* green manuring, crop residue incorporation, *Azospirillum* @ 3 kg ha^{-1}, phosphobacteria @ 3kg ha^{-1} and K-solubilizer @ 3 kg ha^{-1}) include organic production package.

Protection technologies

- **Management of mealybugs in elephant foot yam corms during storage:** The treatment, dipping of corms in cow dung slurry (2 kg l^{-1}) for 15 minutes followed by shade drying for 24-48 hours and storage in layers for a period of 3 months, is recommended for the management of mealybugs in elephant foot yam corms during storage.
- **Management of postharvest rot in elephant foot yam:** For the management of postharvest rot in elephant foot yam corms stored for seed purpose, single application of combination fungicide containing mancozeb + carbendazim 0.2% by dipping the corms in the solution for 10 minutes, followed by shade drying for 12-24 hours and storage in layers for a period of three months is recommended for inclusion in package of practices for Eastern Plateau and Hills region (West Bengal, Chhattisgarh), Middle Gangetic Plains Region (Bihar, Jharkhand), Western Himalayan Region (Himachal Pradesh), Gujarat Plains and Hills Region (Gujarat), East Coast Plains and Hills Region (Andhra Pradesh), Eastern Himalayan Region (Tripura, Assam), and Central Plateau and Hills Region (Rajasthan).
- For the organic management of postharvest rot in elephant foot yam corms stored for seed purpose, dipping the corms in cow dung slurry enriched with *Trichoderma* @ 5g kg^{-1} of corm for 10 minutes is recommended for inclusion in package of practices for Eastern Plateau and Hills region (West Bengal, Chhattisgarh), Middle Gangetic Plains Region (Bihar, Jharkhand), Western Himalayan Region (Himachal Pradesh), Gujarat Plains and Hills Region (Gujarat), East Coast Plains and Hills Region (Andhra Pradesh),

Eastern Himalayan Region (Tripura, Assam), and Central Plateau and Hills Region (Rajasthan).

Research-Extension interface

Integrated farming system studies involving tuber crops: The demonstrations are in progress in nine states (Tripura, Meghalaya, Assam, Manipur, Jharkhand, Odisha, Chhattisgarh, Himachal Pradesh and Andaman & Nicobar Islands) through AICRP centres. After intervention with Integrated Farming System comprising improved varieties of tuber crops, vegetables, pulses, cereals, fruit crops, piggery, fish culture and poultry resulted in 2-5 fold increase in the net income, 2-3 fold increase in B:C ratio and year round employment opportunities.

IFS model was demonstrated in the field of Shri Sukramani Debbarma, Bhati Fatikchora, Kamalghat, West Tripura. IFS model: Horticulture + piggery + poultry + fishery + duckery was introduced comprising a sustainable and highly productive cropping sequence with high yielding vegetable varieties to increase the cropping intensity to 195 and productivity to about 25 t ha^{-1}, and high value livestock namely, fishery, piggery, duckery, poultry and cattle. After intervention of improved technologies in the integrated farming system based on high yielding vegetables and livestock, productivity of vegetable crops increased from 15 t ha^{-1} to 25 t ha^{-1}, meet production of pig increased from 55 kg to 150 kg, backyard poultry with improved breeds increased annual egg production from only 55 eggs $year^{-1}$ to 130 eggs $year^{-1}$, and fish production increased from 120 kg $year^{-1}$ to 270 kg $year^{-1}$. Adoption of IFS technology increased the annual gross income from ₹ 93,100 to ₹ 2,16,500 with B:C ratio of 2.7.

Planting material production and distribution

Planting materials of improved varieties of tuber crops were multiplied and distributed to farmers by all the centres. The centres produced a total of 1,88,423 stems of cassava, 96,020 vine cuttings of sweet potato, 29 tons of elephant foot yam corms, 10 tons of taro cormels, 2 tons of greater yam tubers, 1.86 tons of lesser yam tubers, 1.10 tons of dasheen taro corms, 1 ton of arrow root, 615 kg of yam bean seed, 300 kg of tannia cormels and 210 kg of aerial yam tubers as part of planting material production programme.

23rd Annual Group Meeting of AICRP on Tuber Crops

The 23rd Annual Group Meeting (AGM) of All India Coordinated Research Project on Tuber Crops (AICRP TC) was organized during 10-12 May 2023 at Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani, West Bengal. Dr. A.K. Singh, Deputy Director General (DDG), Horticultural Science, ICAR, New Delhi was the Chief Guest and inaugurated the meeting. Dr. S.B. Goswami, Vice Chancellor, BCKV; Dr. S.K. Chakrabarti, Vice Chancellor, Uttar Banga Krishi Viswavidyalaya (UBKV), West Bengal; Dr. Sudhakar Pandey, Assistant Director General (ADG), FVS & MP, ICAR; Dr. G. Byju, Director, ICAR-CTCRI; Dr. G.C. Hazra, Director of Research, BCKV; Dr. Jayanta Tarafdar, Professor & AICRP TC-in-Charge, BCKV and Heads of Divisions/Sections/ Regional Station, ICAR-CTCRI and BCKV officials attended the inaugural function. Scientists from 21 different centres spread across 18 states and Andaman & Nicobar Islands presented important achievements of 39 different programmes undertaken during 2022-23 and made concrete recommendations in six technical sessions as well as in plenary session. Plan of action for 2023-23 were also discussed and finalized. A stake-holders interface was also organized as a part of the three days programme.

Important highlights

- Recommendation for the release 15 new varieties of different tuber crops for various traits.
- Recommendation for inclusion in package of practices for different agro-eco-zones
  1. Customized fertilizers for cassava and taro
  2. Organic production technology for cassava
  3. Water saving technique in cassava
  4. Management of postharvest rot in elephant foot yam by organic and chemical means

Summary of general recommendations

1. Characterization of germplasm at different centers need to be unified by using same DUS/ NBPGR/APGRI descriptors by all centres. First part of catalogues of major crops will be brought out by December 2023.
2. Development of core collections of major crops in each centre need to be completed by March 2024.

3. The originating centres of 15 entries recommended for release will take immediate steps for release of the varieties. All scientist(s) involved in IET, URT and MLT of each entry recommended for release will be duly given credit as co-developers of the variety even if it is not recommended for the state where his/her centre exists.
4. All centres will take immediate steps to include the 8 crop production/protection technologies in the package of practices of the respective ACZ (states). All scientist(s) involved will be duly given credit as co-developers of the technology even if it is not recommended for the state where his/her centre exists.
5. The principal developer of the above 15 lines and 8 crop production/protection technologies will consolidate and analyze data and prepare and submit manuscripts of research papers in high impact journals for publication by December 2023.
6. Planting material production need to be strengthened by minisett techniques in cassava, yams, elephant foot yam and taro by centres, and possibility of large-scale multiplication using tissue culture techniques need to be explored at CTCRI HQ.
7. Decentralized seed multipliers (DSM) will have to be identified and got registered by all centres (minimum of five DSM by each centre every year) to meet the demand of quality planting materials by farmers. The details of the farms including geo-coordinates need to be collected and reported during mid-term review during November-December 2023.
8. The test variety will be the same for all centres in all future trials on agrotechniques.
9. While presenting the data, the units of parameters should be uniform across all centres.
10. While presenting pooled analysis, season 1 and 2 data and results of pooled analysis should be presented as per SOP and detailed technical programme.
11. A midterm review meeting will be conducted during November-December 2023 to review the progress of work by all centres.
12. A brainstorming session on elephant foot yam will be organized by HRS, Kovvur centre during 2023.

Technologies Assessed, Transferred, Consultancy and Patent Services

Technologies transferred

The Intellectual Property and Technology Management Unit & Professional Services 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 during 2023.

Technology commercialization

Technology licensed

1. MoA was signed with the Uzhavoor Mythri Farmer Producer Company Limited, Pullickal Kavala, Vazhoor on 01 March 2023 to transfer the technology for commercial production of fried snack foods from cassava for an amount of ₹ 29,500.
2. Technology on fried snack foods and fried chips from cassava was licenced to M/s Madappally Block Vanitha Food Processing Industrial Co-Operative Society Ltd. No. S.IND (K) 342, Madappally Block, Changanacherry, Kottayam, Kerala by signing MoA on 12 April 2023 for an amount of ₹ 29,500.
3. Technology on fried snack foods and fried chips from cassava was licenced to M/s Dnalife Private Limited, PVR Arcade, Lumbini Avenue, Gachibowli, Hyderabad, Telangana by signing MoA on 15 May 2023 for an amount of ₹ 29,500.
4. Three bio-formulations with pesticidal action developed from cassava crop residues were commercialized to M/s Green Edge Agri Imports Pvt. Ltd., No.31, Ganapathy Nagar, Ariyamangalam, Tiruchirappalli, Tamil Nadu by signing MoA on 22 June 2023 for an amount of ₹ 5,90,000.
5. ICAR-CTCRI signed MoA with M/s Entryway Shipping and Logistics Pvt Ltd., MIV CFS Admin Building, Vallarpadam, Cochin, Kerala on 27 July 2023 to transfer the technology of wax coating of cassava tubers to extend shelf life for an amount of ₹ 29,500.
6. Technology on Chinese potato foliar micronutrients 'Micronol' was licensed to M/s Linga Chemicals, Madurai, Tamil Nadu on 04 September 2023 for an amount of ₹ 1,18,000.

Professional services

Contract research

1. MoU was signed with M/s KCM Agri Clinic, Sivanthi Patti Road, Thiagaraja Nagar, Maharaja Nagar, Tamil Nadu for contract research on 'Development of cassava custard' on 03 May 2023 for an amount of ₹ 8,26,320.
2. A contract research project on 'Development of value-added products from *Mudali* (*Colocasia esculenta*) and *Kone* (*Dioscorea*)' was signed on 22 July 2023 with an NGO, M/s Spudnik Foods, Bengaluru, Karnataka for an amount of ₹ 6,48,174.

Consultancy service

1. MoU signed with M/s Xobu Foods and Beverages Private Limited, Bhagyodaya Apartments, Vidya Nagar, Rajahmundry East Godavari, Andhra Pradesh for consultancy service in 'Development of biofortified sweet potato value chain for industrial production in Telangana, Karnataka & Odisha' on 28 November 2023 for an amount of ₹ 6,82,720.

Patent filed

1. Patent application was filed for an apparatus for peeling an agricultural product (Inventors: Krishnakumar, T. and Sajeev, M.S.; Patent application No.: 202341088486) on 23 December 2023.

Technologies certified by ICAR

1. e-Crop Based Smart Farming (Lead Developer: V.S. Santhosh Mithra; Associate Developers: G. Byju, J. Sreekumar and D. Jaganathan)

2. Methodology for measurement of pith density of cassava stem for assessment of drought tolerance (Lead Developer: A.V.V. Koundinya; Associate Developers: B.R. Ajeesh, N. Sai Lekshmi, Vivek Hegde and M.N. Sheela)
3. Drought tolerance index scale for cassava (Lead Developer: A.V.V. Koundinya; Associate Developers: B.R. Ajeesh, N. Sai Lekshmi, Vivek Hegde and M.N. Sheela)
4. Multi-micronutrient formulation for Chinese potato (Lead Developer: G. Byju; Associate Developers: D. Jaganathan and R. Muthuraj)
5. Package of practices for organic production of cassava (Lead Developer: G. Suja; Associate Developers: A.R. Seena Radhakrishnan, P. Subramanian, R. Surekha, D. Jaganathan and G. Byju)
6. Wax coating for fresh cassava tubers: Improving preservation and enhanced shelf-life (Lead Developer: Saravanan Raju)
7. Power operated size based Chinese potato grader (Lead Developer: T. Krishnakumar; Associate Developers: M.S. Sajeev, C. Pradeepika, R. Muthuraj and D. Jaganathan)
8. Methodology on assessing factors influencing adoption (Lead Developer: P. Prakash; Associate Developers: Pramod Kumar, Amit Kar and Awani Kumar Singh)

Revenue generated at the Institute is indicated in Table 20.

Table 20. Revenue generated through technology commercialization and other professional service functions

Sl. No.	Activity	Revenue generated (₹)
1.	Technology licensing	826000
2.	Sale of technological products, machineries and value-added products	3829087
3.	ABI incubatee companies	148800
4.	Consultancy and contract research	1330894
5.	Students fees	373441
6.	Sale of products and ABI enrolment fee	82750
7.	Training/exposure visit programme	173453
	Total	**6764425**

Varieties released/submitted for release

a. Released and notified by the Centre

1. Sree Kaveri: a CMD resistant variety, resistant to both *Indian cassava mosaic virus* and *Sri Lankan cassava mosaic virus,* developed from an inbred (S_2) line, was released centrally for the states of Kerala, Tamil Nadu and Andhra Pradesh.

b. Released by State

1. Sree Hira: A new elite variety of taro has been released for Odisha through SVRC, Odisha.
2. Sree Telia: A new short duration variety of taro has been released for Odisha through SVRC, Odisha.

c. Submitted for release

1. Anthocyanin rich purple flesh biofortified sweet potato hybrid SPH-31 (IC650535) has been submitted to SVRC Odisha during 2023 for release in Odisha in the name Sree Arunima.
2. High yielding variety of yam bean YBH-3x8 (IC650536) has been submitted to SVRC Odisha during 2023 for release in Odisha in the name Sree Chandrika.

Education and Training

Education

ICAR-CTCRI is the approved Research Centre of University of Kerala and Kannur University, Kerala; Manonmaniam Sundaranar University, Tamil Nadu; Utkal University and Odisha University of Agriculture and Technology, Odisha and Jawaharlal Nehru Krishi Viswavidyalaya, Jabalpur, Madhya Pradesh, for undertaking Ph.D. programmes on tuber crops. During the period, the Institute has offered exposure trainings to students and imparted technical guidance to Ph.D. programmes and project work of M.Sc. students. Besides, the scientists of ICAR-CTCRI have handled courses at College of Agriculture, Vellayani for the students of B.Sc.-M.Sc. (Integrated) Biotechnology.

Sl. No.	Particulars of the programme	Number of students/ scholars
1.	B.Sc./B.Tech project work	132
2.	M.Sc./B.Sc.-M.Sc. (Integrated) Biotechnology project work	44
4.	Ph.D.	22

M.Sc./B.Sc. - M.Sc. (Integrated) Biotechnology Projects

Sl. No	Student name	Subject, College and University	Thesis title	Name of the guide
1.	Mr. Akshay Kumar	M.Sc. (Ag.) Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar	Evaluation and characterization of sweet potato (*Ipomoea batatas* (L.) Lam) germplasm	Dr. V.B.S. Chauhan Mr. K.Hanume Gowda
2.	Ms. Maria Joji	M.Sc. Biotechnology, St. Berchmans College, Changanassery, MG University, Kerala	A CRISPR/Cas9 based approach targeting *gbss* gene in cassava (*Manihot esculenta* Crantz)	Dr. N. Krishna Radhika
3.	Ms. A.R. Roja	M.Sc. Biotechnology, Mar Thoma College of Science & Technology, Ayur, University of Kerala	Morphological and molecular characterization of sweet potato (*Ipomoea batatas* (L.) Lam.) germplasm	Dr. Shirly Raichal Anil
4.	Mr. L.K. Akilan	M.Sc. Biotechnology, Kerala Agricultural University, Kerala	Particle bombardment mediated genetic transformation in cassava (*Manihot esculenta* Crantz)	Dr. N. Krishna Radhika
5.	Mr. Muragadapu Hari Sankar Sai	M.Sc. (Ag.) Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar	Indirect regeneration and fidelity assessment of yam bean (*Pachyrhizus erosus* L. Urban.)	Dr. Kalidas Pati
6.	Ms. S. Jayalekshmi	M.Sc. Biotechnology, Mar Thoma College of Science & Technology, Ayur, University of Kerala	Bulk segregant analysis for CMD resistance in cassava using markers	Dr. C. Mohan
7.	Ms. S. Lavanya	M.Sc. Biotechnology, Amrita Vishwa Vidya Peetham, Kollam	Identification of molecular markers associated with high starch content in cassava	Dr. C. Mohan

8.	Ms. S. Anagha	M.Sc. Biotechnology, St. Berchmans College, Changanassery, MG University, Kerala	Validation of CMD associated SSR markers in cassava using highly susceptible and resistant progeny	Dr. C. Mohan
9.	Ms. N. Aneesa	M.Sc. Biotechnology, St. Berchmans College, Changanassery, MG University, Kerala	Identification markers associated with high starch content in cassava using SSR and starch gene specific primers	Dr. C. Mohan
10.	Ms. S. Anjana	M.Sc. Botany, KVVS College of Science and Technology, Adoor, University of Kerala	Study on variability for morphological and yield traits of cassava clonal progenies	Dr. C. Visalakshi Chandra
11.	Ms. Devika	M.Sc. Botany, KVVS College of Science and Technology, Adoor, University of Kerala	Study on variability for quantitative and qualitative traits in sweet potato	Dr. C. Visalakshi Chandra
12.	Ms. S. Roshni	M.Sc. Botany, KVVS College of Science and Technology, Adoor, University of Kerala	Morphological characterization of tuber traits of elephant foot yam (*Amorphophallus paeoniifolius* (Dennst). Nicolson) using standard descriptors	Dr. A. Asha Devi
13.	Ms. Jomol John	M.Sc. Botany, KVVS College of Science and Technology, Adoor, University of Kerala	Key genetic traits, seed quality characterization of selected varieties and wild species of sweet potato	Dr. P. Murugesan
14.	Ms. S Sreelakshmi	M.Sc. Biotechnology, Mar Thoma College of Science & Technology, Ayur, University of Kerala	Identification of SSR marker associated with drought tolerance in cassava	Dr. K.M. Senthilkumar
15.	Ms. Anitta Treesa Antony	M.Sc. Biotechnology, St. Berchmans College, Changanassery, MG University, Kerala	Screening and identification of molecular marker associated with drought tolerance in cassava	Dr. K.M. Senthilkumar
16.	Ms. Eleeshwa Shaji	M.Sc. Biotechnology, St. Berchmans College, Changanassery, Mahatma Gandhi University, Kerala	Molecular characterization of lesser yam [*Dioscorea esculenta* (Lour.) Burkill] using Inter Simple Sequence Repeat (ISSR) markers	Dr. T.P. Sujatha
17.	Ms. Rinku Mariam Varghese	M.Sc. Biotechnology, St. Berchmans College, Changanassery, Mahatma Gandhi University, Kerala	Molecular characterization of white Guinea yam (*Dioscorea rotundata* Poir.) using Inter Simple Sequence Repeat (ISSR) markers	Dr. T.P. Sujatha
18.	Ms. V.S. Aiswarya	M. Sc. (Microbiology) Mar Athanasius College (Autonomous) of Arts and Science, Kothamangalam, Ernakulam	Effect of minisett pretreatments on portray nursery of yam	Dr. K. Sunilkumar
19.	Ms. Deva Priya	M.Sc. (Microbiology) Mar Athanasius College (Autonomous) of Arts and Science, Kothamangalam, Ernakulam	Effect of slow-release fertilization characteristics of zeolites on soil enzyme and glomalin parameters	Dr. V. Ramesh
20.	Mr. Tammineni Venkata Sai Kumar	M.Sc. (Ag.) (Soil Science & Agricultural Chemistry)	Effect of different sources and levels of nitrogen on soil fertility and yield performance of elite sweet potato genotypes	Dr. K. Laxminarayana

21.	Ms. Poonam Sai Keerthi	M.Sc. (Ag.) (Soil Science & Agricultural Chemistry)	Response of integrated nutrient management on soil fertility, yield and proximate composition of greater yam in Alfisols	Dr. K. Laxminarayana
22.	Ms. M. Afeefa	M.Sc. Microbiology Indira Gandhi College of Arts and Science, Nellikuzhy, Kothamangalam M.G. University, Kottayam	Diversity of micro-arthropods and microbes in tuber crop fields	Dr. E.R. Harish
23.	Ms. K.A. Aleena	M.Sc. Microbiology M.E.S. M.K. Mackar Pillay College for Advance Studies, Aluva M.G. University, Kottayam	Protocol standardization to test the pathogenicity of *Fusarium* species causing cassava stem or root rot	Dr. M.L. Jeeva
24.	Ms. R. Praveena	M.Sc. Microbiology Mar Athanasius College, Kothamangalam M.G. University, Kottayam	Mining the efficacy of *Trichoderma* against *Fusarium falciforme* causing cassava stem and root rot	Dr. M.L. Jeeva
25.	Ms. C.P. Nihala Fabin	M.Sc. Microbiology Indira Gandhi College of Arts and Science, Kothamangalam M.G. University, Kottayam	Efficacy of biocontrol soil bacteria against *Fusarium* species associated with cassava stem and root rot pathogen	Dr. M.L. Jeeva
26.	Ms. M. Lakshmi	M.Sc. Microbiology M.E.S. M.K. Mackar Pillay College for Advance Studies, Aluva, M.G. University, Kottayam	Bioefficacy of botanicals on *Fusarium* associated with the cassava stem and root rot	Dr. M.L. Jeeva
27.	Athira K. Jayan	M.Sc. Biotechnology Bishop Heber College, Tiruchirappalli, Tamil Nadu, Bharathidasan University, Tiruchirappalli	Comparison of leaf protein isolation protocol from different wild *Ipomoea* spp. and bioassay of protein against sweet potato weevil	Dr. B.G. Sangeetha
28.	Ms. Kesya Mary Reji	M.Sc. Microbiology M.E.S. M. K Mackar Pillay College for Advanced Studies, Edathala, Aluva M.G. University, Kottayam	Utilization of bacterial isolates for growth promotion and pathogen suppression	Dr. S.S. Veena
29.	Mrs. Sruthi Sunil	M.Sc. Microbiology M.E.S.M.K Mackar Pillay College for Advanced Studies, Edathala, Aluva M.G. University, Kottayam	Antifungal activity of *Trichoderma* against *Sclerotium rolfsii*, the causal agent of collar rot disease in elephant foot yam	Dr. S.S. Veena
30.	Ms. P. Neethu Krishna	M.Sc. Microbiology Indira Gandhi College of Arts and Science, Nellikuzhy, Kothamangalam M.G. University, Kottayam	Exploration of oil cakes for pathogen suppression and as media for bioagent multiplication	Dr. S.S. Veena
31.	Ms. V.A. Athulya	B.Sc.-M.Sc. Integrated Biotechnology, Kerala Agricultural University	Role of microbes in the management of cassava mosaic disease	Dr. T. Makeshkumar
32.	Ms. S. Anjana	M.Sc. Botany and Plant Science Technology National Institute of Plant Science Technology M.G. University, Kottayam	Diagnosis of elephant foot yam Dasheen mosaic virus through serological and molecular methods	Dr. T. Makeshkumar

33.	Mr. Senigarapu Srinath	M.Sc. Plant Biotechnology Mar Athanasios College for Advanced Studies, M.G. University, Kottayam	Diagnosis of sweet potato feathery mottle virus using serological and molecular methods	Dr. T. Makeshkumar
34.	Mr. C. Abdu Raheem	M.Sc. Food Science &Technology, D.G.M.M.E.S Mampad College, Malappuram, Kerala	Study on starch-protein interactions on the physicochemical and functional properties of cassava starch	Dr. A.N. Jyothi
35.	Mr. K. Afeef Thahir	M.Sc. Food Science & Technology, D.G.M.M.E.S Mampad College, Malappuram, Kerala	Development of resistant starch enriched cassava flour by complexation with plant and animal proteins and its utilization in pasta making	Dr. A.N. Jyothi
36.	Ms. A. K. Athira	M.Sc. Food Technology and Quality Assurance, MAR Athanasios College for Advance Studies (MACFAST), Thiruvalla, Pathanamthitta, Kerala	Development of sweet potato and bajra based choco-filled cookies	Dr. C. Pradeepika
37.	Ms. K. Athulya	M.Sc. Food Technology and Quality Assurance, College of Indigenous Food Technology (CFT-K), CFRD, Konni, Pathanamthitta, Kerala	Investigation of nutritional, functional and rheological properties of sweet potato and barnyard millet composite flours based noodles	Dr. C. Pradeepika
38.	Ms. K. Sruthilaya Raj	M.Sc. Food Science & Technology, Calicut University Campus, Thenhipalam, Malappuram, Kerala	Investigation of nutritional, functional and rheological properties of low-calorie cookies from sweet potato and pearl millet-based composite flours	Dr. C. Pradeepika
39.	Mr. Shahasin K. Moideen	M.Sc. Food Science & Technology, D.G.M.M.E.S Mampad College, Malappuram, Kerala	Development of sweet potato and sorghum thin cookies	Dr. C. Pradeepika
40.	Mr. Ajay Sajeev	M.Sc. Food Technology and Quality Assurance, Mount Royal College, Munnar, Kerala	Development of TPS from cassava starch-bees wax composites	Dr. M.S. Sajeev
41.	Mr. P.P. Muhammed Shameem	M.Sc. Food Science & Technology, D.G.M.M.E.S Mampad College, Malappuram, Kerala	Development of rice analogue from cassava-pearl millet based composite flour	Dr. M.S. Sajeev
42.	Ms. Athira Unnikrishnan	M.Sc. Food Technology and Qulity Assurance, CFRD, Konni, Pathanamthitta, Kerala	Development of pasta from cassava-pearl millet-soy based composite flour	Dr. M.S. Sajeev
43.	Ms. P. Laksmi Priya	M.Sc. Food Technology and Quality Assurance, MACFAST, Thiruvalla, Pathanamthitta, Kerala	Development of rice analogue from cassava-barn yard millet based composite flour by cold extrusion	Dr. M.S. Sajeev
44.	Mr. P.A. Ansa	M.Sc. Food Technology and Quality Assurance, MACFAST, Thiruvalla, Pathanamthitta, Kerala	Development of cookies from cassava and finger millet based composite flour	Dr. M.S. Sajeev

Training Programmes

A total of 5916 farmers, 105 students and 703 officials and other stakeholders from different parts of the country had undergone training at ICAR-CTCRI. They were trained on the recent technologies of tuber crops for enhancing productivity and profitability in farming.

On-campus training programmes

Sl. No.	Particulars of training	Date	Details of participants
1.	Production technologies of tuber crops	31 January 2023 to 01 February 2023	25 start-ups/entrepreneurs
2.	Tuber crops cultivation, processing and value addition	27 February 2023	40 farmers each from Pandalam, Pathanamthitta District and Manathavady, Wayanad District
3.	Tuber crops cultivation	15 March 2023	40 farmers from Adoor, Pathanamthitta, Kerala
4.	Statistics for data analysis	20-24 March 2023	06 technical staff of the Institute (One technical staff from each Division/Section)
5.	Internship on the topic Business aspirations of youth involved in tuber crops	01-28 March 2023	01 student from Malankara Catholic College, Kaliyikavilai, Tamil Nadu
6.	IP awareness programme on World Intellectual Property Day-Women and IP: Accelerating Innovation and Creativity	26 April 2023	95 participants from across the country
7.	Improved technologies of tropical tuber crops	23-26 May 2023	02 SMSs of KVK, Chandrapur, Maharashtra
8.	Improved technologies of tropical tuber crops	25 May 2023	30 farmers from Kilimanoor, Thiruvananthapuram
9.	Improved technologies of tropical tuber crops	08 June 2023	40 farmers from Thiruvallam, Krishi Bhavan, Thiruvananthapuram
10.	Training for the Kerala Administrative Service officer trainees	16 June 2023	110 KAS officer trainees
11.	Improved technologies of tropical tuber crops in collaboration with Department of Horticulture, Govt. of Tamil Nadu	21-23 June 2023	10 progressive farmers from Salem district of Tamil Nadu
12.	Improved technologies of sweet potato and Chinese potato	26-27 June 2023	13 tribal women under ATMA Interstate exposure visit in collaboration with KVK, Chandrapur, Maharashtra
13.	Internship training on Improved technologies of tuber crops	12 June-07 July 2023.	06 third year B.Sc. Hons. (Agriculture) students from VIT, Vellore, Tamil Nadu
14.	Improved technologies and value addition in tropical tuber crops	08 August 2023	130 Kudumbashree members
		14 August 2023	110 Kudumbashree members
		18 August 2023	90 Kudumbashree members
		22 August 2023	91 Kudumbashree members
		05 September 2023	100 Kudumbashree members
15.	Agrotechniques and value addition in tropical tuber crops in collaboration with VFPCK, Govt. of Kerala	10-11August 2023	28 farmers from Thiruvananthapuram
16.	Value added products for entrepreneurship development in tuber crops	12 July 2023	26 farmers from ATMA, Cherthala, Alappuzha
17.	Value added products for entrepreneurship development in tuber crops sponsored by KIEDS, Govt. of Kerala	31 July 2023	23 farmers of Thiruvananthapuram
18.	Value added products for entrepreneurship development in tuber crops	16 August 2023	32 participants from FPO Pala, Kottayam

19.	New varieties of cassava and improved technologies in cassava	07 September 2023	200 farmers from Nagercoil, Kanyakumari District, Tamil Nadu
20.	Training to improved technologies of tuber crops and micronol application through drone in cassava	08 September.2023	170 farmers of Nagercoil and Manveli of Kanyakumari District, Tamil Nadu
21.	Value added products for entrepreneurship development in tuber crops	13 September 2023	23 participants from KVK, Kottayam
22.	Value added products for entrepreneurship development in tuber crops	22 September 2023	25 participants from DIC, Kollam and Kottayam in Kerala
23.	Agrotechniques and value addition in tropical tuber crops in collaboration with VFPCK, Govt. of Kerala	19 October 2023	28 farmers from Kerala
24.	Agrotechniques and value addition in tropical tuber crops in collaboration with VFPCK, Govt. of Kerala	02 November 2023	28 farmers from Kerala
25.	Improved technologies of tropical tuber crops	16 October 2023 to 17 November 2023	12 RAWE students of ITM University, Gwalior, Madhya Pradesh
26.	Advances in quality planting material production of tropical tuber crops	20-22 November 2023	09 participants from Kerala
27.	Soil, plant and water analysis for efficient nutrient management	18-22 December 2023	15 participants from Kerala
28.	Tapioca production and value addition in collaboration with Department of Horticulture, Govt. of Tamil Nadu	21-22 December 2023	45 farmers from Tamil Nadu

On-campus training programmes by Techno Incubation Centre

Sl. No.	Particulars of training	Date	Details of participants
1.	Value addition and entrepreneurship development in tuber crops	03-09 January 2023	20 aspiring entrepreneurs from Kerala
		17 January 2023	22 farmers from ATMA, Chathannoor, Kollam, Kerala
		19 January 2023	35 aspiring entrepreneurs from Kerala
		20 January 2023	18 entrepreneurs from Kerala
		25 January 2023	29 farmers from RATTC, Kazhakoottam, Thiruvananthapuram
		27 January 2023	28 farmers from ATMA Madappalli, Kottayam, Kerala
2.	Value addition and entrepreneurship development in tuber crops	07 February 2023	29 aspiring entrepreneurs from Kerala
		09 February 2023	50 farmers from Kattakada, Kerala
		06 March 2023	16 farmers from FPOs Kottayam, SFAC, Kottayam
		06 March 2023	28 farmers from Karakkonam, Tamil Nadu
3.	Tuber crops-based snack foods and pasta	11 May 2023	24 entrepreneurs from different districts of Kerala
		22 May 2023	25 entrepreneurs from Kottayam, Kerala
4.	Value addition and entrepreneurship development in tuber crops	08-09 June 2023	27 aspiring entrepreneurs from Thrissur, Kerala
		13 June 2023	47 aspiring entrepreneurs from Kollam, Kerala
5.	Value addition and entrepreneurship development in tuber crops	27 June 2023	21 entrepreneurs from Kottayam, Kerala
6.	Value added products for entrepreneurship development in tuber crops	12 July 2023	26 farmers from ATMA, Cherthala, Alappuzha, Kerala
		31 July 2023	26 entrepreneurs from Ernakulam, Kerala
		16 August 2023	32 farmers from FPO Pala, Kottayam, Kerala
		13 September 2023	23 farmers, KVK, Kottayam, Kerala
7.	Demonstrations on Value added products preparation	08, 11, 14, 18 and 22 August 05 September 2023	550 SHG members, Kudumbasree, Thiruvananthapuram, Kerala

8.	Value added products for entrepreneurship development in tuber crops	22 September 2023	25 entrepreneurs, DIC, Kollam and Kottayam, Kerala
9.	Value addition and entrepreneurship development in tuber crops	06 October 2023	16 engineering students from KCAET, Tavanur, Malappuram, Kerala
		12 October 2023	26 farmers, KADS DCL, Thodupuzha, Idukki, Kerala
		18 October 2023	20 entrepreneurs from different districts of Kerala
		28 October 2023	18 entrepreneurs from Kottayam, Kerala
10.	Value addition and entrepreneurship development in tuber crops	14 November 2023	34 farmers, Krishi Bhavan, Pathanapuram, Kollam, Kerala
		16 November 2023	30 farmers, Krishi Bhavan, Chathannoor, Kollam, Kerala
		06 December 2023	02 farmers, Krishi Bhavan, Kollam, Kerala
		18 December 2023	23 farmers from Profugo Real FPO, Wayanad, Kerala
		20 December 2023	16 entrepreneurs, College of Agriculture, Vellanikkara, Trissur, Kerala
		22 December 2023	34 farmers from Puthukotai district, Tamil Nadu

Off-campus training programmes

Sl. No.	Particulars of training	Date	Details of participants
1.	Training and demonstrations on improved varieties and technologies of cassava	21 February 2023 & 23 February 2023	50 farmers of Agatti Islands and 43 farmers of Kavaratti Islands, Lakshadweep
2.	Improved technologies of tropical tuber crops in collaboration with Department of Agriculture, Kilimanoor, Govt. of Kerala	25 May 2023	30 farmers of Thiruvananthapuram
3.	Smart vilavinu Smart Krishi	27 May 2023	100 farmers, ATMA, Wayanad and Krishibhavan, Ambalavayal
4.	Tuber crops seed village - farmers training and distribution of planting materials	02 June 2023	44 farmers of Venganoor, Gramapanchayath
5.	Nutrition awareness programme on biofortified tuber crops for school children and launching of SCHOOL CONNECT programme	16 June 2023	56 participants of Agali, Palakkad
6.	Stakeholders' meeting on Scaling up biofortified tuber crops for achieving nutritional security	16 June 2023	171 farmers of Attapadi
7.	Business pitching for technology development incubation	15 May 2023 20 May 2023 23 May 2023 20 June 2023	100 participants from KVK, Thrissur, KVK, Kottayam, KVK, Wayanad and KVK, Pathanamthitta
8.	Profitable cultivation of tuber crops in coconut gardens in collaboration with VFPCK, Chenkal, Thiruvananthapuram	16 August 2023	47 farmers of Chenkal
9.	Organic farming in coconut in collaboration with Department of Horticulture, Pollachi, Coimbatore	17 August 2023	54 farmers of Pollachi, Coimbatore
10.	Launching of Tuber crops scheme 2023-24 cum training programme & distribution of critical agricultural inputs under SCSP programme	05 October 2023	150 farmers of Parakkode, Pathanamthitta, Kerala
11.	Training programme on Natural farming under SCSP programme	05 October 2023	100 farmers of Ezhamkulam, Adoor, Pathanamthitta, Kerala

12.	Stakeholders interface programme on Site specific nutrient management in cassava & drone demonstrations for tuber crops	26 October 2023	65 farmers of Namakkal, Tamil Nadu
13.	Awareness-cum-training programme on Provisions of the Protection of Plant Varieties and Farmers Rights (PPVFRA) Act, 2001	26 October 2023	155 farmers of ICAR-KVK, Namakkal, Tamil Nadu
14.	Stakeholders interface programme on Site specific nutrient management in Chinese potato & drone demonstrations for tuber crops	06 November 2023	55 farmers of Pallakal Pothukudi, Tirunelveli
15.	Stakeholders interface programme on Site specific nutrient management in Chinese potato & drone demonstrations for tuber crops	07 November 2023	45 farmers of Govindaperi, Kadayam taluk, Tenkasi
16.	One day training programme on Tuber crops varieties and its conservation	14 December 2023	32 SC farmers from Kilimanoor, Thiruvananthapuram
17.	Farmers workshop cum awareness programme on Biofortified sweet potato	27 December 2023 & 28 December 2023	122 farmers of Wahkhen village, Meghalaya and Wadagokgre village, Garo Hills

Trainings at Regional Station, ICAR-CTCRI, Bhubaneswar

Sl. No.	Particulars of training	Date	Details of participants
1.	Production and postharvest technology in horticultural and tuber crops in collaboration with ICAR-IIHR-CHES, Bhubaneswar	16-20 January 2023	15 farmers each from Koraput and Nabarangpur districts of Odisha
2.	Production and value addition in tropical tuber crops under MIDH project	01 February 2023 02 February 2023 06 February 023 07 February 2023	280 farmers from different districts of Odisha
3.	Production and value addition of biofortified tuber crops	20 February 2023 21 February 2023	100 farmers from Koraput district of Odisha
4.	Scientific methods of cultivation, nutrient management and value addition in tuber crops under MIDH Programme	09 March 2023 10 March 2023	36 farmers of Jagatsinghpur district of Odisha
5.	Agrotechniques and production of quality planting materials of tuber crops	14-15 March 2023	228 farmers of Kandhamal district of Odisha
6.	Value addition in tuber crops under AICRP TC-SCSP	19 March 2023 22 March 2023	100 farmers of Jaipur district of Odisha
7.	Production and post-harvest technology in horticultural and tuber crops	20-24 March 2023	15 farmers from Koraput and 15 farmers from Nabarangpur, Odisha
8.	Production and value addition in tuber crops under MIDH project	08 June 2023 09 June 2023 14 June 2023 15 June 2023	240 farmers from different districts of Odisha
9.	Crop diversification with tuber crops	20 August 2023 21 August 2023 28 September 2023 29 September 2023	242 farmers from different districts of Odisha
10.	Interaction meeting with the beneficiary farmers and to monitor the tuber crops demonstration	17-18 November 2023	100 farmers from different blocks of Rayagada district

11.	Interaction meeting with the beneficiary farmers and to monitor the tuber crops demonstration	20-21 November 2023	100 farmers from Bangriposi and Kuliana blocks of Mayurbhanj district, Odisha
12.	Tropical tuber crops technologies for livelihood improvement and commercial farming	03 November 2023 & 07 November 2023	18 participants from College of Agricultural Engineering and Technology, OUAT, Bhubaneswar
13.	Production and value addition in tuber crops in the interstate exposure visit under ATMA	07 November 2023	19 farmers from Anakapalli, Visakhapatnam and Manyam districts of Andhra Pradesh
14.	10th Indigenous Seed and Food Festival	02 December 2023	500 participants from Sambalpur, Odisha
15.	Value addition in tuber crops	02 December 2023	80 farmers from Punjasargi, Mohana, Gajapati district
		03 December 2023	70 farmers from Gortili, Bissam Cuttack, Rayagada district
16.	Production and value addition in yams, taro, sweet potato and elephant foot yam	16 December 2023	25 farmers from Balasore district, Odisha
17.	Value addition in tuber crops	23 December 2023	66 farmers from Pukali, Pottangi, Koraput district
		24 December 2023	50 farmers from Peta, Lamtaput block, Koraput district
18.	Agrotechniques in tuber crops in the exposure visit under ATMA	28 December 2023	18 farmers from Bhadrak district, Odisha

Resource person in training programmes

More than 200 classes on varieties, quality planting material production, agrotechniques, organic farming, natural farming, protection, mechanization, processing, value addition, smart farming, entrepreneurship etc. were handled through online and offline mode by the scientists of various divisions/sections and regional station, Bhubaneswar under different programmes within and outside the Institute beneficial to department officials, subject matter specialists, students and farmers all over the country.

Exposure visits cum training programme

One day exposure visit cum training on 'Improved technologies of tuber crops' was organized for the benefit of 713 farmers, 2791 students and 403 officials across the nation at ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram. A total of 742 farmers and other stakeholders were trained at ICAR-CTCRI, Regional Station, Bhubaneswar.

Trainings attended by ICAR-CTCRI staff

Scientific staff

Sl. No.	Name	Particulars of the training	Period
1.	Dr. N. Krishna Radhika	ICAR sponsored winter school on Development, evaluation, and bio-safety assessment of genome edited crops: Hands-on training at ICAR-Indian Institute of Rice Research, Hyderabad	20 January to 09 February 2023
2.	Dr. T.P. Sujatha	NABL Assessors' training course on ISO/IEC 17025:2017 at ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Bengaluru, Karnataka	06-10 February 2023
3.	Dr. E.R. Harish	Winter school on Emerging problems and recent advances in agriculture and allied sciences: Basic to molecular approaches (EPRAAS-2023), Astha Foundation, Meerut, Uttar Pradesh	26 February-18 March 2023
4.	Dr. C. Visalakshi Chandra Dr. R. Arutselvan Dr. T.P. Sujatha	Data visualization using R (Online mode) by ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana	01-08 March 2023
5.	Dr. K.M. Senthilkumar	International workshop on Phenotyping for drought tolerance, jointly organized by the Alliance Biodiversity International & CIAT, Colombia and ICAR-National Research Centre for Banana, Trichy, Tamil Nadu	07-11 March 2023
6.	Dr. R. Arutselvan	National training workshop on Big data analytics in agriculture (online)	09-10 March 2023
7.	Dr. K. Sunilkumar	Training on Approaches for doubling farmers income through secondary and smart agriculture: A way forward, at ICAR-Indian Agricultural Research Institute, Pusa, New Delhi	10-30 March 2023
8.	Dr. H. Kesava Kumar	IP awareness/training program under National Intellectual Property Awareness Mission organized by Intellectual Property Office, India (Online mode)	17 March 2023
9.	Dr. E.R. Harish Dr. R. Arutselvan	Training programme on Multivariate data analysis (Online mode) by ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana	20-27 March 2023
10.	All Scientists	Online course on Introduction to emerging technologies by Karmayogi Bharat	March 2023
11.	Dr. J. Suresh Kumar	Cocoponics/soil less culture-A new method of growing vegetables and medicinal herbs in terrace/roof top at ICAR-Indian Institute of Horticultural Research, Bengaluru	27 April 2023
12.	Dr. S.S. Veena	Prevention, prohibition and redressal of sexual harassment of women at work place by Institute of Secretariat Training and Management, New Delhi (online mode)	01 May 2023
13.	Dr. K. Sunilkumar	Management development programme on innovation and design thinking: Train the trainer's programme for mentors of K-DISC, Govt. of Kerala at Indian Institute of Management, Kozhikode	03-05 May 2023
14.	Dr. Kalidas Pati	Workshop on E-Processing and management of DUS testing data in plant variety examination	25-26 May 2023
15.	Dr. C. Pradeepika	International training on Technology innovation in Agriculture, Horticulture, Animal Husbandry, Fisheries, Sericulture and Allied Sectors for sustainable entrepreneurship (21 days) organized by College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh	16 June-06 July 2023

16.	Dr. M.S. Sajeev Dr. T. Krishnakumar	Six-week online course on Practical animal nutrition for augmenting livestock and poultry productivity organised by Commonwealth of Learning, Canada and Madras Veterinary College, TANUVAS, Chennai	11 July-31 August 2023
17.	Dr. M.S. Sajeev	Recent advances in millet crop production, processing and value addition and marketing organized by ICAR-Indian Institute of Millet Research, Hyderabad, Telangana	16-25August 2023
18.	Dr. G. Byju	Executive development programme (EDP) on Leadership development, at ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana	21-26 August 2023
19.	Dr. Sheela Immanuel	Training on e HRMS	28 August 2023
20.	Dr. K.M. Senthilkumar Dr. E.R. Harish	Online training on Biosecurity and biosafety: policies, diagnostics, phytosanitary treatments and issues, by ICAR-National Bureau of Plant Genetics Resources, New Delhi (Online)	04-14 September 2023
21.	Dr. V. Ramesh	Climate risk management: Policy and governance at Lal Bahadur Shastri National Academy of Administration, Mussoorie, Uttarakhand	11-15 September 2023
22.	Dr. M. Nedunchezhiyan	SAMAGRA: Enabling the Incubator (A sensitizing workshop of ICAR-ABIs) organized at NASC complex, PUSA, New Delhi	21-22 September 2023
23.	Dr. K.M. Senthilkumar	Online training on Omics data analysis: Genome to proteome by ICAR-Indian Agricultural Statistics Research Institute, New Delhi	09-18 October 2023
24.	Dr. Shirly Raichal Anil Dr. C. Visalakshi Chandra	Training on marker-assisted selection and advanced molecular breeding toolsat International Potato Centre (CIP), Av. La Molina 1895, La Molina, Lima, Perú.	15-20 October 2023
25.	Dr. E.R. Harish Dr. T.P. Sujatha Dr. S.N. Rahana	Biological data exploration and visualization using R, organized by ICAR-Indian Institute of Spices Research, Kozhikode, Kerala (Online)	06-08 November 2023
26.	Dr. T. Krishnakumar	A taste of the future: What's next for safety and quality testing in the food industry? organized by Separation Science (Online)	16 November 2023
27.	Dr. B.G. Sangeetha	Online training programme on Next generation sequencing and data analysis organized by ICAR-National Academy of Agricultural Research Management, Hyderabad.	16-20 November 2023
28.	Dr. S.N. Rahana	Training on Advances in quality planting material production of tropical tuber crops organized by ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram.	20-22 November 2023
29.	Dr. V. Ramesh	One day workshop on J-Gate@CeRA at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu	05 December 2023
30.	Dr. G. Suja	Management Development Programme Training on Leadership development at ICAR-National Academy of Agricultural Research Management, Hyderabad	11-22 December 2023
31.	Dr. S. Sunitha Dr. J. Suresh Kumar	Hands on training on Farm design in farming system perspective organized by All India Network Programme on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Uttar Pradesh	20 December 2023

Technical staff

Sl. No.	Name	Particulars of the training	Period
1.	Dr. B.S. Prakash Krishnan Dr. S. Karthikeyan Smt. Rini Alocious Smt. R. Nijamol Smt. S.S. Sneha	In-house training on Statistics for data analysis using R, ICAR-CTCRI, Thiruvananthapuram, Kerala	20-24 March 2023
2.	Shri. T.M. Shinil	Training on Remote pilot by Garuda Aerospaces Private Limited, Chennai	17-27April 2023
3.	All technical staff from ICAR-CTCRI, HQ	Training programme on Personality development organized by ICAR-Central Tuber Crops Research Institute and Institute of Management in Government, Thiruvananthapuram, Kerala	16-18 October 2023

Awards and Recognitions

Newly selected positions

Dr. G. Byju, Principal Scientist & Head (A) joined as Director, ICAR-CTCRI on 23.01.2023

G. Byju obtained his M.Sc. (Ag.) and Ph.D. in Soil Science & Agricultural Chemistry from Kerala Agricultural University, India. He specializes in site specific nutrient management (SSNM) and climate modelling studies in tuber crops. Dr. Byju has over 33 years of field experience working in most of the tuber crops growing regions in India on site specific nutrient management (SSNM). He served as Head (A), Division of Crop Production (2021-2023), principal scientist (2009-2021), senior scientist (2001-2008) and scientist (1992-2001) at ICAR-CTCRI. Dr. Byju has published 122 refereed journal articles, 107 conference/seminar presentations, 3 books, 13 book chapters, 14 technical bulletins, 64 technical folders/leaflets and 184 popular articles. He has served in several scientific advisory bodies including academic council and board of studies of Kerala Agricultural University, board of studies of ICAR-IARI Bengaluru academic hub and board of studies of Amrita Vishwavidyalaya (a deemed to be university). Dr. Byju has developed SSNM recommendations for 7 crops using modified QUEFTS models and formulated and popularized zone-specific secondary-and micronutrient-inclusive customized fertilizers for 6 crops by conducting more than 500 validation trials/OFTs/FLDs across 12 Indian states. Six technologies of multi-micronutrient formulations for tuber crops developed by him have been licensed to a private company. He has also developed climate resilient agriculture (CRA) for cassava and yams and validated 5 models (ECOCROP, WOFOST, MaxEnt, CROPWAT and Aquacrop) for climate change modelling studies. Ten decision support systems for tuber crops including potato were also developed by him. Dr. Byju has completed 42 institute research projects and brought ₹ 21.23 crores through 18 external aided projects. He has mentored 1 post-doctoral, 7 Ph.D. and 19 M.Sc./M.Tech. students, besides acting as external examiner for 105 Ph.D./M.Sc. (Ag.) students at Agricultural Universities and others including Wageningen University and Research (WUR), The Netherlands. Fifty farmers trainings were organized by him during the last 5 years benefitting 5000 farmers. He is a fellow of 3 professional societies and recipient of 7 awards. He has visited 12 countries on various professional assignments.

Dr. G. Suja, Principal Scientist & Head (A) joined as Head, Division of Crop Production, ICAR-CTCRI on 10.07.2023

G. Suja, obtained B.Sc. Ag. with university first rank; M.Sc. (Ag.) with first position and Ph.D. from Kerala Agricultural University. With 30 years of expertise in tropical tuber crops, Dr. Suja served as Head (i/c & A), Division of Crop Production (09.02.23 to 09.07.23), principal scientist (2009-2023), senior scientist (2002-2008) and scientist (1993-2002) at ICAR-CTCRI. She has made outstanding research contributions in the field of organic farming, cropping systems, conservation agriculture, and best agronomic practices involving tropical tuber crops through 20 institute projects, 12 external funded projects (generating ₹ 7.28 crores) and 127 FLDs/OFTs. She has developed 15 technologies, including package of practices for organic farming of 7 tuber crops and evolved 6 sustainable cropping system models. She has published 83 refereed journal articles, 78 papers in seminars/symposia, 12 book chapters and books, 11 technical bulletins, 26 technical and extension folders, 53 popular articles and 7 issues of Journal of Root Crops. She is fellow of 2 professional societies and recipient of 18 awards, including ICAR Jawaharlal Nehru Award (2003), Netherlands Fellowship (2013), Best Centre Award of AINPOF (2019-2020) and ISA Gold Medal (2022). Dr. Suja has guided 4 Ph.D. students, 9 M.Sc., 26 B.Sc./B.Sc. (Ag.) students and 2 Certified Farm Advisors, and holds membership in 10 professional societies. She has been external examiner for 73 Ph.D./M.Sc. (Ag.) students. She has visited 4 countries. She has created facilities like ICAR-CTCRI Dairy unit, Integrated Organic Farming System (IOFS) model and Agronomy Laboratory with the state-of-art facilities. She has occupied notable positions within the institute like Member Secretary, Research Advisory Committee, for six continuous years; Deputy Management Representative for implementation of ISO 9001-2008 certificate; Editor and Chief Editor, Journal of Root Crops; Chief Editor, Annual Report and Research Highlights, besides Councilor (Kerala), Indian Society of Agronomy.

Dr. T. Makeshkumar, Principal Scientist joined as Head, Division of Crop Protection, ICAR-CTCRI on 10.07.2023

T. Makeshkumar obtained his M.Sc. (Ag.) in Mycology and Plant Pathology from Banaras Hindu University, Varanasi and Ph.D. in Plant Pathology from Indian Agricultural University, New Delhi. He has 27 years of research experience on diseases and their management apart from associating with varietal development and planting material production of tropical tuber crops. He served as principal scientist (2013-2023), senior scientist (2006-2013) and scientist (1997-2006) at CTCRI. He has published 56 refereed journal articles, 86 conference/seminar presentations, 12 book chapters, 2 technical bulletins, and 9 popular articles. He has served in several scientific advisory bodies including Institute Management Committee of ICAR-CPCRI, ICAR-IISR and DBT Nominee for Institute Biosafety Committee of ICAR-IISR, Kozhikode, ICAR-NRCB, Trichy & Kerala Agricultural University. He has developed various techniques for disease diagnosis of pathogens infecting tuber crops (ELISA, DIBA, PCR, RT-PCR, LAMP, RCA, RPA, Lateral flow device etc.) and several integrated disease management strategies, which include production of virus free healthy planting materials of tuber crops through tissue culture and development of transgenics. Associated with development of five cassava mosaic disease resistant and two high starch triploid varieties. Transgenic cassava resistant to cassava mosaic disease was carried out in collaboration with ETH, Zurich under Indo-Swiss Cassava Network program and produced transgenic cassava (Indian var. H-165) with RNAi hairpin constructs for *Sri Lankan Cassava Mosaic Virus*. He has organized symposia and training and participated in several farmers meeting. Dr. Makeshkumar has completed 10 institute research projects and brought ₹ 9.445 crores through 10 external aided projects. He has mentored 3 post-doctoral, 9 Ph.D. and 32 M.Sc. students, besides acting as external examiner for 96 Ph.D./M.Sc. (Ag.) students at Agricultural Universities and others including, University of Leige, Belgium and University of Johanesberg, South Africa. He is a fellow of 3 professional societies and recipient of ICAR-Jawaharlal Nehru Award for best Ph.D. thesis and M.J. Narasimhan Award and S.N. Dasgupta Memorial Award from Indian Phytopathological Society. He has visited 14 countries on various professional assignments, including USA, Belgium, Uganda, Germany, Switzerland, Cambodia and China. He was invited as scientific expert from India for tackling the spread of cassava mosaic disease to South East Asia (Cambodia). He is involved in various institute building activities like PME-in-charge, created facilities like Transgenic lab, Transgenic glass house and Disease diagnostic lab from externally funded projects

Dr. Manas R. Sahoo, Principal Scientist joined as Head, Division of Crop Improvement, ICAR-CTCRI on 13.07.2023

Manas R. Sahoo completed his B. Sc. (Ag & AH) from Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India and subsequently obtained his M.Sc. (Ag.) and Ph.D. in Horticulture from Visva Bharati-A Central University, Santiniketan, India. Dr. Manas R. Sahoo served at OUAT, Bhubaneswar, for 6 years (2006-2012); ICAR Research Complex for NEH Region, Manipur Centre for 9 years (2012-2020), and 3 years at ICAR-IIHR-CHES, Bhubaneswar (2020-2023). He has worked on the biotic and abiotic stress tolerance in vegetables, Taro-*Phytophthora* and Tomato-*Ralstonia* pathosystem, Tree bean microbiome, *in vitro* regeneration of underutilized fruits, vegetables, and flowers etc. He has released 4 varieties, developed 84 underutilized fruits and vegetables value-added products, 20 technologies, and commercialized 6 technologies. He has mentored two start-up entrepreneurs and two farmers' clubs in horticulture and allied sectors. Dr. Sahoo has imparted 50 training programmes to the stakeholders in the field of horticulture. He has completed over 10 institutional and externally funded projects and mentored 1 post-doc, 4 Ph.D., 10 M.Sc. students, and 4 international fellows under various exchange programmes. He has generated ₹ 4.8 crores as revenue under various competitive research grants. Dr. Sahoo did his post-doctoral research at the University of Tennessee, Knoxville, Tennessee, USA. He has published 55 refereed journal articles, 45 research abstracts, 27 leaflets, manuals and bulletins, 16 books and book chapters and 14 popular articles. He has visited countries such as China, Russia, Spain, and the USA under different inter-institutional programs.

Awards

1. Dr. G. Suja was conferred Indian Society of Agronomy Gold Medal Award 2022, instituted by Indian Society of Agronomy. The gold medal and certificate along with citation was presented in the National Symposium on Climate Smart Agronomy for Resilient Production Systems and Livelihood Security organized during 22-24 November 2023 at ICAR-Central Coastal Agricultural Research Institute, Goa.
2. Dr. G. Suja was conferred Fellow of the Indian Society for Root Crops 2022, instituted by Indian Society for Root Crops. The certificate along with citation and memento was presented in the National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience organized during 28-29 November 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.
3. Dr. P. Murugesan received the Fellow of Indian Academy of Horticulture Science 2023 in Horticulture in the 10th Indian Horticulture Congress held during 06-09 November 2023 at Guwahati.
4. Dr. T.P. Sujatha was conferred the Fellow of Indian Society of Oilseeds Research, Hyderabad for contribution in the field of oilseeds research and development in India in the International Conference of Vegetable Oils held during 17-21 January 2023 at Hyderabad.
5. Dr. J. Suresh Kumar was conferred Fellow of the Crop and Weed Science Society 2023 at the 6th Crop and Weed Science Society International Conference on Agricultural Innovations for Sustainable Development Goals with special focus on Natural Farming (AISDGONF-2023) held during 30 September-02 October 2023 at Kalyani, West Bengal, India.
6. Dr. C. Pradeepika bagged the Best Research Paper Award for Scientist 2022 for the research paper titled 'Development of low-fat and anthocyanin rich purple sweet potato vacuum fried chips' (Authors: Pradeepika, C., Giri, N., Krishnakumar, T., Sajeev, M.S. and Safiya, S.), published in *Journal of Food Science*, 2022, 87(7): 2894-2907 (NAAS score: 9.69) on 22 July 2023 during the 60th Foundation Day Celebration of ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.
7. Dr. C. Visalakshi Chandra bagged the Young Scientist Award 2023 from Indian Society for Root Crops (ISRC) for the oral presentation titled 'Postharvest physiological deterioration (PPD) response and association with agronomic and biochemical traits in cassava clonal progenies' in the National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience (NCTTC 4 STAR) organized during 28-29 November 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.
8. Ms. Varsha Acharya received the Best Research Paper Award for the research article titled 'Structural insights into the RNA interaction with yam bean mosaic virus (coat protein) from *Pachyrhizus erosus* using bioinformatics approach' published in *PloS One*, 17(7), e0270534. (NAAS: 9.24) (Authors: Acharya, V., Arutselvan, R., Pati, K., Rout, A.K., Dehury, B., Chauhan, V.B.S. and Nedunchezhiyan, M.) on 22 July 2023 during ICAR-CTCRI Foundation Day Celebration.
9. Dr. S.N. Rahana bagged the Young Scientist Excellence Award in the International Conference AGRIINNOVA 2023 held during 11-12 August 2023 at The Indian Agriculture College, Radhapuram, Tirunelveli, Tamil Nadu.
10. Ms. S.U. Shilpa bagged Dr. A. Abraham Award for the best paper published in *Journal of Root Crops* 47 (1 &2), 2021 for the paper titled 'Harnessing the diversity of bacterial endophytes isolated from wild and cultivated taro plants against *P. colocasiae'* (Authors: Shilpa, S.U., Jeeva, M.L., Veena S.S., Amrutha, P.R., Makeshkumar, T. and Tom Cyriac) in the National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience held during 28-29 November 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.
11. Dr. R. Saravanan bagged the Best Oral Paper Award for the research paper titled 'Climate-driven threats to cassava: Uncovering the physiological consequences of cassava mosaic disease' (Authors: Saravanan R., Makeshkumar, T., Aparna Rajan, Senthilkumar, K.M., Resmi T.R. Nair and Ravi, V.) in the National Symposium on Plant Health Management held during 11-12 September 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.
12. Dr. Pravi Vidyadharan bagged the Best Poster Award for the research paper titled 'Lateral flow immunoassay for on-site detection of viral diseases of tuber crops' (Authors: Resmi, T.R., Pravi Vidyadharan, Jayakrishnan, J.T., Jeeva, M.L. and Makeshkumar, T.) in VIROCON 2023 held during 01-03 December 2023 at ICAR-National Research Centre for Banana, Tiruchirappalli, Tamil Nadu.
13. Ms. Merlin Graceson Cherian bagged the Best Poster Award for the research paper titled 'Molecular cloning and characterization of partial RNA dependent RNA polymerase gene and coat protein gene of Dasheen mosaic virus' (Authors: Merlin Graceson Cherian and Makeshkumar, T.) in the National Symposium on Plant Health Management: Current Trends and Novel Mitigation Strategies held during 11-12 September 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.

Awards received in the National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience (NCTTC 4 STAR) held at ICAR-CTCRI during 28-29 November 2023

Sl. No.	Name of awardee	Award and category	Title of the paper	Authors
1.	Dr. J. Sreekumar	Best oral paper award in Session II on Bioinformatics, Omics, AI and IoT Applications	AI assisted approaches in revolutionizing plant breeding: Advancements, challenges and future prospects	Sreekumar, J.
2.	Dr. Manas R. Sahoo	Best oral paper award as corresponding author in Session I on Biodiversity, Genetic Resources and Crop Improvement	Transcriptional profiling of *Colocasia esculenta* L. Schott. to understand molecular mechanisms of resistance against *Phytophthora colocasiae*	Dasgupta, M., Devi, M.P., Sharma, S.K., Hegde, V., and Sahoo, M.R.
3.	Dr. D. Jaganathan	Best oral paper award in Session VI on Transfer of Technology and Commercialization	Farmer participatory demonstrations on improved varieties of cassava: Potentials and strategies	Jaganathan, D., Sheela Immanuel, Muthuraj, R., Prakash, P. and Byju, G.
4.	Dr. T. Krishnakumar	Best oral paper award in Session V on Secondary Agriculture	Effect of different packaging materials on the quality & shelf-life of cassava flour during storage	Krishnakumar, T., Sajeev, M.S. and Pradeepika, C.
5.	Dr. P. Prakash	Best poster paper award in Session VI on Transfer of Technology and Commercialization	Cassava cultivation in India: Growth trends, challenges and sustainable strategies	Prakash, P., Jaganathan, D. and Sheela Immanuel
6.	Dr. Pravi Vidyadharan	Best oral paper award in Session IV on Pests and Diseases Management	Lateral flow dipstick immunoassay-based detection of *Dasheen mosaic virus* causing mosaic disease in elephant foot yam	Resmi, T.R., Pravi Vidyadharan, Jayakrishnan, J.T., Arutselvan, R., Jeeva, M.L. and Makeshkumar, T.
7.	Dr. M. Senthil alias Sankar	Best poster paper award in Session V on Secondary Agriculture	Screening of different flesh-colored sweet potato genotypes as a source of bioactive compounds	M. Senthil alias Sankar, Pradeepika C. and Visalakshi Chandra, C.
8.	Ms. Reshma Maria Joseph	Best poster paper award in Session I on Biodiversity, Genetic Resources and Crop Improvement	A modified method for isolation of total RNA from sweet potato *Ipomoea batatas* (L.) Lam	Reshma Maria Joseph, Shirly Raichal Anil, Krishna Radhika N., Senthilkumar K.M. and Prakash Krishnan, B.S.
9.	Ms. S.U. Shilpa	Best poster paper award in Session IV on Pests and Diseases Management	Utilizing endophytic growth promoting bacteria inhabiting taro to mitigate taro leaf blight	Shipla, S.U., Jeeva, M.L., Veena, S.S., Amrutha, P.R and Tom Cyriac

Recognitions

Dr. G. Byju, Director

1. Member, Institute Management Committee, ICAR-NAARM, Hyderabad.
2. Member, Board of Studies, Bengaluru Academic Hub, ICAR-IARI, New Delhi for 2023-24.
3. Member, Board of Studies, Amrita School of Sustainable Futures, Amrita Viswa Vidyapeetham, Vallikkavu, Kollam, Kerala since February 2023.

Crop Improvement

Dr. Manas Ranjan Sahoo

1. Reviewer, Molecules, International Journal of Molecular Science, BMC Plant Biology, Agricultural Water Management, Applied Sciences, Forests, Plos One, International Journal of Genomics and Agriculture.

Dr. M.N. Sheela

1. Member, Institute Management Committees of ICAR-CPRI, Shimla and ICAR-IIHR, Bengaluru.
2. External examiner for 1 Ph.D. and 11 M.Sc. students, Kerala Agricultural University.
3. Invited speaker, National Symposium on Plant Health Management: Current trends and Novel Mitigation Strategies held during 11-12 September 2023, ICAR-CTCRI, Thiruvananthapuram, organized by Indian Phytopathological Society and presented a paper on 'Innovative approaches in plant health management on breeding for resistance against cassava mosaic disease'.

4. Member, DPC for assessment of scientists under Career Advancement Scheme at ICAR-IIVR, Varanasi.
5. Invited speaker, Syposium on Drisya Narendram organised by Sri Arabindo Cultural Society on 21 September 2023 at Bhagyamala Auditorium, Chadrasekharan Nair Stadium, Thiruvananthapuram and delivered a talk on 'Agricultural revolutions of India'.
6. Lead speaker, Symposium VIROCON, 2023-Advancements in Global Virus Research-Towards One Health held at ICAR-NRC for Banana, Tiruchirappalli during 01-03 December 2023. Co-Chaired the Session on Management of viral diseases through conventional methods and breeding for resistance.

Dr. P. Murugesan

1. Invited speaker and delivered the Dean (SPGS) endowment lecture held at AC & RI Madurai, Tamil Nadu on 03 February 2023.
2. Adjunct faculty, SKLTSHU, Telangana in the discipline of Horticulture.
3. External examiner of a Ph.D. student of Seed Science and Technology, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu.
4. Invited speaker, First Global Symposium on Farmers Rights – Conservation and Promotion of Traditional Varieties held on 14 September 2023.
5. Invited expert, TNAU-Seed Centre-Brain storming session on exploring researchable area-think tank – Seed Science Technology on 10 October 2023 at Directorate of Seed Science Technology, TNAU Coimbatore.
6. Delivered an invited lecture on 'Experiences on community involvement and need for value addition - underutilized tuber crops germplasm' on the theme 'Forgotten foods' in the International Convention on Millets on 10 November 2023 at Odisha.
7. PG Faculty in the discipline of Horticulture-Vegetable Science, ICAR-IARI-IIHR.
8. Reviewer, Journal of Environmental Biology.

Dr. K.I. Asha

1. Member, special expert committee by the Vice Chancellor, University of Kerala to evaluate, modify and approve the syllabus of B.Voc. in Agriculture - Plant Breeding and Genetics Programme.
2. External examiner, B.Sc.-M.Sc. Integrated Biotechnology student of Molecular Biology and Biotechnology, Kerala Agricultural University.

Dr. C. Mohan

1. External examiner for a Ph.D. student, University of Calicut.
2. Reviewer, Journal of Applied and Natural Science and PLOS ONE.

Dr. A. Asha Devi

1. Adjudicator for evaluating the Session on Biotechnology for sustainability in the International Seminar on New Horizons in Plant Sciences 2023 Emergent and Innovative Technologies in Plant Sciences (NHPS 2022) during 21-23 March 2023.
2. Nominated as Virtual Biodiversity Cadre, Kerala State Biodiversity Board, from ICAR-CTCRI.
3. Reviewer, Journal of Root Crops and Indian Journal of Horticulture.

Dr. Shirly Raichal Anil

1. Reviewer, Current Science and Genetic Resources and Crop Evolution.
2. Adjudicator for evaluation of posters in the International Seminar on New Horizons in Plant Sciences-NHPS 2023-Emergent and Innovative Technologies in Plant Sciences, organized by University of Kerala during 21-23 March 2023.
3. Adjudicator for evaluation of oral presentations in the Session of Plant Science in the International Conference on Recent Advances in Biological Science at Interuniversity Centre for Evolutionary and Integrative Biology held during 17-19 January 2023.

Dr. N. Krishna Radhika

1. Member, Advisory Board, M.Sc. Biotechnology, Kerala Agricultural University.
2. External examiner, M.Sc. student, Kerala Agricultural University.
3. Rapporteur, Session on Nature-based solutions for sustainable agri-food systems, TS-3: Ensuring nutritional security through natural resource management in the XVI Agricultural Science Congress 2023 held at Kochi during 10-13 October 2023.
4. Reviewer, Genetic Resources and Crop Evolution.

Dr. Kalidas Pati

1. Delivered an invited lecture titled 'Biodiversity of tuber crops' in the workshop of PPV & FRA, Technical session III: Agro-biodiversity and conservation at ICAR-NRRI, Cuttack, Odisha on 12 May 2023.

Dr. C. Visalakshi Chandra

1. Reviewer, South African Journal of Botany, BMC Biology and BMC Genomics.

Dr. K.M. Senthilkumar

1. Research guide for Ph.D. at the Kerala University of Digital Sciences, Innovation and Technology, Kerala.
2. Research guide and faculty for M.Sc. and Ph.D. at the IARI Mega University, New Delhi (for Bengaluru Hub).

3. External examiner, one B.Sc.-M.Sc. (Integrated) Biotechnology student, Kerala Agricultural University.
4. Reviewer, Frontiers in Plant Science, Journal of Sugarcane Research, Plos One, Pakistan Journal of Zoology.
5. Review Editor, Frontiers in Nutrition.
6. Rapporteur, Session II: Bioinformatics, Omics, AI and IoT Applications in the National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience held at ICAR-CTCRI during 28-29 November 2023.

Dr. V.B.S. Chauhan

1. External question paper setter, end term examination of M.Sc. (Horticulture) subject 'Production of warm season vegetable crops' of College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh.
2. Certificate of Editorial board membership awarded by Science Publishing Group, Rockefeller Plaza, New York for Journal of Plant Science.

Dr. T.P. Sujatha

1. Reviewer, Australasian Plant Pathology, Gene and Phyton.
2. Qualified and recognized as assessor of National Accreditation Board for Testing and Calibration Laboratories (NABL).
3. Assistant Editor, Applied Biochemistry and Biotechnology, Section: Biological processes and Genomics, Springer.
4. Associate Editor, Journal of Rice Research.

Dr. S.N. Rahana

1. External expert, selection committee for conducting interview of Project fellow in the project entitled 'Cardamom for rainforest conservation conducted by Kerala State Council for Science, Technology and Environment - Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram, Kerala.

Crop Production

Dr. G. Suja

1. Received ICAR technology certificate for package of practices for organic production of cassava, from Dr. Himanshu Pathak, Hon'ble DG, ICAR on the occasion of Foundation Day Celebration of ICAR-CTCRI on 22 July 2023.
2. Subject expert for tuber crops, Scientific Advisory Committee meetings of ICAR-KVK, Kumarakom, Kottayam and KVK, Mithraniketan, Thiruvananthapuram, Kerala.
3. Member, Jury Committee, State Level Award for Best Agricultural Researcher as nominated by Director of Extension, Kerala Agricultural University.
4. DG nominee as Subject expert in CAS of Scientists (Agronomy), ICAR-Central Plantation Crops Research Institute
5. External Examiner, 10 Ph.D. and 4 M.Sc. Agronomy students, Tamil Nadu Agricultural University and Kerala Agricultural University.
6. Reviewed a book titled Tropical Agronomy: Principles, Heritage and Gender Perspectives authored by Dr. C. George Thomas, which was published in AESA Book Review 48 (August 2023).
7. Reviewer, Biological Agriculture and Horticulture, International Journal of Plant Production, Communications in Soil Science and Plant Analysis, Journal of Environmental Biology, Journal of Spices & Aromatic Crops and Journal of Root Crops.

Dr. K. Susan John

1. Technical expert, Central Soil Analytical Laboratory under Department of Soil Survey and Soil Conservation, Government of Kerala.
2. Member, School Management Committee of Bharatiya Vidyabhavan School, Manvila, Thiruvananthapuram.
3. Nodal Officer, Soil Health Card Programme.
4. Chairperson, the Scientific session III A of the International Conference on Environmental pollution and health: Governance for a Sustainable Future at University of Kerala during 22-24 November 2023 and evaluated posters of the session on 23 November 2023.
5. As judge, evaluated 11 oral presentations at the National Seminar on Soil and water Symbiosis for Sustainable Agriculture on 06 December 2023 at College of Agriculture, Vellayani in connection with World Soil Day 2023.
6. Delivered the World Soil Day lecture 2023 at the Department of Environmental Sciences, University of Kerala on the topic 'Soil and water: the resources for life on 07 December 2023.
7. Consultant for the technology validation of polysulphate in cardamom in collaboration with Indian Cardamom Research Institute.
8. External examiner, 5 Ph.D. and 1 M.Sc. students, Kerala Agricultural University.
9. Reviewer, 1 book proposal for Springer Nature, 1 research project proposal, 4 research articles for 4 journals including Journal of Root Crops and 2 pre-proposals of project for funding by KSCSTE, Govt. of Kerala.

Dr. S. Sunitha

1. Advisory committee member of 1 Ph.D. programme in Agronomy, Kerala Agricultural University.
2. External examiner, 3 Ph.D. and 7 M.Sc. students, Kerala Agricultural University and Tamil Nadu Agricultural University.
3. External expert, qualifying viva voce of 22 M.Sc. (Ag.) students of Kerala Agricultural University.
4. Judge, evaluated oral and poster papers in Biozion - International Biotechnology Conclave - Theme Agriculture, conducted from 07 to 11 August 2023 at College of Agriculture, Vellayani, Kerala Agricultural University.

Dr. K. Laxminarayana

1. External examiner, 2 M.Sc. (Ag.) students, ANGRAU, RARS, Tirupati, Andhra Pradesh and OUAT, Bhubaneswar.
2. Reviewer, Communications in Soil Science and Plant Analysis.
3. Member, screening committee for the post of Dean (Students' Welfare), OUAT, Bhubaneswar.
4. Guest of Honour, Indigenous Seed and Food Festival organized by Bhittibhumi Seva Sanghathan and Desi Bihan Suraksya Mancha at Krishak Bazar (RMC), Bargarh, Odisha on 18 December 2023.
5. Member, Technical Expert Committee for finalization of SOP for the production of Certified Seed Potato in Odisha.

Dr. K. Sunilkumar

1. PG Faculty under Bengaluru Hub of IARI Mega University, ICAR.
2. Observer on duty by ASRB for Competitive examination for NET-2023, SMS (T6), Senior Technical Officer (T6) Examination-2023 held during April 2023 at Thiruvananthapuram Centre.
3. Reviewed the book titled 'Mountain Ecosystems and Resource Management' for Grasslands Institute, Canada.
4. External examiner, 7 M.Sc. students, Dr. YSR Horticulture University and Kerala Agricultural University.

Dr. V. Ramesh

1. Reviewer, Journal of Environmental Biology and Journal of Root Crops and the book tilted 'Mountain Ecosystems and Resource Management' for Grasslands Institute, Canada.
2. Judge, oral presentation competition held on the occasion of World Soil Day at the Department of Soil Science & Agricultural Chemistry, College of Agriculture, Vellayani on 06 December 2023.
3. External examiner, 2 M.Sc. (Ag.) students, Kerala Agricultural University and Tamil Nadu Agricultural University.
4. Mentor, Young Innovators Program, K-DISC, Govt. of Kerala.

Dr. R. Muthuraj

1. External expert committee member in the Kerala State Award Committee for selection of Best Farmer Award for 2022-23 based on field visits to different districts during 24 July-03 August 2023.

Dr. J. Suresh Kumar

1. External examiner, 3 M.Sc. students, Tamil Nadu Agricultural University.

Crop Protection

Dr. T. Makeshkumar

1. Organizing Secretary, National Symposium on Plant Health Management: Current trends and Novel Mitigation Strategies during 11-12 September 2023 at ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram under Indian Phytopathological Society South Zone chapter.
2. Organizing Secretary, National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR) held during 28-29 November 2023 at ICAR-CTCRI, Thiruvananthapuram.
3. DBT nominee, Institute Biosafety Committee, ICAR-NRC for Banana, Trichy.
4. External expert, Institute Biosafety Committee, College of Agriculture, Vellayani and ICAR-Indian Institute of Spices Research, Kozhikode.
5. President 2023 (Southern Zone), Indian Phytopathological Society, New Delhi.
6. External examiner, two Ph. D. and two M. Sc. Plant Pathology students, ICAR-IARI, Banaras Hindu University, Tamil Nadu Agricultural University and Kerala Agricultural University.
7. DG nominee as Subject expert in CAS of Scientists (Plant Pathology), ICAR-Central Plantation Crops Research Institute.
8. Member, Advisory committee of 2 Ph.D. students, Kerala Agricultural University
9. Secretary, Indian Society for Root Crops
10. Convenor, Plant Virology Technical Sessions in Virocon-2023 Advancements in Global Virus Research towards One Health during 01-03 December 2023 at Tiruchirappalli, Tamil Nadu.

Dr. M.L. Jeeva

1. External examiner, 2 Ph. D. and 5 M. Sc. Students, Tamil Nadu Agricultural University and Kerala Agricultural University.

Dr. S.S. Veena

1. Co-organizing Secretary, National Symposium on Plant Health management: Current Trends and Novel

Mitigation Strategies, 11-12 September 2023, ICAR-CTCRI, Thiruvananthapuram.

2. Zonal Councillor 2023 (Southern Zone), Indian Phytopathological Society, New Delhi.
3. Reviewer, Journal of Horticultural Sciences, Indian Journal of Agricultural Sciences, International Journal of Agricultural Policy Research, Indian Phytopathology and Journal of Root Crops.
4. Evaluator, Research proposals under the Ecology and Environment Scheme (E&E). KSCSTE.
5. External examiner, 2 Ph.D. and 2 M.Sc. students, ICAR-IARI, New Delhi and Mahatma Gandhi University and Kerala Agricultural University.
6. Member, Advisory committee of 2 Ph.D. students at Kerala Agricultural University.
7. Member, BLAKC, Office of ADA, Attingal, Thiruvananthapuram.

Dr. E.R. Harish

1. Organizing Secretary, Brainstorming Meeting on Management of Mealybugs in Cassava- Present Status and Future Strategies, 23 May 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram.
2. Member, Expert committee, Government of Kerala to formulate guidelines for identifying endosulfan victims in the State of Kerala.
3. Member, State Agricultural Award Committee, Government of Kerala to select agricultural awards of 2022-2023 in various categories.
4. Executive committee member, Association for Advancement of Entomology.
5. Reviewer, Springer Nature.
6. External examiner, M.Sc. (Ag.) students, Kerala Agricultural University.
7. Evaluator for the research project proposals submitted to KSCSTE, Kerala.

Dr. H. Kesava Kumar

1. Organizing Secretary, National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience (NCTTC 4 STAR 2023), 28-29 November 2023, ICAR-CTCRI, Thiruvananthapuram, Kerala.
2. Councillor, South Zone (2023-2025), Nematological Society of India.
3. Delivered a lead talk on 'Entomopathogenic nematodes: A farmer friendly solution for pest problems' and cochaired Session on Crop Protection in the International Conference on Recent Innovations & Technological Advancements in Agriculture, Horticulture, Agricultural Engineering, Sericulture, Food Science, Biotechnology and Rural Entrepreneurship' (AGRI INNOVA 2023) at The Indian Agriculture College, Radhapuram, Tirunelveli, Tamil Nadu on 11 August 2023.
4. Mentor, Young Innovators Programme, K-DISC, Government of Kerala.
5. Member, Advisory committee, M.Sc. (Ag.) programme, Kerala Agricultural University.

Dr. B.G. Sangeetha

1. Member, Advisory committee, Ph.D. student, Kerala Agricultural University.

Crop Utilization

Dr. A.N. Jyothi

1. Member, Technical committee, Kerala State Pesticide Testing Laboratory, Department of Agriculture, Government of Kerala.
2. Mentor for the Young Innovators Program of Kerala Development and Innovation Strategic Council (K-DISC), Govt. of Kerala.
3. Evaluated one research idea under the YIP programme of K-DISC, Government of Kerala.
4. Member, Advisory committees of 2 Ph.D. students, Department of Communication Science, Kerala Agricultural University and Department of Food Process Engineering, School of Bioengineering, SRMIST, Kattankulathur, Tamil Nadu.

Dr. M.S. Sajeev

1. Chairman, session on Food waste/Circular economy linked food chain with sustainable upstream and downstream process, 29th ICFoSt, Indian Convention of Food Scientist and Technologists, 07 January 2023.
2. Nodal officer, KIED Sponsored one week training programme on Value added products from tuber crops, 03-11 January 2023.
3. Member, Advisory committee of Ph.D. student, CSIR-NIIST, Thiruvananthapuram.
4. Expert member, Project report preparation for setting up of a processing unit on value added products from tapioca, banana and coconut, Athiyannoor Block Panchayath, Thiruvananthapuram on 19 June 2023.
5. Member, Technical committee for the evaluation of business plan of MSME entrepreneurs for back ended subsidy, SFAC, Thiruvananthapuram on 23 November 2023.
6. Member, Technical committee, All India Seminar on Processing and Value addition in Agriculture for Increasing farmers Income-an Engineering Perspective, held during 25-26 October 2023 at Institution of Engineers (India), Kerala State Centre, Thiruvananthapuram.
7. Invited member, International Workshop on Food Loss & Waste Prevention in the South Asian Region, New Delhi, 30 October to 01 November 2023,

organized by Division of Agricultural Engineering, Indian Council of Agricultural Research, New Delhi.

8. Member, Advisory committee of 1 Ph.D. student, Department of Community Science, Kerala Agricutural University, Thiruvananthapuram.
9. Reviewer, 8 manuscripts for peer reviewed journals.

Dr. T. Krishnakumar

1. Technical member, Sectional committee of FAD 16 – Foodgrains, Allied products and other agricultural produce, Bureau of Indian Standards (BIS), Govt. of India.
2. External examiner, 2 M.Tech. (Dairy Technology) students, Tamil Nadu Veterinary and Animal Sciences University and University of Agricultural Sciences, Raichur, Karnataka.
3. Question paper setter, B.Tech. (Agricultural Engineering) and B.Tech. (Food Process Engineering) final year courses of Tamil Nadu Agricultural University.
4. Reviewer, LWT- Food Science and Technology, Journal of Food Processing and Preservation, Journal of Food Science and Technology and Journal of Root Crops.

Extension & Social Sciences

Dr. J. Sreekumar

1. Co-opted/External member for the evaluation of the thesis of 3 Ph.D. Bioinformatics students, IARI, New Delhi by the PG School IARI, New Delhi.
2. External examiner, 1 M.Sc. Agricultural Statistics student, Kerala Agricultural University.
3. Member, Editorial Board, Journal of Tropical Agriculture, Kerala Agricultural University.
4. Reviewer, 3 Biotech.
5. Research guide, Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala).

Dr. Sheela Immanuel

1. External examiner, final examination of PGDAEM-MANAGE correspondence courses in March 2023.
2. Question paper setter, M.F.Sc. course on Monitoring, Evaluation and Impact assessment, KUFOS.
3. Reviewer, Indian Journal of Fisheries and Journal of Marine Biological Association.

Dr. V.S. Santhosh Mithra

1. Research guide, Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala).
2. Chaired the session on High-tech Agriculture and use of drones during the seminar on Modern Day Challenges and Opportunities in Kerala's Agriculture held during 20-21 November 2023 at ICAR-CTCRI under the auspices of Coir Board and Bharatiya Kisan Sangh.
3. Delivered an invited talk on Urban smart farming innovations for sustainable agriculture during the workshop on Greener Cities, Healthier Lives: Urban Agriculture Unleashed at College of Agriculture, Vellayani on 18 October 2023 in collaboration with the French Institute of India and Alliance Francaise, Thiruvananthapuram.
4. Delivered an invited lead talk on IoT in Soil Science at College of Agriculture, Vellayani, Thiruvananthapuram on 06 December 2023 during the National Seminar on Soil and Water Symbiosis for Sustainable Agriculture.

Dr. P.S. Sivakumar

1. Delivered an invited talk on IPR management in agricultural research: An ICAR-CTCRI perspective at the WIPO Roving seminar on the Patent Cooperation Treaty (PCT) on 03 March 2023 organized by ICAR-CTCRI, Thiruvananthapuram, Kerala.
2. Delivered an invited talk at the National Online Conference on Intellectual Property Rights (IPRs) on 21 March 2023 organized by the TM NSS College, Dhanuvachapuram, Thiruvananthapuram, Kerala.
3. External examiner, final examination of PGDAEM-MANAGE correspondence courses.
4. Delivered an invited talk on Advanced research methods in behavioral research-An orientation in MANAGE-KAU online training programme on 'Advances in Agricultural Extension Research', 02-04 May 2023.
5. Delivered an invited talk on 'Tuber crops-based value chain and entrepreneurship development' at the FPPP Masters training Phase II at SAMETI, Thiruvananthapuram (02 June 2023), ICAR-KVK, Wayanad (15 June 2023) and ICAR-KVK, Pathanamthitta on 20 June 2023.
6. Delivered an invited talk on 'Advanced research methods in social sciences' on 13 June 2023 in the training on 'MANAGE TNAU Collaborative online Training on Faculty Development Programme for Extension Professionals', 13-16 June 2023.
7. Delivered an expert talk on 'Agriculture and Plant Sciences' to college students and young researchers anchored by K-DISC, 25 June 2023.
8. Delivered an invited talk on 'IP development and commercialization-Case studies' in the 'IPR Seminar: National Intellectual Property Festival' on 26 July 2023 at CSIR-NIIST Campus, Thiruvananthapuram.
9. Delivered lead lecture on 'Making KVKs efforts count: Capturing the impacts with innovative methodologies' at the Annual Zonal Workshop of

KVKs of Zone X, Hyderabad during 17-19 August 2023 at TNAU, Coimbatore.

10. Delivered lead lecture on 'The new generation extension research-A pathway focused approach' at the National Conference on NexGen Extension for Evolving Resilient Agri-Ecosystems, 25-27 September 2023.
11. Expert member, review team of KSCSTE-ED-SC-ST-WISTEM project on 12 December 2023.
12. Panelist for Workshop on the Behaviour Change Communication Best Practices to Promote Natural Farming organized by VERTIVER at Delhi, 08 December 2023.
13. Research guide, Kerala University of Digital Sciences, Innovation and Technology, Thiruvananthapuram.
14. Jury member – 'Tigers' Claw' a business pitching competition at the Huddle Global 2023 of Kerala Startup Mission, 16-17 November 2023.
15. Expert member, evaluation of student projects presented at the IDEA FEST organized by the Kerala Startup Mission on 18 December 2023.

Dr. D. Jaganathan

1. Nodal Officer, National Survey on Resources Devoted to S&T Activities 2021-22 of ICAR-CTCRI, Thiruvananthapuram.
2. External examiner, 1 M.F.Sc., 2 M.Sc. (Ag.) and 3 Ph.D. students, Kerala University of Fisheries and Ocean Studies (KUFOS) and Kerala Agricultural University.
3. External expert, Defense seminar, Ph.D. scholar, Kerala Agricultural University.
4. External examiner, final examination of PGDAEM-MANAGE correspondence courses.
5. External expert, Scientific Advisory Committee of ICAR-KVK, Ernakulam.
6. External expert, formulation of KERA Mission project proposal funded by World Bank during 26-27 April 2023 at SAMETI, Anayara, Thiruvananthapuram.
7. Reviewer, Journal of Plantation Crops.
8. External expert, Interview Board for the selection of SRF for the externally aided project at ICAR-Indian Institute of Oil Palm Research, Palode, Thiruvananthapuram.

Dr. P. Prakash

1. Delivered an invited talk on 'Agricultural marketing in India' in the Training and Capacity Building Workshop for Nurturing and Strengthening of FPOs on 09 March 2023 organized by NABARD at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala.
2. Reviewer, Cogent Food and Agriculture, Tobacco Research, African Association of Agricultural Economics, Frontiers in Plant Science and Sugar Tech.
3. Research guide, Indian Institute of Horticultural Research, Bangalore by Indian Agricultural Research Institute, New Delhi.

Linkages and Collaborations

International collaborations

1. International Potato Centre (CIP), Lima, Peru
2. International Centre for Tropical Agriculture (CIAT), Cali, Columbia

Organizations having MoU with ICAR-CTCRI

1. Digital University of Kerala (DUK), Thiruvananthapuram, Kerala
2. Indian Institute of Technology Palakkad, Kerala
3. Mahatma Gandhi University, Kottayam, Kerala
4. a-IDEA, Techno Business Incubator (TBI), ICAR-NAARM, Hyderabad
5. College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram, Kerala
6. National Institute of Food Technology, Entrepreneurship and Management, Thanjavur (NIFTEM-T), Tamil Nadu
7. Jawaharlal Nehru Krishi Vigyan Kendra, Jabalpur, Madhya Pradesh
8. Dr. YSR Horticultural University, Andhra Pradesh
9. Coconut Development Board, Ministry of Agriculture & Farmers' Welfare, Government of India
10. Odisha University of Agriculture & Technology, Bhubaneswar, Odisha
11. Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai, Tamil Nadu
12. M/s SAGOSERVE, Salem, Tamil Nadu
13. M/s KCM Agri Clinic, Tirunelveli, Tamil Nadu
14. M/s Spudnik Foods, Bengaluru, Karnataka
15. M/s Linga chemicals Pvt. Ltd., Madurai, Tamil Nadu
16. M/s Xobu Foods and Beverages Private Limited, Rajahmundry, East Godavari, Andhra Pradesh
17. M/s MicroNutrich Pvt. Ltd., Tiruvallur, Tamil Nadu

Linkages through collaborative research and extension activities

1. ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka
2. ICAR-Central Institute of Women in Agriculture, Bhubaneswar, Odisha
3. ICAR-National Rice Research Institute, Cuttack, Odisha
4. ICAR-Central Institute of Fisheries Technology, Kochi, Kerala
5. ICAR-Central Plantation Crops Research Institute, Kasaragod, Kerala
6. ICAR-Indian Institute of Farming Systems Research, Modipuram, Uttar Pradesh
7. ICAR Research Complex for NEH Region, Barapani, Meghalaya
8. ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana
9. ICAR-Indian Institute of Spices Research, Kozhikkode, Kerala
10. ICAR-Sugarcane Breeding Institute, Coimbatore, Tamil Nadu
11. Agricultural Technology Application Research Institute, Bengaluru, Karnataka
12. National Research Centre for Banana, Trichy, Tamil Nadu
13. ICAR Central Institute of Agricultural Engineering Regional Office, Coimbatore, Tamil Nadu
14. ICAR-Central Institute for Research on Cotton Technology, Mumbai, Maharashtra
15. National Institute of Technology, Trichy, Tamil Nadu
16. CIPET: Institute of Petrochemicals Engineering & Technology (IPT), Kochi, Kerala
17. National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Thanjavur, Tamil Nadu
18. Kerala Agricultural University, Thrissur, Kerala
19. Orissa University of Agriculture & Technology, Bhubaneswar, Odisha
20. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu
21. College of PG Studies in Agricultural Sciences, Central Agricultural University (Imphal), Umiam, Meghalaya.
22. Department of Horticulture and Department of Agriculture, Government of Odisha
23. Department of Agriculture, Government of Kerala
24. Department of Horticulture, Government of Tamil Nadu
25. Rubber Research Institute of India, Kottayam

Linkages through project funding

1. ICAR, National Agricultural Innovation Fund (NAIF), Government of India
2. Protection of Plant Varieties & Farmers' Rights Authority (PPV&FRA), Government of India
3. Department of Science and Technology, Government of India
4. Department of Biotechnology, Government of India
5. National Bank for Agriculture and Rural Development (NABARD), Government of India
6. Coconut Development Board
7. Rashtriya Krishi Vikas Yojana (RKVY)
8. Government of Odisha
9. Government of Kerala
10. Department of Agriculture and Farmer's Welfare, Government of Kerala
11. Kerala State Planning Board
12. Small Farmers Agri-business Consortium (SFAC), Government of Kerala
13. Kerala State Council for Science, Technology and Environment (KSCSTE), Government of Kerala
14. Kerala State Horticulture Mission, Government of Kerala

Others

1. ICAR-CTCRI with its Intellectual Property and Technology Management Unit & Professional Services Cell (IPTMU & PSC) has developed collaboration with National Institute of Agricultural Extension Management (MANAGE), Hyderabad and Centre for Research on Innovation and Science Policy (CRISP), Hyderabad.
2. ICAR-CTCRI ABI has collaboration with Indian Institute of Technology, Roorkee and Central Agricultural University (CAU), Imphal.
3. Kerala State Industrial Development Corporation (KSIDC)
4. Kerala Start-up Mission, Department of Agriculture, Government of Kerala
5. ICAR Research Complex for North Eastern Hills, Umiam, Meghalaya
6. North Eastern Hill University, Tura Campus, Meghalaya
7. Krishi Vigyan Kendra, Tura, Meghalaya
8. Horticulture Department, West Garo Hills and Meghalaya Basin Development Agency
9. Krishi Vigyan Kendra, Namsai, Arunachal Pradesh
10. Madurai Agribusiness Incubation Forum of NABARD, Madurai
11. Under Tribal Sub Plan, linkages were developed with research organizations, NGOs and Department of Agriculture in Koraput, Kandhamal and Ranchi districts for the livelihood improvement of tribal farmers.
12. The Institute is the approved research centre of the University of Kerala and Kannur University for Ph.D. programmes.
13. AICRP on Tuber Crops at ICAR-CTCRI Headquarters has collaboration with 21 centres spread over 18 states and one Union Territory.

Publications

Research papers in peer reviewed journals

1. Ajeesh, B.R., Koundinya, A.V.V., Senthilkumar, K.M., Vivek Hegde and Kalidas Pati. 2023. Genetic diversity in cassava based on agronomical, physiological and EST-microsatellite markers under moisture stress conditions. *Ind. J. Hort.*, **80**(40): 319-325. (*NAAS score: 6.00*).
2. Ambu Vijayan, Mohan, C., Sheela, M.N. and Sreekumar J. 2022. SNP marker development in cassava for cassava mosaic disease resistance using bioinformatics tools. *J. Root Crops*, **48**(1&2): 57-63.
3. Amom, T., Tikenndra, L., Potshangbam, A.M., Bidyananda, N., Devi, R.S., Dey, A., Sahoo, M.R., Vendrame, W.A., Jamir, I. and Nongdam, P. 2023. Conservation strategies for endemic *Dendrocalamus manipureanus*: A study on genetic diversity and population structure based on molecular and phytochemical markers. *South Afr. J. Bot.*, **152**: 106-123. (*NAAS score: 9.11*).
4. Amrutha, P.R., Jeeva, M.L., Sreelatha, G.L., Akhil, K.M., Tom Cyriac and Shilpa, S.U. 2023. Efficacy of *Bacillus licheniformis* – a biocontrol agent against *Colletotrichum gloeosporioides* Penz. (Penz. & Sacc.) causing anthracnose in greater yam (*Dioscorea alata* L.). *Egypt. J. Biol. Pest Control.*, **33**(1): 112, https://doi.org /10.1186/s41938-023-00755-3. (*NAAS score: 8.06*).
5. Anil, S.R., Devi, A.A., Asha, K.I., Beevy, S.S. and Siril, E.A. 2023. Intraspecific inflorescence and palynological variations in the morphotypes of *Amorphophallus paeoniifolius*. *Genet. Resour. Crop Evol.*, **70**(6): DOI:10.1007/s10722-023-01631-7. (*NAAS score: 7.88*).
6. Anjali Kumar, S., Korra, T., Thakur, R., Arutselvan, R., Kashyap, A.S., Nehela, Y. and Keswani, C. 2023. Role of plant secondary metabolites in defence and transcriptional regulation in response to biotic stress. *Plant Stress*, **8**: 100154. doi: https://doi.org/10.1016/j.stress.2023.100154. (*Impact Factor: 5.00*).
7. Asha Devi, A., Ann P. George, Krishna Radhika, N., Shirly Raichal Anil and Asha, K.I. 2022. Standardization of an efficient DNA isolation protocol in tannia (*Xanthosoma sagittifolium* (L.) Schott). *J. Root Crops*, **48**(1&2): 21-25.
8. Asha, K.I., Aswani, S.A., Krishna Radhika, N. and Prakash Krishnan, B.S. 2023. Genetic variability and diversity analysis of Chinese potato (*Solenostemon rotundifolius* (Poir.) J.K. Morton) germplasm using morphological and molecular markers. *South Afr. J. Bot.*, **155**: 171-177. (*NAAS score: 9.11*).
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3. ICAR-CTCRI. 2023. *Action Taken and Progress Report of Second Meeting of IX Research Advisory Committee*, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 71 p.
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5. ICAR-CTCRI. 2023. *49th Annual IRC meeting: Salient Achievements (2022-23)*, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 167 p.
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7. ICAR-CTCRI. 2023. *Ranking Document of ICAR-CTCRI 2022*, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 1010 p.
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9. ICAR-CTCRI. 2023. *ICAR-CTCRI Newsletter April-June 2023 (Quarterly)*, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, **40**(2): 20 p.
10. ICAR-CTCRI. 2023. *ICAR-CTCRI Newsletter July-September 2023 (Quarterly)*, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, **40**(3), 28 p.
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13. ICAR-CTCRI. 2023. *Quarterly Review Meeting of Scientists: Progress Report (October-December 2023)*, ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, 224 p.

Radio talks

1. Santhosh Mithra, V.S. 2023. *Smart farming: Enthu, enthinu* (Malayalam), in Vayalum veedum, All India Radio, Thiruvananthapuram, on 24 December 2023.
2. Santhosh Mithra, V.S. 2023. *Technology and new challenges in agriculture*, All India Radio, Thiruvananthapuram, on 11 March 2023.
3. Susan John. K. 2023. *INM in tropical tuber crops,* in Vayalum veedum, All India Radio, Thiruvananthapuram, on 7 July 2023.
4. Susan John. K. 2023. *Soils of Kerala and their nutrient requirement,* in Vayalum veedum, All India Radio, Thiruvananthapuram, on 1 October 2023.
5. Veena, S.S. 2023. *Kizhangu varga vilakalude vilaveduppu, sambharanam vithu samrakshanam* (Malayalam), All India Radio, Thiruvananthapuram, on 05 January 2023.
6. Veena, S.S. 2023. *Roga theevratha kuraykkan maracheeni nadumpol sradhiykkenda karyangal* (Malayalam), All India Radio, Thiruvananthapuram, on 09 June 2023.

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1. Harish, E.R. 2023. *Live phone-in programme on pest management of tuber crops* (Malayalam), Krishi Darshan, Doordarshan Kendra, Thiruvananthapuram, on 24 March 2023.
2. Jaganathan, D. 2023. *Drone applications in agriculture in Kanyakumari district,* News 18 Tamil Channel, on 06 August 2023.
3. Muthuraj, R. and Jaganathan, D. 2023. *Field day cum harvest festival on improved varieties of cassava for higher yield and profitable income in Namakkal district of Tamil Nadu*, DD Podhigai (Tamil), on 24 January 2023.
4. Santhosh Mithra, V.S. 2023. *Smart vilavinu smart krishi* in Kisan Krishideepam, Asianet, on 14 April 2023.
5. Sheela, M.N. 2023. *Tuber crop varieties developed by ICAR-CTCRI*, Doordarshan Kendra, Thiruvananthapuram, on 28 July 2023.

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.	29th Indian Convention of Food Scientist and Technologists-ICFoSt	Association of Food Scientists and Technologists, Thiruvananthapuram 07 January 2023	Dr. M.S. Sajeev
2.	International Conference on Recent Advances in Biological Science 2023	Inter University Centre for Evolutionary and Integrative Biology, Thiruvananthapuram 19 January 2023	Dr. K. M. Senthilkumar
3.	Scientific Advisory Committee Meeting	Krishi Vigyan Kendra, Kumarakom, Kottayam, Kerala 24 January 2023	Dr. G. Suja
4.	Review meeting of ICAR-CRP on Vaccines and Diagnostics	ICAR-IIVR Regional Centre, Bengaluru 24-25 January 2023	Dr. T. Makeshkumar
5.	National Conference on Agro-ecology based Agri-food Transformation System in zoom platform	27 January 2023	Dr. G. Suja
6.	2nd Indian Rice Congress	ICAR-NRRI, Cuttack 02 February 2023	Dr. Kalidas Pati
7.	Webinar on Innovations in Agricultural Marketing-Experiences of NIAM and Strategies for Tuber Crops	ICAR-CTCRI, Thiruvananthapuram 09 February 2023	All Scientists
8.	Institutional Biosafety Committee Meeting	ICAR-IISR, Kozhikode 14 February 2023	Dr. T. Makeshkumar
9.	Official Language Workshop organised for officers/officials of member offices in connection with the observance of Rajbhasha Parv 2022-23	TOLIC (office-1), Trivandrum Circle 21 February 2023	Dr. T.P. Sujatha
10.	Scientific Advisory Committee Meeting	Krishi Vigyan Kendra, Kollam 25 February 2023	Dr. Sheela Immanuel Dr. J. Sreekumar
11.	Scientific Advisory Committee Meeting	Krishi Vigyan Kendra, Mithranikethan, Thiruvananthapuram 28 February 2023	Dr. G. Suja
12.	Roving Seminar on the Patent Cooperation Treaty (PCT)	WIPO, IPC and ICAR-CTCRI, Thiruvananthapuram 03 March 2023	All Scientists
13.	International Women's Day Celebration	ICAR-CTCRI, Thiruvananthapuram 08 March 2023	All Staff Members
14.	Winter School on Approaches for Doubling Farmers Income through Secondary and Smart Agriculture: A Way Forward	CPCT, IARI, New Delhi 10-30 March 2023	Dr. K. Sunilkumar
15.	Scientific Seminar on Kerala Genome Data Centre	Kerala Development and Innovation Strategic Council (K-DISC), Thiruvananthapuram 13-14 March 2023	Dr. J. Sreekumar

16.	K-DISC Genomic Centre meeting	K-DISC, Thiruvananthapuram 14 March 2023	Dr. T. Makeshkumar
17.	Conclave on Millets, Agro & Food Processing Exports and Prospects of Industrial Biotechnology	CSIR-National Institute for Interdisciplinary Sciences (NIIST), Thiruvananthapuram 17 March 2023	Dr. M.S. Sajeev Dr. A.N. Jyothi Dr. C. Pradeepika
18.	Stakeholders Interface on Millets for Food and Nutrition	ICAR-CTCRI, Thiruvananthapuram 18 March 2023	All Scientists
19.	National Conference on Sustainable Microbial Bio-energy-Present and Future Perspectives (NCSMB-2023)	Sadakathullah Appa College, Tirunelveli 20 March 2023	Dr. C. Visalakshi Chandra
20.	International Seminar on New Horizons in Plant Sciences 2023 Emergent and Innovative Technologies in Plant Sciences	University of Kerala and Kerala University Botany Alumni Association, Thiruvananthapuram 21-23 March 2023	Dr. M.N. Sheela Dr. A. Asha Devi Dr. Shirly Raichal Anil Dr. C. Visalakshi Chandra
21.	Online Gene Editing Group Meeting	ICAR-CTCRI, Thiruvananthapuram 25 March 2023	Dr. T. Makeshkumar Dr. N. Krishna Radhika Dr. T.P. Sujatha Dr. K.M. Senthilkumar
22.	Meeting of the Odisha State Seed Sub-committee for Horticultural Crops	Krushi Bhawan, Bhubaneswar 28 March 2023	Dr. Kalidas Pati
23.	MoU signing with Digital University of Kerala	Digital University of Kerala, Thonnakkal, Thiruvananthapuram 25 April 2023	Dr. T. Makeshkumar
24.	World Intellectual Day Celebration	ICAR-CTCRI, Thiruvananthapuram 26 April 2023	Dr. S.S. Veena
25.	Webinar on Cocoponics/Soil less Culture-A New Method of Growing Vegetables and Medicinal Herbs in Terrace/Roof top	ICAR-DCR, Puttur 28 April 2023	Dr. H. Kesava Kumar
26.	Training on Innovation and Design Thinking: Train the Trainers for Mentors of K-DISC, Govt of Kerala	IIM-Kozhikode 03-05 May 2023	Dr. K. Sunilkumar
27.	23rd Annual Group Meeting of AICRP on Tuber Crops	BCKV, Kalyani, West Bengal 09-12 May 2023	Dr. G. Suja Dr. K. Laxminarayana Dr. S.S. Veena Dr. P. Murugesan Dr. A.N. Jyothi Dr. J. Sreekumar Dr. Shirly Raichal Anil Dr. V.S. Santhosh Mithra Dr. Kalidas Pati Dr. J. Sureshkumar
28.	Regional Workshop on PPV&FR Act, 2021 and Exhibition on Agro-biodiversity	ICAR-NRRI, Cuttack 11-12 May 2023	Dr. Kalidas Pati
29.	Brainstorming Session on SOP Preparation of Tapioca Starch and Sago	Sagoserve, Salem 17-18 May 2023	Dr. A.N. Jyothi Dr. M.S. Sajeev Dr. T. Krishnakumar Dr. J. Sreekumar
30.	Chertala Fest-Karapuram Karshika Kazchakal (Exhibition)	Cherthala, Alapuzha 19 May 2023	Dr. C. Visalakshi Chandra Dr. C. Pradeepika
31.	Brainstorming Meeting on Management of Mealybugs in Cassava: Present Status and Future Strategies	ICAR-CTCRI, Thiruvananthapuram 23 May 2023	All Scientists
32.	Review Meeting of ICAR-CTCRI with Hon'ble Minister of Agriculture and Farmers' Welfare, Govt. of India	Krishi Bhavan, New Delhi 31 May 2023	Dr. G. Byju Dr. V.S. Santhosh Mithra
33.	H.H. Sree Visakham Thirunal Endowment Lecture-2023	ICAR-CTCRI, Thiruvananthapuram 05 June 2023	All staff members

34.	7th Y.R. Sarma Memorial Lecture	ICAR-IISR, Kozhikode 09 June 2023	Dr. S.S. Veena
35.	National Training Conclave 2023	Capacity Building Commission, Pragathi Maidan, New Delhi 11 June 2023	Dr. Sheela Immanuel
36.	Phytochemical Techniques on Aromatic Plants Research	Central Instrumentation Facility, (KSCSTE-JNTBGRI), Palode, Thiruvananthapuram 15-16 June 2023	Dr. B.G. Sangeetha
37.	International Yoga Day	ICAR-CTCRI, Thiruvananthapuram 21 June 2023	All staff members
38.	Institutional Biosafety Committee Meeting	ICAR-CTCRI, Thiruvananthapuram 22 June 2023	Dr. G. Byju Dr. T. Makeshkumar Dr. M.L. Jeeva Dr. N. Krishna Radhika Dr. K.M. Senthilkumar
39.	Technology license agreement signing ceremony for bioformulations with M/s Green Edge AGRI Imports Pvt. Ltd, Trichy	ICAR-CTCRI, Thiruvananthapuram 22 June 2023	Dr. T. Makeshkumar Dr. M.L. Jeeva Dr. S.S. Veena Dr. E.R. Harish
40.	24th Meeting of Foodgrains, Allied Products & Other Agricultural Produce Sectional Committee FAD 16 (Online)	Bureau of Indian Standards (BIS), Government of India 26 June 2023	Dr. T. Krishnakumar
41.	Brain Storming Session on Policy Framing and Guidelines for Registration of Bio-stimulants (Online)	Indian Phytopathological Society, New Delhi 04 July 2023	Dr. S.S. Veena
42.	Inaugural Function of the Samagra Susthira Vikasana Padhathi program of Govt. of Kerala	Venganoor, Thiruvananthapuram 12 July 2023	Dr. K.M. Senthilkumar
43.	MoU signing Meeting	IIT- Palakkad Kanjikode, Palakkad 13 July 2023	Dr.T. Makeshkumar
44.	60th Foundation Day Celebration of ICAR-Central Tuber Crops Research Institute	ICAR-CTCRI, Thiruvananthapuram 22 July 2023	All staff members
45.	IPR Seminar on National Intellectual Property Festival	CSIR-NIIST, Thiruvananthapuram 26 July 2023	Dr. H. Kesava Kumar
46	Stakeholder Workshop on TEEB Agri-food Initiative in UP in Zoom Platform	PC Unit, ICAR-IIFSR, Modipuram 01 August 2023	Dr. S.S. Veena
47	Virtual Meeting on ICAR-CSR Guidelines	ICAR, New Delhi 03 August 2023	All Scientists
48.	Webinar on Wiley online Library: How it can help researchers? (Online)	CeRA 03 August 2023	Dr. M.L. Jeeva Dr. S.S. Veena Dr. K. Sunilkumar Dr.V. Ramesh Dr. T.P. Sujatha
49.	Online Review Meeting of the Genome Editing Project entitled 'Enabling climate resilience and ensuring food & nutritional Security through genome editing in horticultural crops'	ICAR-CTCRI, Thiruvananthapuram 07 August 2023	Dr. G. Suja Dr. T. Makeshkumar Dr. A.N. Jyothi Dr. N. Krishna Radhika Dr. T.P. Sujatha Dr. K.M Senthilkumar
50.	Zoom Meeting on Sparrow	ADG (ICT) ICAR, New Delhi 09 August 2023	Dr. M.L. Jeeva Dr. S.S. Veena
51.	Seminar on Cassava Cultivation and its Value Addition and Demonstrations on Drone Applications in Agriculture	Scott Christian College, Nagercoil 07 September 2023	Dr. R.Muthuraj Dr. H. Kesava Kumar Dr. T. Krishnakumar

52.	DPC meeting of CAS	ICAR-CPCRI, Kasaragod 09 September 2023	Dr. T. Makeshkumar Dr. G. Suja
53.	National Symposium on Plant Health Management: Current Trends and Novel Mitigation Strategies	IPS (South zone) and ICAR-CTCRI, Thiruvananthapuram 11-12 September 2023	Dr. T. Makeshkumar Dr. M.L. Jeeva Dr. Manas R. Sahoo Dr. C.Visalakshi Chandra Dr. S.S. Veena Dr. E.R. Harish Dr. H. Kesava Kumar Dr. B.G. Sangeetha Dr. R. Arutselvan Dr. L.S. Rajeswari Dr. S. Karthikeyan
54.	First Global Symposium on Farmers Rights	FAO, Rome, PPV&FRA 12-15 September 2023	Dr. Kalidas Pati
55.	Webinar on Role of Nanotechnology in Plant Disease Management	S.V. Agricultural College, Tirupati 21 September 2023	Dr. S.S. Veena
56.	Sensitization Workshop of ICAR-Agri-Business Incubation Centres (ABIs)	IPTM Unit of ICAR, New Delhi 21-22 September 2023	Dr. P. Sethuraman Sivakumar
57.	Workshop on SAMAGRA: Enabling the Incubator (A Sensitizing Workshop of ICAR-ABIs)	NASC complex, PUSA, New Delhi 21-22 September 2023	Dr. M. Nedunchezhiyan
58.	Brainstorming Session on Prospects of dsRNA Biopesticides for Crop Protection in Indian Agriculture (Online)	NAAS, New Delhi 26 September 2023	Dr. T. Makeshkumar Dr. S.S. Veena Dr. E.R. Harish Dr. H. Kesava Kumar Dr. B.G. Sangeetha
59.	6th CWSS International Conference on Agricultural Innovations for Sustainable Development Goals with Special Focus on Natural Farming (AISDGONF-2023)	BCKV, Kalyani, West Bengal 30 September-02 October 2023	Dr. J. Suresh Kumar
60.	Global Micronutrient Summit 2.0	Leela Palace Hotel, New Delhi 05-06 October 2023	Dr. K. Susan John
61.	Brainstorming on Chinese Potato for Empowering Stakeholders: Challenges and Strategies	ICAR-CTCRI, Thiruvananthapuram 06 October 2023	All Scientists
62.	Brain Storming Think Tank 2023 organized by Dean, Horticulture, Tamil Nadu Agricultural University and presented on the topic Future research focus in tropical tuber crops in Google Meet	09 October 2023	Dr. G. Suja
63.	Institute Biosafety Committee Meeting	College of Agriculture, Vellayani, Thiruvananthapuram 09 October 2023	Dr. T. Makeshkumar
64.	XVI Agricultural Science Congress and ASC Expo, Transformation of Agrifood Systems for Achieving Sustainable Development Goals	NAAS, New Delhi and ICAR-CMFRI, Kochi 10-13 October 2023	Dr. A. N. Jyothi Dr. J. Sreekumar Dr. D. Jaganathan Dr. N. Krishna Radhika
65.	World Food Day Talk (Online)	ICAR Alumni Association and IARI, New Delhi 17 October 2023	Dr. M.L. Jeeva
66.	International Seminar on Exotic and Underutilized Horticultural Crops: Priorities and Emerging Trends	ICAR-IIHR, Bengaluru 17-19 October 2023	Dr. K.I. Asha Dr. N. Krishna Radhika

67.	Institutional Biosafety Committee Meeting	ICAR-IISR, Kozhikode 18 October 2023	Dr. T. Makeshkumar
68.	Workshop on Greener Cities, Healthier Lives: Urban Agriculture Unleashed	French Institute of India and Alliance Francaise, Thiruvananthapuram and College of Agriculture, Vellayani 18 October 2023	Dr.V.S. Santhosh Mithra
69.	Hindi Workshop on Role of Official Language Implementation in Central Government Offices	ICAR-CTCRI, Thiruvananthapuram, 20 October 2023	Dr. H. Kesava Kumar
70.	State Level Conference on Rabi Campaign 2023-24	Loka Seva Bhavan, Bhubaneswar 20 October 2023	Dr. K. Laxminarayana
71.	All India Seminar on Processing and Value Addition in Agriculture for Increasing Farmers Income-An Engineering Perspective	Institution of Engineers (India), Kerala State Centre, Thiruvananthapuram 25-26 October 2023	Dr. M.S. Sajeev
72.	Sensitization Meeting for Data Collection for Calculation of Ecosystem Services of Natural Farming Experiments under AINPOF in zoom platform	26 October 2023	Dr. G. Suja
73.	Awareness-cum-Training Programme on Provisions of the Protection of Plant Varieties and Farmers Rights (PPVFRA) Act, 2001 at Namakkal, Tamil Nadu	26 October 2023	Dr. R. Muthuraj
74.	Workshop on Challenges and Opportunities in Horticulture for Doubling Farmers' Income	Krishi Vigyan Kendra, Khordha, ICAR-CIFA, Bhubaneswar 27 October 2023	Dr. K. Laxminarayana
75.	International Conference on Biochemical and Biotechnological Approaches for Crop Improvement (IBBACI 2023)	SPBB and ICAR-IARI, New Delhi 30 October-01 November 2023	Dr. B.G. Sangeetha Dr. C. Pradeepika
76.	International Workshop on Food Loss & Waste Prevention in the South Asian Region	Division of Agricultural Engineering, ICAR, New Delhi 30 October-01 November 2023	Dr. M.S. Sajeev
77.	Meeting on Cultivation Practices and Pest Management in Chinese Potato	Govindaperi village, Tenkasi 01 November 2023	Dr. H. Kesava Kumar
78.	Karshika Seminar in the Keraleeyam	Kerala State Legislative Complex, Thiruvananthapuram 02 November 2023	Dr. G. Suja
79.	Online Workshop on Biological Data Exploration and Visualisation using R	ICAR-IISR, Kozhikode 06-08 November 2023	Dr. J. Sreekumar Dr. S.N. Rahana Dr. E.R. Harish
80.	10th Indian Horticulture Congress	Assam Agricultural University & IAHS, Jorhat, Assam 06-09 November 2023	Dr. P. Murugesan
81.	Webinar on Calcium Conference	09 November 2023	Dr. K. Susan John
82.	Expert Discussion Event on A taste of the future: What's next for safety and quality testing in the food industry? (Online)	Separation Science (www.sepscience.com) 16 November 2023	Dr. T. Krishnakumar
83.	Preliminary Meeting for Variety Release in Horticultural Crops	Krushi Bhawan, Bhubaneswar 17 November 2023	Dr. Kalidas Pati
84.	Webinar on DUS and PVP Data Management	17 November 2023	Dr. Kalidas Pati
85.	Seminar on Modern Day Challenges and Opportunities in Kerala's Agriculture under the auspices of Coir Board and Bharatiya Kisan Sangh	ICAR-CTCRI, Thiruvananthapuram 20-21 November 2023	Dr. V.S. Santhosh Mithra
86.	National Symposium on Climate Smart Agronomy for Resilient Production Systems and Livelihood Security, ICAR-Central Coastal Agricultural Research Institute, Goa	22-24 November 2023	Dr. G. Suja

87.	National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR 2023)	ICAR-CTCRI, Thiruvananthapuram 28-29 November 2023	All Scientists and Technical Personnel
88.	Annual Project Review Meeting under TMOC scheme of the Coconut Development Board funded project titled Soil health management in coconut-based cropping system involving tuber crops for enhanced yield and income (Online)	Coconut Development Board, Kochi 01 December 2023	Dr. D. Jaganathan
89.	National Conference on Advancements in Global Virus Research Towards One Health	IVS, New Delhi and ICAR-NRCB, Tiruchirappalli 01-03 December 2023	Dr. M.N. Sheela Dr. T. Makeshkumar Dr. M.L. Jeeva
90.	World Soil Day	ICAR-CTCRI, Thiruvananthapuram 05 December 2023	All staff members
91.	Workshop on J-Gate@CeRA	TNAU, Coimbatore 05 December 2023	Dr.V. Ramesh
92.	National Seminar on Soil and Water Symbiosis for Sustainable Agriculture	College of Agriculture, Vellayani 06 December 2023	Dr.V.S. Santhosh Mithra
93.	Review meeting of ICAR Institutes by Secretary, DARE and DG, ICAR, New Delhi (Online)	ICAR, New Delhi 14 December 2023	Dr. G. Byju Dr. K.I. Asha Dr. K. Susan John Dr. S.S. Veena Dr. D. Jaganathan Dr. H. Kesava Kumar
94.	State Level Project Screening Committee (SLPSC) Meeting of RKVY	Lok Seva Bhawan, Bhubaneswar 19 December 2023	Dr. Kalidas Pati
95.	Workshop on Sexual Harassment at the Workplace Law	Partners for Law in Development and Sakhi Women's Resource Centre, Thiruvananthapuram 20 December 2023	Dr. S.S. Veena

Visits Abroad

Name of the Scientist	Period	Place of visit	Purpose
Dr. G. Byju	10-12 October 2023	Bangkok, Thailand	To present invited talk on 'Advances in nutrient management in root and tuber crops' at the IFA Crossroads Asia Pacific 2023 Conference
Dr. Shirly Raichal Anil Dr. C. Visalakshi Chandra	15-20 October 2023	International Potato Center (CIP), Lima, Peru	To attend training on marker-assisted selection and related molecular breeding tools

Distinguished Visitors

1. Dr. Himanshu Pathak, Secretary, Department of Agricultural Research and Education & Director General, Indian Council of Agricultural Research, New Delhi.
2. Dr. Bikash Mandal, Assistant Director General, International Relations, Indian Council of Agricultural Research, New Delhi.
3. Padma Shri Prof. T. Pradeep, Institute Professor, IIT Madras, Chennai.
4. Dr. N.K. Krishna Kumar, Former Deputy Director General (Horticultural Science), Indian Council of Agricultural Research, New Delhi.
5. Dr. S.K. Pandey, Former Director, ICAR-Central Potato Research Institute, Shimla.
6. Dr. K. Umamaheswaran, Former Professor, Kerala Agricultural University.
7. Dr. Sanjaya Kumar Dash, Dean, College of Agriculture & Technology, Odisha University of Agriculture and Technology, Bhubaneswar.
8. Dr. H. Philip, Former Director of Extension, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu.
9. Dr. Stephen Winter, Department Plant Viruses, Leibniz, Institute DSMZ, German collection of microorganisms and cell cultures GmbH, Braunschweig, Germany.
10. Prof. Dr. E. Balaguruswamy, Former Member, Union Public Service Commission and Chairman, Tamil Nadu Planning Commission and Vice-Chancellor, Anna University.
11. Dr. K. Ramasamy, Former Vice-Chancellor, Tamil Nadu Agricultural University, Vice Chancellor of Karpagam Academy of Higher Education, Coimbatore, Chancellor of Karpagam Academy of Higher Education.
12. Prof. Dr. P. Rajendran, Former Vice-Chancellor, Kerala Agricultural University.
13. Dr. B. Neeraja Prabhakar, Vice Chancellor, Sri Konda Laxman Telangana State Horticultural University, Telangana.
14. Dr. Mohanan Kunnummal, Vice-Chancellor, Kerala University of Health Sciences and University of Kerala.
15. Shri. V. Palaniswamy IIS, Additional Director General, Press Information Bureau, Thiruvananthapuram.

16. Smt. Silpa V. Kumar IFS, Conservator of Forest, Government of Kerala.
17. Dr. K. Aravindakshan, Former Registrar, Kerala Agricultural University.
18. Prof. P.V. Balachandran, Former Director of Extension, Kerala Agricultural University.
19. Dr. Jacob John, Director of Extension, Kerala Agricultural University, Thrissur.
20. Dr. Achuth Shankar S. Nair, Professor, Department of Computational Biology and Bioinformatics, University of Kerala.
21. Ms. Christine Bonvallet, Director, PCT International Cooperation Division, Patents and Technology Sector, WIPO.
22. Dr. Suma Divakar, Professor, Department of Community Science, College of Agriculture, Vellayani,Thiruvananthapuram.
23. Dr. S. Gopakumar, Nodal Officer to the Commission and Director of Education, KAU.
24. Dr. S.K. Chakrabarti, Former Director, ICAR-CTCRI, Thiruvananthapuram.
25. Dr. V. Ravi, Former Director (A), ICAR-CTCRI, Thiruvananthapuram.
26. Dr. K.B. Hebbar, Director, ICAR-CPCRI, Kasaragod.
27. Dr. R. Dinesh, ICAR-Indian Institute of Spices Research, Kozhikode.
28. Dr. A. Gopalakrishnan, Director, ICAR-Central Marine Fisheries Research Institute, Kochi.
29. Dr. George Ninan, Director, ICAR-Central Institute of Fisheries Technology, Kochi.
30. Dr. P. Irene Vethamoni, Dean (Horticulture), Tamil Nadu Agricultural University, Coimbatore.
31. Dr. Sheeba Rebecca Isaac, Associate Director of Research, RARS, Kumarakom, Kerala.
32. Dr. Sabu Joseph, Professor and Director, School of Earth Sciences, University of Kerala.
33 Sh. B. Anil, Deputy Director, Central Hindi Directorate, Ministry of Education, Govt. of India.
34. Smt. K.R. Ranjini, Assistant Director (OL) and Member Secretary, TOLIC-I.
35. Shri. T. Rangarajan, Assistant Director (OL), Southern Air Command, Thiruvananthapuram.

Personnel

Scientific Staff

Headquarters, Thiruvananthapuram	
Dr. M.N. Sheela (till 22.01.2023)	Director (Acting)
Dr. G. Byju (wef 23.01.2023)	Director
Division of Crop Improvement	
Dr. M.N. Sheela	Principal Scientist (Genetics and Plant Breeding) & Head (Acting) (till 20.03.2023); Principal Scientist (Genetics and Plant Breeding)
Dr. P. Murugesan	Principal Scientist (Vegetable Science) & Head (Acting) (till 12.07.2023); Principal Scientist (Vegetable Science)
Dr. Manas Ranjan Sahoo	Principal Scientist (Horticulture) & Head (wef 13.07.2023)
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	Scientist (Genetics and Plant Breeding)
Dr. K.M. Senthilkumar	Scientist (Agricultural Biotechnology)
Dr. T.P. Sujatha	Scientist (Agricultural Biotechnology)
Dr. S.N. Rahana	Scientist (Genetics and Plant Breeding) (wef 12.10.2023)
Division of Crop Production	
Dr. G. Byju	Principal Scientist (Soil Science) & Head (Acting) (till 22.01.2023)
Dr. G. Suja	Principal Scientist (Agronomy) & Head (Acting) (till 09.07.2023) & Head (wef 10.07.2023)
Dr. K. Susan John	Principal Scientist (Soil Science)
Dr. S. Sunitha	Principal Scientist (Agronomy)
Dr. K. Sunilkumar	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. M.L. Jeeva	Principal Scientist (Plant Pathology) & Head (Acting) (till 12.04.2023); Principal Scientist (Plant Pathology)
Dr. S.S. Veena	Principal Scientist (Plant Pathology) & Head (Acting) (till 09.07.2023); Principal Scientist (Plant Pathology)
Dr. T. Makeshkumar	Principal Scientist (Plant Pathology) & Head (wef 10.07.2023)
Dr. C.A. Jayaprakas (Rtd. 31.05.2023)	Principal Scientist (Agricultural Entomology)
Dr. E.R. Harish	Senior Scientist (Agricultural Entomology)
Dr. H. Kesava Kumar	Senior Scientist (Nematology)
Dr. B.G. Sangeetha	Scientist (Agricultural Biotechnology)
Section of Crop Utilization	
Dr. M.S. Sajeev	Principal Scientist (Agricultural Structures & Process Engineering) & Scientist in charge (till 01.01.2023); Principal Scientist (Agricultural Structures & Process Engineering)
Dr. A.N. Jyothi	Principal Scientist (Agricultural Chemicals) & Scientist in charge (wef 02.01.2023)
Dr. Pradeepika Chintha	Scientist (Vegetable Science)
Dr. T. Krishnakumar	Scientist (Agricultural Structures & Process Engineering)

Section of Extension and Social Sciences	
Dr. Sheela Immanuel	Principal Scientist (Agricultural Extension) & Scientist in charge (till 01.01.2023); Principal Scientist (Agricultural Extension)
Dr. J. Sreekumar	Principal Scientist (Agricultural Statistics) & Scientist in charge (wef 02.01.2023)
Dr. V.S. Santhosh Mithra	Principal Scientist (Computer Applications & IT)
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	Technical Officer
Shri. A.S. Manikuttan Nair	Technical Officer
Shri. G. Suresh	Technical Officer
Dr. S. Shanavas	Technical Officer
Dr. B.S. Prakash Krishnan	Technical Officer
Shri. G. Shajikumar	Technical Officer
Smt. B.S. Deepa	Senior Technical Assistant
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	Senior Technician
Shri. D.T. Rejin	Senior Technician
Shri. T.M. Shinil	Senior Technician
Shri. T. Manikantan Nair	Technician
Shri. K. Chandran	Technician
Smt. S.S. Sneha	Technician
Smt. R. Nijamol	Technician
Shri. Sreenath Vijay	Technician
Smt. Rini Alocious	Technician
Administrative and Accounts Staff	
Shri. T.D.S. Prakash (till 21.02.2023)	Senior Finance and Accounts Officer
Shri. S. Bhadra Kumar (wef 08.03.2023)	Senior Administrative Officer (i/c)
Smt. Jessymol Antony (wef 20.02.2023)	Senior Finance and Accounts Officer (i/c)
Shri. T. Vijayakumara Kurup	Assistant Administrative Officer
Shri. A. Lakshmana Rao (wef 05.01.2023)	Assistant Administrative Officer
Shri. S. Sasikumar	Private Secretary
Shri. M. Padmakumar (Rtd.31.05.2023)	Private Secretary
Smt. L. Saritha	Personal Assistant
Smt. S. Sunitha	Personal Assistant
Smt. B. Presanna (Rtd.31.05.2023)	Assistant
Shri. P.S. Suresh Kumar (Rtd.30.06.2023)	Assistant
Shri. J. Unni (till 30.07.2023)	Assistant

Shri. K. Unnikrishnan Nair (VRS on 01.04.2023)	Assistant
Shri. S. Sreekumar	Assistant
Shri. O.C. Ayyappan	Assistant
Shri. R.S. Adarsh	U.D.C.
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.
Smt. S. Anjitha	L.D.C.
Skilled Support Staff	
Shri. P. Udayakumar (Rtd.31.10.2023)	Skilled Support Staff
Shri. K. Saratchandra Kumar	Skilled Support Staff
Shri. G. Madhu	Skilled Support Staff
Shri. S. Radhakrishnan Nair	Skilled Support Staff
Shri. T. Lawrence (Rtd.31.07.2023)	Skilled Support Staff
Shri. K. Sivadas	Skilled Support Staff
Shri. L. Samynathan	Skilled Support Staff
Shri. S. Sreekumaran	Skilled Support Staff
Smt. 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	Principal Scientist (Soil Science) & Scientist in charge
Dr. M. Nedunchezhiyan	Principal Scientist (Agronomy)
Dr. Kalidas Pati	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. Bibhuti Bhusan Das	Senior Technical Officer
Shri. Pramod Kumar Mati	Technical Officer
Shri. Sushanta Kumar Jata	Technical Officer
Shri. Keshab Paikaray	Senior Technician
Administrative Staff	
Shri. P.K. Acharya (Rtd. 31.01.2023)	Principal Private Secretary
Shri. J. Unni (wef 31.07.2023)	Assistant
Shri. Amit Vengraj (till 16.08.2023)	U.D.C.
Skilled Support Staff	
Shri. Babuli Sethi	Skilled Support Staff
Shri. Prakash Kumar Nayak	Skilled Support Staff

Other Information

Second Meeting of the IX Research Advisory Committee

The second meeting of IX RAC of ICAR-CTCRI was held during 12-13 April 2023 at ICAR-CTCRI, Thiruvananthapuram. Dr. N.K. Krishna Kumar, Former DDG (Hort. Sci.), ICAR chaired the meeting. Dr. G. Byju, Director, ICAR-CTCRI welcomed the Chairman and members. He made a presentation on Institute profile and significant research achievements and briefed about the achievements of AICRP on tuber crops. The constitution of IX RAC is given below.

IX RAC of ICAR-CTCRI

1.	Dr. N.K. Krishna Kumar, Former DDG (Horti. Sci.), ICAR, New Delhi	Chairman
2.	Dr. S.K. Pandey, Former Director, ICAR-CPRI, Shimla	Member
3.	Dr. K. Umamaheswaran, Former Professor, College of Agriculture, Vellayani, Thiruvananthapuram	Member
4.	Dr. Sanjaya Kumar Dash, Dean, College of Agricultural Engineering & Technology, OUAT, Bhubaneswar	Member
5.	Dr. H. Philip, Former Director (Extension), TNAU, Coimbatore	Member
6.	Dr. Sudhakar Pandey, ADG (HS-I), ICAR, KAB-II Pusa, New Delhi	Member
7.	Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram	Member
8.	Dr. P. Murugesan, Principal Scientist, ICAR-CTCRI Thiruvananthapuram	Member Secretary

The action taken report of the first meeting of IX RAC was presented and approved. The project leaders presented the salient achievements of eight ongoing Institute projects and the targets for 2023-24. The chairman and members emphasized the research focus on doubling farmers' income, strategic, anticipatory and adaptive research along with smart tools in the context of gene editing, climate change, digital farming, bio-fortification, and aligning the research activities as per vision 2050. The team also visited the Institute farm, museum and techno incubation centre. The meeting was coordinated by Dr. P. Murugesan, Principal Scientist & Member Secretary.

49th Meeting of Annual Institute Research Council

The 49th Annual Institute Research Council (IRC) meeting of ICAR-CTCRI was held during 17-20 April 2023. The meeting was inaugurated on 17 April 2023 by Dr. G. Byju, Director and Chairman, IRC. The Director made a presentation on salient research achievements and targets of ICAR-CTCRI. During his inaugural speech, he congratulated all the scientists and other staff members for their dedication and commitment towards research programmes because of which ICAR-CTCRI has bagged the 14th position in the ranking among 93 ICAR Institutes during 2022. The Chairman urged all the scientists to apply for external aided projects, publish research papers in high rated journals, generate revenue through technology commercialization, consultancy and sale of technological products besides undertaking research and extension programmes. The Director also informed that the scientists are expected to deliver 'One Scientist One Product' (OSOP) for which the Institute has recently published a document on 'One Scientist One Product for the year 2023' as per the suggestion by the Secretary, DARE and Director General, ICAR, New Delhi.

Under the chairmanship of the Director, all the 42 projects under 8 Institute mega projects and 3 developmental projects viz., SCSP, TSP and NEH were presented by the respective project leaders in five sessions viz., Crop Improvement, Crop Production, Crop Protection, Crop Utilization and Extension & Social Sciences during 17-20 April 2023. Significant achievements and outputs of all the projects were thoroughly discussed and the technical programme and targets for the year 2023-2024 were finalized. Six new project proposals and three new experiments under ongoing research projects were presented and approved during the meeting. Twenty four externally aided projects of the Institute were also discussed during the meeting. The

meeting was chaired by Dr. G. Byju, Director and co-chaired by Dr. J. Sreekumar, SIC, Extension & Social Sciences; Dr. S.S. Veena, Head (A), Crop Protection; Dr. A.N. Jyothi, SIC, Crop Utilization; Dr. G. Suja, Head (A), Crop Production; Dr. P. Murugesan, Head (A), Crop Improvement and Dr. K. Laxminarayana, SIC, RS, Bhubaneswar. Dr. T. Makeshkumar, SIC, PME Cell convened the meeting. Dr. D. Jaganathan, Senior Scientist and Member Secretary organized the 49th IRC meeting.

23rd Annual Group Meeting of the All India Coordinated Research Project on Tuber Crops

The 23rd annual group meeting (AGM) was held at Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani, West Bengal during 10-12 May 2023. Dr. Anand Kumar Singh, Deputy Director General (Hort. Sci.), ICAR; Dr. Sudhakar Pandey, Assistant Director General (FVS & MP), ICAR; scientists from 21 centres, external experts, Heads of Divisions and nominated scientists of ICAR-CTCRI participated in the deliberations. There were seven sessions including the session on action taken report (ATR) of recommendations of 22nd AGM. A critical and constructive evaluation of different programmes carried out by different centres was done and recommendations for future action are included in the proceedings. Fifteen entries (cassava: 3, greater yam: 4, eddoe taro: 4, dasheen taro: 3 and elephant foot yam: 1) were recommended for release. Six crop production and protection technologies have also been recommended for inclusion in package of practices (PoP) of different agro-climatic zones (ACZ) in India. The best centre award for 2022-2023 was shared by Dr. YSRHU, Peddapuram and Dr. YSRHU, Kovvur, the two AICRP TC centres of Dr. YSRHU, Andhra Pradesh.

Tuber Crops Day

The Regional Station of ICAR-Central Tuber Crops Research Institute, Bhubaneswar along with PREM (NGO) organized 'Tuber crops day' on 18 January 2023 at Dimiripongala village, Mohana block, Gajapati district. Dimiripongala is a model village and free from alcohol consumption. Dr. N.K. Krishna Kumar, former DDG (Hort.), ICAR, Bangalore was the Chief Guest of the function and Dr. M.N. Sheela, Director (A), ICAR-CTCRI, Thiruvananthapuram planted a tree in the village and inaugurated 'Community Washing Centre' and dedicated to Dimiripongala village. Dr. N.K. Krishna Kumar inaugurated the exhibition, wherein tribal farmers exhibited various products of tuber crops, millets, cereals, pulses, vegetables, honey etc. They also exhibited models of nutri-gardens (circular model, rectangular model and model for landless farmers).

Mr. Sivaprasad Acharya, Project manager, PREM (NGO) anchored the 'Tuber crops day' programme. Dr. K. Laxminarayana, Head, Regional Station of ICAR-CTCRI, Bhubaneswar welcomed the delegates and tribal farmers and spoke about the activities Regional Station of ICAR-CTCRI and importance of root and tuber crops in food and nutrition. Dr. M. Nedunchezhiyan, Principal Scientist & PI (TSP), Regional Station gave a brief account about TSP activities in Odisha and specially in Gajapati district. In Gajapati district we have adopted 100 tribal farmers and distributed planting materials of tuber crops (greater yam, elephant foot yam, taro, biofortified sweet potato varieties, Bhu Sona and Bhu Krishna, yam bean, cassava), vegetable seeds, small implements (crow-bar, sickle, pick-axe, spade, sprayer and hand-hoe) for reducing drudgery in field operations and also chicks (10 nos. each farmers) were distributed to reduce malnutrition and livelihood improvement. Dr. M.N. Sheela, Director (A), ICAR-CTCRI gave presidential address on the 'Role of root and tuber crops in livelihood improvement'. Dr. N.K. Krishna Kumar, Dr. M.N. Sheela and Mr. Jacob Thundyil distributed awards to five best tuber crops tribal farmers and five best tuber crops exhibiters. The tribal women farmers spoke about the benefits accrued by them through TSP project. They expressed that their livelihood has improved due to tuber crops intervention along with vegetable and poultry farming. Dr. N.K. Krishna Kumar highlighted the importance of tuber crops in the livelihood of tribal farmers. He also stressed holistic development of villages through TSP. Mr. Jacob Thundyil, President, PREM (NGO) briefed about the model village of Dimiripongala. It is alcohol free village having community computer center, solar lights, toilets for each household and education for all the children and appreciated the contribution made by ICAR-CTCRI. Mr. Rajendra Dora, PREM, Project Co-ordinator proposed the vote of thanks.

Institute Biosafety Committee Meeting (IBSC)

The Institute Biosafety Committee Meeting (IBSC) was held at ICAR-CTCRI, Thiruvananthapuram on 22 June 2023 to review the rDNA based research projects. Dr. G. Byju, Director, ICAR-CTCRI & Chairman, IBSC; Dr. R. Selvarajan, Principal Scientist, ICAR-NRCB, Tiruchirapalli, DBT Nominee; Dr. T. Bindu, Medical Officer, Govt. of Kerala, Thiruvananthapuram, Biosafety Officer; Dr. A. Ishwara Bhat, Principal Scientist, ICAR-IISR, Kozhikode, External expert; and Internal experts, Dr. M.N. Sheela, Principal Scientist; Dr. M.L. Jeeva, Principal Scientist; Dr. T. Makeshkumar, Principal Scientist & SIC, PME and Dr. K.M. Senthilkumar, Scientist attended the meeting and reviewed the progress of rDNA-based research projects of ICAR-CTCRI. The committee members appreciated the scientists for strict adherence to the biosafety guidelines at the research laboratories of the Institute.

Webinar on Innovations in Agricultural Marketing-Experiences of NIAM and Strategies for Tuber Crops

A webinar on 'Innovations in agricultural marketing-Experiences of NIAM and strategies for tuber crops' was organized on 09 February 2023 in collaboration with Chaudhary Charan Singh National Institute of Agricultural Marketing, Rajasthan, to understand the roles and functions of NIAM and to discuss the scope for collaboration between NIAM and ICAR-CTCRI for strengthening tuber crops marketing sector. Dr. G. Byju, Director, ICAR-CTCRI, delivered the presidential address and highlighted that tuber crops are mostly grown by small and marginal farmers and disadvantaged population. He also emphasized that the major tuber crops like cassava and sweet potato have short and medium shelf life and price fluctuation occurs based on demand and supply which need to be addressed through technological and policy interventions. Dr. Shuchi Mathur, Assistant Director, CCS NIAM, Rajasthan delivered an expert lecture on the topic. The scope and possibilities for collaborations in the areas of training, education, research and startups were discussed. Scientists, technical and project staff of ICAR-CTCRI participated in the webinar.

Farmer Innovator Meet

A Farmer Innovator Meet was organized at Tamil Nadu Veterinary and Animal Sciences University (TANUVAS) Satellite Incubation Centre on 24 February 2023. During the meeting, two farmers innovations i.e., traditional food products from cassava and a modified rat trap were assessed for scaling up. Ten farmers and five scientists participated in the meet.

MoU signed with Digital University of Kerala (DUK) and MG University

The ICAR-CTCRI signed MoU with Digital University of Kerala (DUK). Dr. Saji Gopinath, Vice Chancellor, DUK and Dr. G. Byju, Director, CTCRI signed the MoU on 02 March 2023 in the presence of Deans and higher officials of the University. Ph.D. Scholars from the University will be allotted to ICAR-CTCRI and National & International collaborative research programmes of common interest will be developed in future.

Another MoU was signed with MG University, Kottayam for possible collaborations in various fields of biosciences including biotechnology, biochemistry, microbiology, climate change, nanotechnology, smart farming as well as processing & value addition. Prof. Sabu Thomas, Vice Chancellor, MG University and Dr. G. Byju, Director, CTCRI signed the MoU on 27 March 2023. This bilateral relation between a university and a national research institute will help in transforming agricultural sector by solving many issues of the society at large.

International Seminar on Patent Cooperation Treaty (PCT)

Indian Patent Office (IPO) in collaboration with the World Intellectual Property Organization (WIPO) conducted an International Seminar on Patent Cooperation Treaty (PCT) at ICAR-CTCRI on 03 March 2023 to promote the awareness in respect of protecting the intellectual property and innovations globally through PCT. Dr. G. Byju, Director, ICAR-CTCRI in his presidential address emphasized the importance of intellectual property rights for innovations. Ms. Lisa Jorgenson, Deputy Director General, Patents and Technology Sector, WIPO, Geneva in her video address stated that there was an increasing trend of patent filing in Asian countries with a world share of 66% filing during 2022. At present the e-filing system is cost effective and WIPO is committed to innovators for providing help in filing and protecting their rights globally. Ms. Christine Bonvallet, Director, PCT International, Cooperation Division, Patents and Technology Sector, WIPO, in her special address highlighted the steady growth of PCT filing in India in recent years and the growth of 60% in last decade and the role of WIPO in achieving this. Mr. P.H. Kurian, Chairman K-RERA and Ex CGPDEM, IPO delivered the inaugural speech in which he emphasized the need for increase in patent filing in tune with the economic growth of India. In last year, Indian share is only 2000 out of 2.78 lakhs globally. More innovation need to come from R & D institutions and a share of the income from commercialization should pump back to help patent filing. The seven technical sessions were handled by experts from WIPO & IP offices and about 270 participants attended the seminar.

Celebration of International Women's Day

International Women's Day 2023 was celebrated on 08 March 2023 under the presidentship of Dr. G. Byju, Director, ICAR-Central Tuber Crops Research Institute. Smt. Silpa V. Kumar IFS, Conservator of Forest, Kerala Forests & Wildlife Department delivered a speech on the focal theme, 'DigitALL: Innovation and technology for gender equality'. In connection with the event, competitions, viz., logo making, essay and painting competitions were conducted for the women at ICAR-CTCRI. The chief guest honored Women Achievers of ICAR-CTCRI for the year 2022.

International Year of Millets (IYoM) Programmes

A live web telecast of the inauguration of International Millet Conference by Hon'ble Prime Minister and Stakeholders interface on millets for food and nutrition was organized at ICAR-CTCRI on 18 March

2023. Dr. Suma Divakar, Professor, Department of Community Science, College of Agriculture, Vellayani, Thiruvananthapuram delivered a lecture cum discussion on 'Value addition of millets for health and food security' during the interface. More than 100 farmers, students and staff of ICAR-CTCRI, Thiruvananthapuram and other stakeholders attended the programme. Sixty farmers from Balasore district of Odisha, 20 staff and students from Regional Station of ICAR-CTCRI, Bhubaneswar attended the programme.

Biofortified Sweet Potato and Millet Food Festival

ICAR-CTCRI, Thiruvananthapuram along with NEHU Incubator, NEHU, Tura, Meghalaya organized a 'Biofortified sweet potato and millet food festival' on the theme 'Converging the goodness of millets with healthy sweet potato' on 23 March 2023 at Tura under the 'Indradhanush Aahaar Abhiyaan' (Rainbow Diet Campaign) programme as a part of the International Year of Millets campaign to encourage the students to develop and promote innovative recipes by integrating millets and bio-fortified sweet potato. The programme was inaugurated by Prof. Sujata Gurudev, Pro-Vice Chancellor of NEHU. Fifty stakeholders including government officials, private companies, NEHU faculties and students. Twenty recipes by integrating purple-fleshed sweet potato var. Bhu Krishna and millets viz., muffins, cakes, pakkodas, paratha, kheer, baked chips and halwa were prepared and showcased.

Millets Museum at ICAR-CTCRI

With an aim to create awareness and increase production and consumption of millets, Government of India had proposed to the United Nations General Assembly for declaring 2023 as the International Year of Millets (IYoM 2023). To commemorate this, ICAR-CTCRI has established a millet museum at the Institute comprising nine millets viz., sorghum, pearl millet, finger millet, foxtail millet, proso millet, kodo millet, barnyard millet, little millet and brown top millet was established at the Institute premises on 28 April 2023. It was inaugurated by Dr. G. Byju, Director, ICAR-CTCRI, in the presence of the staff of the Institute. Students, farmers and other stakeholders who are visiting the Institute are also taken to the millet museum and explained about the nutritive value and importance of millets in our daily life.

Under the IYoM programme, awareness campaigns on Nutritive value of millets and value addition was conducted in four MGMG villages viz; Karakulam (30 May 2023), Muttakkadu (02 June 2023), Thiruvallam (15 June 2023) and Saigramam (09 August 2023) and at ICAR-CTCRI, Thiruvananthapuram (20 June 2023). More than 180 farmers and farm women participated.

Brainstorming Meeting on Mealybugs in Cassava

Mealybugs are serious pests of a number of crops including cassava, the fifth most produced staple food crop of the world. The introduction of a parasitoid wasp, *Anagyrus lopezi* by ICAR-National Bureau of Agricultural Insect Resources (NBAIR) in 2021 and its subsequent release in Tamil Nadu in 2022 and in Thrissur during April 2023 for biological control of cassava mealybug assumes great importance. Considering the gravity of the problem, ICAR-CTCRI, Thiruvananthapuram organized a one-day brainstorming meeting on 23 May 2023 for bringing together scientists from NBAIR, ICAR-CTCRI, Kerala Agricultural University and Tamil Nadu Agricultural University along with different stakeholders including officials from all Krishi Vigyan Kendras (KVKs) in Kerala, State Department of Agriculture & Farmers Welfare, progressive farmers and students. Dr. S.C. Dubey, Assistant Director General (Plant Protection & Biosafety), ICAR, New Delhi and Dr. S.N. Sushil, Director, NBAIR, Bengaluru were present to prepare the roadmap.

The parasitoid wasps were released in cassava fields and distributed to officials of agriculture department, progressive farmers, eight KVKs from Kerala and also from Tamil Nadu and Maharashtra. Five important topics were discussed by experts, which were (i) Hurdles in the management of mealybugs in agricultural crops (Dr. C.A. Jayaprakas, ICAR-CTCRI), (ii) Management of mealy bugs using entomopathogenic fungi (Dr. O.P. Reji Rani, KAU), (iii) Mass culturing technique of cassava mealybug parasitoid, *Anagyrus lopezi* (Dr. Sampath Kumar, NBAIR), (iv) Management of *Paracoccus marginatus* in cassava (Dr. M.T. Ranjith, KAU) and (v) Status of cassava mealybugs in Salem district and other cassava growing areas of Tamil Nadu and their management strategies (Dr. P.A. Saravanan, TNAU).

In the plenary session of panel discussion, experts in the field interacted and addressed all queries raised by different stakeholders. Dr. G. Byju, Director, ICAR-CTCRI, in his concluding remarks said that a policy document on management of mealybugs infesting cassava will be prepared considering all the valuable suggestions and recommendations of the sessions and after consultation with ADG (PP&B) and Director, NBAIR, will be published and submitted to the council. Dr. E.R. Harish, Organizing Secretary and Dr. S.S. Veena, Head (A), Division of Crop Protection coordinated the event.

Training Programme on Tuber Crops Seed Village

A training programme on 'Tuber crops seed village-Farmers training and distribution of planting materials' was organised for farmers of MGMG villages viz., Muttakkad, Panangodu, Venniyoor and Nellivila under

Venganoor grama panchayat in Thiruvananthapuram district on 02 June 2023. Dr. K. Sunil Kumar, Principal Scientist and team leader briefed about the seed village concept and Decentralised Seed Multiplier (DSM) programme of tropical tuber crops by ICAR-CTCRI. Dr. M.N. Sheela, former Director and Principal Scientist, ICAR-CTCRI in her presidential address highlighted the salient features of new varieties released from ICAR-CTCRI and improved cultivation practices. Shri. R.S. Sreekumar, President, Venganoor grama panchayat was the Chief Guest of the programme. Dr. J. Suresh Kumar and Dr. K.M. Senthilkumar, Scientist, ICAR-CTCRI, executive members of respective panchayats, and state agriculture department officials attended the programme. Planting materials of tuber crops viz., elephant foot yam (Sree Padma and Gajendra), cassava (Sree Reksha), greater yam (Sree Neelima, Sree Keerthi) and lesser yam (Sree Latha) were distributed to 44 farmers. The technical session included an awareness class on millets in diet and nutritional security.

H.H. Sree Visakham Thirunal Endowment Lecture

The Indian Society for Root Crops (ISRC) along with ICAR-CTCRI, Sreekariyam, Thiruvananthapuram, organized the 'H.H. Sree Visakham Thirunal Endowment Lecture' on 05 June 2023. This endowment lecture is annually delivered by eminent scientists and technocrats from the field of Agricultural/Biological Sciences on topics of contemporary significance. This year, the lecture was delivered by Padma Shri Prof. T. Pradeep, Institute Professor, IIT Madras, Chennai. The programme started at 10 am with a floral tribute to H.H. Sree Visakham Thirunal. Dr. T. Makeshkumar, Principal Scientist & Secretary, ISRC welcomed the participants. Dr. G. Byju, Director, in his presidential address highlighted the importance of natural resources for the existence of life. The Guest of Honour, Prince Adithya Varma from Travancore palace talked about the introduction of tapioca from Brazil in the 18th century and its establishment in Kerala. He emphasized the importance of protecting the environment and getting pollution free air and water for future and urged the students to develop such a culture. Padma Shri Prof. T. Pradeep delivered the endowment lecture on 'Affordable clean water using nanomaterials', in which he explained about the nanomaterial-based water purification system that works without expensive filtration membranes or electricity and its successful use in community water purification. He mentioned the mechanism to remove poisonous arsenic content from water utilizing nanotechnology and about the patent for 'Amrith' water filter, which purifies water at a low cost. He also talked about the importance of developing new materials as sensors and their opportunity in water quality measurement in future. The lecture was attended by the scientists and staff of ICAR-CTCRI and students from Bharatiya Vidya Bhavan school, Thiruvananthapuram.

Farmers Awareness Meeting

An awareness meeting was organized on 13 June 2023 at Olapadi to sensitize the farmers about the benefits of smart farming technology developed by ICAR-CTCRI as well as about the use of drones for spraying nutrients and pesticides. The meeting was organized by Dr. V.S. Santhosh Mithra and Dr. C. Mohan, Principal Scientists of ICAR-CTCRI, Thirvananthapram. Shri. Velmurugan, Assistant Director of Agriculture, Pethanaickenpalayam; Shri. Kubaran, President, Olipadi Panchayat; Mrs. Logaswari, President, Ottampatti Panchayath and Shri. Vijayakumar, ward Councilor participated. About 100 farmers attended the meeting.

Interaction Meeting with Officials of KAU Reforms Commission

An interaction meeting was organized with officials of KAU reforms commission on 20 July 2023 at ICAR-CTCRI, Thiruvananthapuram. Prof. Dr. E. Balagurusamy, Formerly Member UPSC, Chairman, Tamil Nadu Planning Commission and Vice-Chancellor, Anna University; Prof. Dr. P. Rajendran, Former Vice-Chancellor, Kerala Agricultural University; Prof. P.V. Balachandran, Former Director (Extension), Kerala Agricultural University; Dr. K. Aravindakshan, Former Registrar, Kerala Agricultural University; Dr. K. Ramasamy, Former Vice-Chancellor, Tamil Nadu Agricultural University, Vice Chancellor of Karpagam Academy of Higher Education, Coimbatore, Chancellor of Karpagam Academy of Higher Education and Dr. S. Gopakumar, Nodal Officer to the Commission & Director of Education, KAU interacted with Director and Scientists of ICAR-CTCRI.

Foundation Day (Diamond Jubilee) Celebrations of ICAR-CTCRI

ICAR-CTCRI celebrated 60th Foundation Day on 22 July 2023 in the Institute. Dr. Himanshu Pathak, Secretary, DARE & Director General, ICAR, New Delhi was the Chief Guest of the function. He inaugurated Farmer facilitation centre, Climate controlled plant growth facility, eCrop based smart fertigation system, Agri business incubation (ABI) Centre, Diamond Jubilee Hall and exhibition stalls. As part of Diamond Jubilee celebration, one variety of CMD resistant cassava 'Sree Kaveri' and two varieties of high yielding taro varieties 'Sree Hira and Sree Telia were released. In his inaugural address, Dr. Pathak emphasized the role of ICAR as the base of Indian agriculture and according to him agriculture should not be considered just as an occupation, but also as a means to ensure food and nutritional security of the nation. He informed that ICAR

has taken three main initiatives such as certification of technologies, expanding the education in ICAR research institutes and also need of close collaboration with private organizations for technology development and commercialization. Dr. G. Byju, Director, ICAR-CTCRI in his presidential address highlighted research achievements of ICAR-CTCRI, such as release of one cassava variety and two high yielding taro varieties, 15 new varieties recommended for 12 agro-climatic regions of India, and about the eight technologies which were approved by ICAR during the year. In the event, Dr. K.B. Hebbar (Director, ICAR-CPCRI, Kasaragod), Dr. R. Dinesh (ICAR-IISR, Kozhikode), Dr. A. Gopalakrishnan (Director, ICAR-CMFRI, Kochi), Dr. George Ninan (Director, ICAR-CIFT, Kochi) and Dr. Jacob John (Director of Extension, Kerala Agricultural University, Thrissur) were present and delivered felicitations. During the event, MoUs were signed between ICAR-CTCRI and Mar Baselios College of Engineering and Technology, Thiruvananthapuram and Rubber Research Institute of India, Kottayam. Seven progressive tuber crop farmers across India were honoured for their outstanding contributions in tuber crops cultivation. Exhibitions by ICAR/State Institutes were organized for farmers, school children and other stakeholders. In view of Diamond Jubilee celebration, various awards were distributed to ICAR staff and students including best employee awards and best research paper awards. Dr. G. Suja, Principal Scientist & Head, Division of Crop Production, ICAR-CTCRI delivered the welcome address and Dr. T. Makeshkumar, Principal Scientist & Head, Division of Crop Protection, ICAR-CTCRI proposed the vote of thanks. More than 100 farmers and 500 students participated in the celebrations.

Inauguration of New Infrastructure on Climate Controlled Plant Growth Facility

The climate controlled plant growth facility (controlled environment green house) has been created as an effort to carry out research on clean seed production of tropical tuber crops. The unit was constructed as part of the RKVY-RAFTAAR project entitled 'Popularization of climate resilient improved varieties of tuber crops for food, nutrition and doubling income with emphasis on wellness of tribal and marginal farmers in Kerala' funded by Govt. of Kerala. The facility consists of two chambers, a 1000 sq. ft. chamber with complete controlled environment and another 1000 sq. ft. mist chamber cum-net house. In the recirculatory (closed) hydroponics system, the plants are raised under controlled environment to provide optimum growing conditions to achieve near the potential growth and yield. Here specific nutrient requirement, moisture requirement, light requirement, temperature and humidity requirements are provided. The entire system is computer controlled using PLC (Programmable Logic Control) and software (automated). The optimum environmental as well as nutrition and irrigation parameters are set using the computer interface. The mist chamber-cum-net house is provided with micro sprinkler and fogging system and meant for achieving maximum sprouting of minisetts, vine cuttings as well as improving germination of seed propagated crops. In addition to conducting various experiments on rapid multiplication of quality planting materials, the climate controlled plant growth facility would be useful for imparting training on protected cultivation of vegetable crops, especially tropical tuber crops. The honourable Secretary, DARE and DG, ICAR has dedicated the facility on 22 July 2023 during the occasion of inauguration of Diamond Jubilee celebration of ICAR-CTCRI. The ceremony was attended by Dr. G. Byju, Director, ICAR-CTCRI as well as directors of all four ICAR institutions in the state and other dignitaries.

Farmers' Seminar on Cassava Cultivation and its Value addition, Demonstrations on Drone Applications in Agriculture

District level seminar on cassava cultivation and its value addition and drone demonstration was organized by ICAR-CTCRI in collaboration with Department of Horticulture, Govt. of Tamil Nadu on 07 September 2023 at Scott's Christian College, Nagercoil, Tamil Nadu. Dr. G. Byju, Director, ICAR-CTCRI inaugurated the event. Smt. Sheela John, Deputy Director of Horticulture, Kanyakumari presided over the function. Lecture cum discussions on various aspects viz., improved varieties, planting material production, organic farming, pest and disease management, mechanization and value addition, economics and marketing, entrepreneurship development etc. were organized for the benefit of 320 participants from Kanyakumari district. Demonstrations on drone application in agriculture and exhibition were also organized during the event.

Visit of Shri. Lalitaditya Neelam I.A.S., Administrator, SAGOSERVE

Shri. Lalitaditya Neelam I.A.S., Administrator, SAGOSERVE, Salem, Tamil Nadu visited the institute on 08 September 2023 along with Smt. P. Arulmozhi, Manager (Trade) and Shri. V. Senthil Kumaran, Senior Chemist. A meeting of the officials was organized with all HoDs/SICs and scientists of the Section of Crop Utilization, ICAR-CTCRI. Dr. G. Byju, Director, provided an overview of the institute and its ongoing research and development activities. Shri. Lalitaditya Neelam I.A.S. explained the activities of SAGOSERVE and the current problems and issues in the sago industry and shared his insights and expectations for possible collaboration with CTCRI. The HoDs/SICs of ICAR-CTCRI briefed about the major activities and

achievements of their respective divisions/sections. They also visited the techno-incubation centre, biopesticide laboratory, e-Crop and other laboratory/ equipment facilities at CTCRI. Decisions were taken on exploring the possible collaborations between the two organizations.

National Symposium on Plant Health Management: Current Trends and Novel Mitigation Strategies

The symposium was jointly organized by Indian Phytopathological Society (Southern Zone) and ICAR-Central Tuber Crops Research Institute during 11-12 September 2023. Dr. Mohanan Kunnummal, Vice Chancellor, Kerala University of Health Sciences and University of Kerala inaugurated the programme. Dr. Bikash Mandal, Assistant Director General, International Relations, ICAR, New Delhi; Dr. S.K. Chakrabarti, Former Vice Chancellor, UBKV, West Bengal; Shri. S. Premkumar, General Manager, Canara Bank, Thiruvananthapuram circle; Dr. G. Byju, Director, ICAR-CTCRI and Dr. Kajal Kumar Biswas, Secretary, Indian Phytopathological Society, New Delhi addressed the gathering. Dr. T. Makeshkumar, Head, Division of Crop Protection and organizing Secretary delivered the welcome address and Dr. S.S. Veena, Principal Scientist and Co-organizing Secretary proposed the vote of thanks. A total of 130 participants representing various universities, ICAR institutes and central institutes in Kerala, Tamil Nadu, Karnataka and Puducherry participated.

Training Programme on Natural Farming

A training programme on Natural Farming (NF) was held on 05 October 2023 at Ezhamkulam, Adoor, Pathanamthitta, Kerala, under SCSP programme of AINP-OF. Shri. Chittayam Gopakumar, Hon'ble Deputy Speaker, Kerala State Legislative Assembly, inaugurated the programme by distributing planting materials and inputs for natural farming. Dr. G. Byju, Director, ICAR-CTCRI gave special address. Training session on Production technology for tuber crops with special reference to organic farming/natural farming of tuber crops based cropping system was handled by Dr. G. Suja, Head, Division of Crop Production & PI, AINP-OF. Dr. S.S. Veena spoke about bio-intensive measures of disease management and Dr. D. Jaganathan highlighted the extension approaches for promotion of organic farming.

Brainstorming on Chinese potato for Empowering Stakeholders: Challenges and Strategies

ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) organized a one-day brainstorming meeting focusing on the cultivation of Chinese potatoes on 06 October 2023. Over 100 stakeholders from Kerala, Tamil Nadu, and Karnataka participated in the event. The focus was on empowering stakeholders by addressing the challenges faced and strategizing for a sustainable future in Chinese potato cultivation. The meeting was inaugurated by Dr. P. Irene Vethamoni, Dean (Horticulture), Tamil Nadu Agricultural University, Coimbatore. In her inaugural address, Dr. Vethamoni highlighted the nutritional richness of Chinese potatoes, emphasizing their high-calorie content and essential nutrients. She stressed the need for developing high-yielding, pest-disease resistant varieties tailored to different agro-climatic zones, as well as advanced machinery for efficient harvesting and grading of tubers. Dr. Sheeba Rebecca Isaac, Associate Director of Research, RARS, Kumarakom, Kerala was the Guest of Honour. Dr. Isaac underscored the input responsiveness of Chinese potato cultivation and discussed the potential for increasing yields. Dr. G. Byju, Director, ICAR-CTCRI, presided over the meeting and highlighted the significant role played by Chinese potatoes in the agricultural landscape of Kerala and Tamil Nadu, covering over 2000 hectares in India. He emphasized the crop's vital contribution to the livelihoods, income and food security of Chinese potato farmers. A special address was delivered by Mr. B. Muralidharan, Technical Advisor, M/s Linga Chemicals, Madurai, adding an industry perspective to the discussion. Dr. G. Suja, Principal Scientist & Head, Division of Crop Production welcomed and Dr. R. Muthuraj, Principal Scientist, Division of Crop Production expressed vote of thanks. The brainstorming meeting provided a valuable platform for stakeholders to exchange ideas, discuss challenges, and explore innovative solutions for enhancing Chinese potato cultivation in the region. With a focus on sustainable practices and technological advancements, the event aimed to pave the way for a more prosperous future for Chinese potato farmers and contribute significantly to food security in the region.

Training on PPVFRA

Awareness cum Training programme on Protection of Plant Varieties and Farmers' Rights Act, 2001 was organized by the ICAR-CTCRI, Thiruvananthapuram at ICAR-KVK Namakkal, Tamil Nadu on 26 October 2023 for the benefit of farmers, students and other stakeholders. The programme was sponsored by PPVFRA, Ministry of Agriculture and Farmers' Welfare, Government of India, New Delhi. Dr. P. Murugesan, Principal Scientist and Organizing Secretary, ICAR-CTCRI introduced the programme and welcomed the gathering. The programme was presided over by Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram. He emphasized the importance of climate resilient varieties of tuber crops and significant achievements of varietal improvement programmes at CTCRI for addressing

the food and nutritional security in the country. Dr. Shaik N. Meera, Director, ICAR-ATARI, Hyderabad inaugurated the event and delivered the inaugural address. He stressed upon the importance of farmers varieties of tuber crops and benefits of the PPVFR Act, 2001 for the farmers and researchers. He encouraged participation of farmers in biodiversity related meetings and urged the farmers to set the target for registration and conserving traditional varieties by the farmers and other stakeholders. Shri. Rajganesh, Legal Advisor, PPVFRA, New Delhi; Dr. M. Selvaraju, Dean, VC&RI, TANUVAS, Namakkal and Dr. P.P. Murugan, Director of Extension Education, TNAU, Coimbatore graced the inaugural function as Guests of Honours. The technical publications on tuber crops - PPVFRA and registration of farmers' varieties in Tamil and English languages were released and distributed to the participants during the event. Dr. K. Velmurugan, Professor and Head, ICAR-KVK Namakal proposed the vote of thanks. In the technical session, Shri. Rajganesh highlighted the need of PPVFR Act, 2001 and various provisions of the Act. Dr. P. Murugesan, Principal Scientist, ICAR-CTCRI delivered a talk on the released varieties of tuber crops, facilitation of registration of traditional varieties under the PPVFR Act, 2001 and DUS guidelines in tuber crops. Dr. D. Jaganathan, Senior Scientist, ICAR-CTCRI, Thiruvananthapuram highlighted the importance of ITKs and farmers' innovations in sustainable development of tuber crops sector. Dr. K. Ambasankar, Head, ICAR-CIBA, Chennai, spoke on tuber crops for animal and fish feed nutrition and their commercialization prospects. Tuber crops diversity exhibition was organized and best exhibitors' awards were conferred to participants in three categories viz., improved varieties, traditional varieties and best private firm/farmer producer society. A total of 150 participants consisting of farmers, NGO representatives, Subject Matter Specialists, project-coordinators of KVKs, students and other stakeholders participated in the programme.

National Training Programme on Advances in Quality Planting Material Production of Tropical Tuber Crops

A national training programme on 'Advances in quality planting material production of tropical tuber crops' was organised at ICAR-CTCRI during 20-22 November 2023. The programme was inaugurated by Dr. G. Byju, Director. There were 16 lectures covering nine tuber crops including importance of quality planting material (QPM) and prescribed quality standards in tropical tuber crops, methods of *in vivo* and *in vitro* seed multiplication like minisett technique, nursery practices, field quality standards, storage quality standards, protected structures in clean seed production, soil less techniques for seed production, institutions involved in seed production and related activities. The sessions included 16 lectures, hands-on training on various seed multiplication techniques and field visits. A total of nine participants attended the training. Dr. K. Sunilkumar was Course Director and Dr. R. Muthuraj and Dr. J. Suresh Kumar were the Course Coordinators.

National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR 2023)

A National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food systems & Resilience (NCTTC 4 STAR 2023) was jointly organized by Indian Society for Root Crops and ICAR-CTCRI, Thiruvananthapuram during 28-29 November 2023 at the head quarters. The conference was inaugurated by Dr. B. Neeraja Prabhakar, Vice Chancellor, Sri Konda Laxman Telangana State Horticultural University, Telangana. The function was presided over by Dr. G. Byju, Director, ICAR-CTCRI, Thiruvananthapuram and Dr. R. Dinesh, Director, ICAR-Indian Institute of Spices Research, Kozhikode was the Guest of Honour. A total of 150 participants including various stakeholders, viz., scientists, associate professors, assistant professors, and students representing various ICAR institutes, AICRP TC centres and State Agricultural Universities attended the Conference. Apart from one plenary lecture and 11 lead lectures, 130 research papers were presented in the oral and poster sessions.

World Soil Day 2023

At ICAR-CTCRI, Thiruvananthapuram, the World Soil Day 2023 focussing on the theme, 'Soil and water: a source of life' was celebrated on 05 December 2023. Dr. Sabu Joseph, Professor, Environmental Sciences and Dean, Faculty of Applied Sciences & Technology, University of Kerala delivered the theme lecture on 'Soil and Water Pollution in India: Challenges and Mitigations'. A total of 30 students from Government Model High School for Girls, Pattom, Thiruvananthapuram attended the celebration. Dr. G. Suja, Director (i/c) administered the World Soil Day Pledge in both English and Malayalam, which was taken by the audience during the occasion. The students and school were felicitated and were provided with planting materials of 10 high yielding varieties of cassava and sweet potato. The students along with the Chief Guest visited the various facilities and experiments of the Institute and acquainted with the type of research and development going on here. Dr. G. Suja, Dr. K. Susan John, Principal Scientist and nodal officer of the programme and Dr. J. Suresh Kumar, Scientist spoke on the occasion highlighting the significance of observing the World Soil Day every year to create awareness among the public on the importance

of maintaining soil health to sustain this valuable resource for future generations.

At Regional Station, World Soil Day was organized on 05 December 2023. The Director, ICAR-CTCRI, Dr. G. Byju participated as Chief Guest, Dr. Ranjan Kumar Patro, Professor & Head (Retd.), Dept. of Soil Science, College of Agriculture, Odisha University of Agriculture & Technology as Guest of Honour; Dr. R.C. Ray, Principal Scientist & Head (Retd.), ICAR-CTCRI, Regional Station graced the function. About 80 members including farmers from MGMG adopted village (Pubusahi, Khordha), students and project staff attended the programme.

Viksit Bharat @ 2047- Voice of Youth at Raj Bhavan

Kerala Raj Bhavan organized 'Viksit Bharat @ 2047 - Voice of Youth' programme on 11 December 2023. Hon'ble Prime Minister Shri Narendra Modi inaugurated the event via video conferencing at 10.30 am and launched Viksit Bharat @ 2047 Ideas Portal. Shri Dharmendra Pradhan, Hon'ble Minister for Education delivered the welcome address via video conferencing. Hon'ble Governor Shri. Arif Mohammed Khan addressed the participants of the event at Raj Bhavan. The event had discussions on various thematic areas of Viksit Bharat such as Empowered Indians, Thriving and Sustainable Economy, Innovation and Science & Technology, Good Governance & Security and India in the World. It also discussed on how to engage youth in contribution towards Viksit Bharat @ 2047. Vice Chancellors of Universities, academicians and students participated in the discussions.

Dr. G. Byju, Director, ICAR-CTCRI shared his valuable ideas regarding Viksit Bharat in the panel discussion. Research scholars viz., Ms. Reshma, Ph.D. scholar, Division of Crop Improvement; Ms. S. Devi Sanjeev, Ph.D. scholar, Division of Crop Production; Ms. S.U. Shilpa, Ph.D. scholar, Division of Crop Protection; Ms. Pravi Vidhyadharan, Research Fellow, Division of Crop Protection; Dr. Senthil alias Shankar, Research scholar, Section of Crop Utilization participated.

Product-Launch cum Stakeholder Workshop

ICAR-CTCRI ABI along with M/s MicroNutrich, Chennai has organised a Product Launch-cum-Stakeholder Workshop on 'Strategies for Commercializing Biofortified Foods' at Chennai on 18 December 2023. The workshop was inaugurated by Dr. S. Pandian IRS, Additional Commissioner of Income Tax, Chennai in the presence of Dr. G. Byju, Director, ICAR-CTCRI and Shri. Arun Baral, CEO, HarvestPlus. ICAR-CTCRI signed a MoU with M/s MicroNutrich Pvt. Ltd. for commercializing biofortified varieties of sweet potato and other crops. Scientists from IIRR, KAU, Murugappa Foundation and few local colleges in Chennai, and startups participated.

Training on Soil, Plant and Water Analyses for Efficient Nutrient Management

A five days training on Soil, plant and water analysis for efficient nutrient management was organised at ICAR-CTCRI, Thiruvananthapuram during 18-22 December 2023 with an objective of capacity building of various stakeholders like teachers, researchers and extension specialists with advanced knowledge and techniques on soil health and soil quality, latest techniques and skills on soil, water and plant analytical methodologies, enriching the knowledge of the stakeholders on the recent nutrient management and to provide a better and rapid nutrient recommendation to the beneficiaries on soil, plant and water analysis. The analytical and estimation skills in soil physical, chemical and biological properties, besides fungus and nematode identification and enumeration were imparted using lectures and laboratory practicals. There were 15 participants representing Kerala state agriculture soil testing departments and private company from Karnataka. Dr. V. Ramesh was the Course Director and Dr. K. Susan John was Course Co-director.

Nutriseed Villages to Promote Biofortified Varieties in Dhalai, Tripura

As a part of the nutriseed village scheme, a team of scientists including Dr. P. Sethuraman Sivakumar, Principal Scientist and scientist-in-charge, ICAR-CTCRI NEH Programme and Dr. Ashok Chhetri, Assistant Professor and scientist-in-charge, Satellite Incubation Centre, visited Dhalai district and organized two Farmers workshop cum awareness programmes on biofortified sweet potato in Gandhacherra and Bolkhali nutriseed villages on 23 December 2023. During these workshops, ten farmers were identified as 'Nutriseed farmers' for producing quality planting materials of biofortified sweet potato varieties. About 117 tribal farmers (Chakma and Tripuri tribes) participated in the workshops.

Rainbow Diet Campaign Launched in Assam

As a part of the Nutriseed village scheme, a 'Farmers awareness programme on biofortified sweet potato' was organized by ICAR-CTCRI through MSME Incubator, NEHU, Tura and Agricultural Technology Application Research Institute, Guwahati at the Pragjyotishpur University, Hajongbari, Assam on 29 December 2023. Dr. G. Kadirvel, Director, ATARI, Guwahati was the Chief Guest at the event and he introduced the biofortified varieties to the farmers and also distributed inputs to 10 nutriseed farmers selected for the project in the presence of Dr. Amit K. Jaiswal, Lecturer, Food

Technology & Industrial Biotechnology, Technological University Dublin-City Campus, Ireland along with Dr. Leichombam Singhajit Singh, Scientist, ICAR-CPCRI, Kahikuchi and Mr. Bhushan Goswami, Lecturer, Pragjyotishpur University. During the workshop, Dr. P. Sethuraman Sivakumar, Principal Scientist and Principal Investigator of the Rainbow Diet Campaign project explained the need for large-scale production of seeds and quality planting materials of sweet potato, rice and millets. He introduced seven biofortifed sweet potato varieties developed by ICAR-CTCRI to the farmers. Various food products developed from biofortified sweet potato such as nutrient-rich jam and jelly, purple and orange cakes and muffins, orange and purple coloured nutrient rich noodles and pasta, low-oil and high nutrient vacuum fried chips were introduced to the farmers. The nutriseed farmers will be linked to startups for marketing the tubers. Dr R. Sasikumar, Associate Professor and in-charge of MSME Incubator, NEHU explained the farmers about various facilities available at the incubator for developing new food-based businesses. About 91 farmers from Hajongbari and Thakurkuchi villages took part in the event.

State-of-the-art of MGMG

The ICAR-CTCRI, Thiruvananthapuram and its Regional Station implemented the *Mera Gaon Mera Gaurav* (MGMG) programme in collaboration with other stakeholders viz., Department of Agriculture and Horticulture, Krishi Vigyan Kendra, grama panchayat and progressive farmers. Interface meetings (10 nos), training programmes (8 nos), demonstration of improved practices and technologies (80 nos), mobile advisory services and literature on tuber crops production and value addition were distributed to the beneficiaries. A total of 43 scientists adopted 43 villages for the overall development of the villages. As a part of the International Year of Millets 2023, awareness programme on millets were conducted in the MGMG villages.

Swachhata Pakhwada (Swachhata Hi Seva)

Swachhata Pakhwada (Swachhtha Hi Seva) was organized from 15 September to 02 October at ICAR-CTCRI. Swachhtha pledge was taken by all officials in the institute. Apart from daily cleaning drives in the institute including storage sheds, staff quarters premises, guest house, sides of main road outside ICAR-CTCRI, and experimental plots in different blocks, cleaning campaigns were also organised at Government Ayurveda dispensary on 26 September 2023 and Veli Tourist Village, Thiruvananthapuram on the occasion of World Tourism Day on 27 September 2023, to create awareness on Swachhata among public. Awareness on avoidance of food wastage and recycling of food waste was carried out in the staff canteen of ICAR-CTCRI on the occasion of World Awareness Day on Food Waste on 29 September, 2023. Cleaning drive was conducted in Anganwadi and nearby residences of Karakulam Panchayat. The programme concluded on Gandhi Jayanthi on 02 October 2023. After paying floral tributes to Mahatma, a human chain was formed by all staff members in front of the institute and led by the Director, Dr. G. Byju. A swachhata shramdan on the main road side of ICAR-CTCRI was also organised, where non-biodegradable waste materials such as plastic covers, food packets and other degradable wastes were removed.

Swachh Bharat Abhiyan: Special Campaign 2.0 for Disposal of Pending Matters

The Swachhta Special Campaign 2.0 for the disposal of pending matters started on Gandhi Jayanthi 154th birth anniversary of Mahatma Gandhi at ICAR-CTCRI, Thiruvananthapuram on 02 October 2023. Floral tributes were paid to Mahatma and a human chain was formed by all staff in front of office followed by cleanliness drive on the main road side of ICAR-CTCRI, led by Director, Dr. G. Byju.

The scrap items and junk equipment to be removed or discarded were identified and a list was prepared in each division. During the cleaning drives organized from 02-31 October 2023, plastic waste, papers and scrap items dumped at various locations in the institute, such as planting material and yams storage shed, guest house, international training hostel, and roads behind the guest house and international training hostel, library, nematology and acarology lab, Division of Crop Production, Division of Crop Protection, Crop Production lab located in Block IV of farm, techno-incubation dryer unit, experimental plots of Block I and II, premises of the main building and road sides were cleaned. The lab premises and work benches were also cleared off cartons and unwanted materials, empty reagent bottles etc.

Hindi Corner

During the year 2023, one meeting of the Official Language Implementation Committee (OLIC) was held on 10 January 2023 under the Chairmanship of Dr. M.N. Sheela, Director (A) and four meetings on 16 March, 30 June, 26 September and 15 December 2023 under the Chairmanship of Dr. G. Byju, Director and Chairman of OLIC, ICAR-CTCRI, to review the progress of work. The Director expressed his satisfaction over the OL activities taken up in the Institute. During the meetings, various points related to OLIC were raised, discussed and decisions taken were implemented. All quarterly performance reports were sent to the Council. Dr. A. Asha Devi, Principal Scientist and Liaison Officer (OL)

and Shri. M. Padmakumar, Private Secretary & Member Secretary (OLIC) carried out the OL activities at the Institute. Upon superannuation of Shri. M. Padmakumar on 31 May 2023, Dr. S. Shanavas, Technical Officer was entrusted with the charge of Member Secretary, OLIC. During the year, the library purchased Hindi journals/ magazines/books etc. Necessary orders were given to the establishment section to make entries in the service records of awardees of various Hindi competitions. An Official Language Assistant was hired on contract basis for assisting in OL activities. Translation of CTCRI NEWS July-September 2023 issue was done in-house.

During 2023, four Hindi workshops were conducted. The first one was on the topic, 'Official Language-Acts and Rules.' by Smt. K.R. Renjini, Assistant Director (OL) & Member Secretary, TOLIC-I, PMG, Thiruvananthapuram on 18 January 2023, where 28 participants attended. The second workshop was conducted on the topic 'Hands-on training in translation using Google Translate' by Dr. A. Asha Devi, Principal Scientist and Liaison Officer, Rajbhasha, ICAR-CTCRI on 30 June 2023 for 33 participants. The third Hindi workshop was conducted on the topic 'Role of Official Language Implementation in Central Government Offices' by Shri. B. Anil, Deputy Director, Central Hindi Directorate, New Delhi on 20 October 2023 for 29 participants. The last Hindi workshop of the year was conducted on the topic 'Easy methods for using Official Language in your work place' by Sri. T. Rangarajan, Assistant Director (OL), Southern Air Command, Thiruvananthapuram on 07 December 2023 for 35 participants.

The Valedictory function of the Hindi fortnight celebrations 2022, was organized on 18 January 2023. Dr. Sheela Immanuel, Director (i/c) presided over and Smt. K.R. Renjini, Assistant Director (OL) & Member Secretary, TOLIC-I, PMG, Thiruvananthapuram was the Chief Guest. The Incentive Scheme Award 2022 was bagged by Shri. M. Padmakumar, for carrying out maximum official work in Hindi. In the same year, he also won accolades for doing original work in Hindi from the TOLIC-I. The Institute celebrated the Hindi fortnight 2023 during 14-28 September 2023 both at the headquarters and at the Regional Station of ICAR-CTCRI, Bhubaneswar, Odisha with various competitions for the staff and awareness was created for the use of Hindi language for official works. This was followed by the Valedictory function of the Hindi fortnight celebrations 2023 on 20 October 2023 at the headquarters. Dr. G. Suja, Director (i/c) presided and Shri. B. Anil, Deputy Director, Central Hindi Directorate, New Delhi was the Chief Guest. Prize distribution for the various competitions during the Hindi fortnight 2023 was done during the occasion and the Incentive Scheme Award 2023 was bagged by Shri. M. Padmakumar for carrying out maximum official work in Hindi. Officials from the OLIC, ICAR-CTCRI participated in the TOLIC-I meeting held on 11 September 2023.

Library

During this period, library was very active in providing necessary information support services for the research and training activities of the Institute and Regional Station, Bhubaneswar. This year 16 M. Sc. theses, 1 B. Sc. thesis, 10 scientific books, 11 general reading books and 07 Hindi books were added to its collection. In addition, the users availed following services from library

a) Circulation service: A total of 473 books were issued to users on loan

b) CeRA service: A total of 8632 hits were received through various CeRA services like Full text/ Abstracts views, ILL requests and table of contents browsing etc.

c) Reference service: A total of 972 users availed the facility by using reference documents like International Symposium proceedings, Theses, Dictionaries, very old and rare books related to International Symposium on Tropical Root and Tuber Crops.

d) Extension service: A digital copy of library brochure was circulated to 35 colleges in Kerala and 25 colleges in Tamil Nadu for creating awareness of library resources and library services.

Recreation Club

The recreation club started activities for the year 2023 with New Year Celebrations. Cultural programme by the members, distribution of prizes to winners of lucky dip and ceremonial cake cutting etc added colour to the celebration. An Investment awareness programme for the benefit of members of ICAR-CTCRI family was arranged on 16 August 2023 by Federal Bank Ltd., Sreekariyam branch. The Onam festival was celebrated on 24 August 2023 with traditional *Athappookkalam* competition, various sports/games activities and *Onasadya*. A medical diagnostic camp was organized during the month of September by DDRC, Ulloor, Thiruvananthapuram, for all permanent and contractual staff of ICAR-CTCRI. To make the camp more useful, consultation with doctor was arranged as follow up. Farewell functions were organized for the staff members, Smt. B. Presanna, Assistant; Shri. M. Padmakumar, Private Secretary; Shri. P.S. Sureshkumar, Assistant; Shri. T. Lawrence, SSS and Shri. P. Udayakumar, SSS.

Field Level Demonstrations/OFTs Conducted

Demonstrations on improved varieties of cassava, sweet potato, elephant foot yam, taro and Chinese potato; Fertilizer Best Management Practices and other production and protection technologies of tuber crops were established in Kerala, Tamil Nadu, Andhra Pradesh and North Eastern states with 717 farmers for proving the technical feasibility and economic viability of the improved technologies. Farmers were trained to adopt scientific crop management practices. Pests and diseases viz., mealybug, spiraling white fly and cassava mosaic disease in cassava; sweet potato weevil and leaf eating insects in sweet potato and sucking insects and nematode in Chinese potato were managed with integrated pest, disease and nematode management practices.

Demonstrations of Drones

Three hundred and seventy demonstrations were carried out at different places of Kerala and Tamil Nadu, Kerala. Farmer's seminars explaining the benefits of smart farming and drone application were conducted. Spraying was done in rice, banana, Chinese potato, cassava, taro and maize. Nano urea, 19:19:10, Micronol: Tapioca special, Micronol: Chinese potato special and Micronol: Taro special were sprayed in an area of 149, 17, 172, 30 and 2 hectares respectively.

Participation 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. Exhibition in connection with Field day conducted for celebrating the success of seed village demonstrations for quality planting material production (involving 15 farmers in 10 acres) of cassava var. Sree Athulya on 23 January 2023 at Mettupatti village, Namakkal district.
2. Exhibition in connection with Field day conducted for celebrating the success of seed village demonstrations for quality planting material production (involving 15 farmers in 10 acres) of cassava var. Sree Athulya on 24 January 2023 at Manmalai village, Salem district.
3. Krishidarshan exhibition during 24-28 January 2023 at Nedumangad, Thiruvananthapuram, Kerala.
4. Technology and machinery demonstration cum Kisan mela-FARMMECH 2023 during 12-15 February 2023 at Kelappaji College of Agricultural Engineering and Technology, Tavanur, Malappuram, Kerala.
5. Krushi Odisha 2023 exhibition during 16-18 February 2023 jointly organized by Department of Agriculture and Farmers' Empowerment and Federation of India Chamber of Commerce and Industry (FICCI), Bhubaneswar, Odisha.
6. OUAT Farmers Fair-2023 during 27-28 February 2023 organized by Odisha University of Agriculture & Technology, Bhubaneswar, Odisha.
7. VAIGA exhibition during 25 February to 02 March 2023 at Putharikandam Maidanam, Thiruvananthapuram, Kerala.
8. Exhibition in connection with Farmers seminar and inauguration of Krishisree Centre on 01 May 2023 at Kadampanadu, Parakkode block, Adoor, Pathanamthitta, Kerala.
9. Exhibition in connection with Technology Conclave and Expo organized by KSUM at KMEA Engineering College on 10 May 2023 at Aluva, Ernakulam, Kerala.
10. Exhibition in connection with Kalpavajra-Kisan mela cum farmers seminar celebration on 13 May 2023 at ICAR-CPCRI Regional Station, Kayamkulam, Alappuzha, Kerala.
11. Exhibition in connection with 'Chertala Fest-Karapuram Karshika Kazchakal' during 19-28 May 2023 at Chertala, Alappuzha, Kerala.
12. Exhibition in connection with 'Bio-Connect 2023' Kerala Industrial Conclave on Life Sciences during 25-26 May 2023 at Leela Raviz Hotel, Kovalam, Thiruvananthapuram, Kerala.
13. Njattuvela Chantha Programme during 03-06 July 2023 at Poojappura Mandapam Ground, Thiruvananthapuram.
14. ICAR Foundation Day exhibition during 16-17 July 2023 at NASC complex, New Delhi.
15. Exhibition in connection with 60th Foundation Day celebrations of ICAR-CTCRI on 22 July 2023 at ICAR-CTCRI, Thiruvananthapuram.
16. State level Karshakadinam Celebration on 17 August 2023 at Nishagandhi Auditorium, Thiruvananthapuram.
17. Seminar cum exhibition on cassava cultivation and value addition on 07 September 2023 at Scott Christen College, Nagercoil, Tamil Nadu.
18. G-20 exhibition on 09 September 2023 at NASC Complex, New Delhi.
19. Global Symposium on Farmer's Rights during 12-14 September 2023 at ICAR Convention Centre, NASC complex, New Delhi
20. Kisan Mela 'Bharathiya Prathkathi Krishi

Programme'on 21 September 2023 at Kulathoor, Thiruvananthapuram.

21. Exhibition in connection with XVI Agricultural Science Congress and ASC Expo, Transformation of Agri-food systems for achieving sustainable development goals. National Academy of Agricultural Sciences, New Delhi and ICAR-Central Marine Fisheries Research Institute, Kochi during 10-13 October 2023 at Hotel Le Meridien, Kochi, Kerala.
22. Two day all India seminar on 'Processing and Value Addition in Agriculture for Increasing Farmers Income-An Engineering Perspective' during 25-26 October 2023 at Visvesvaraya Bhavan, The Institutions of Engineers, Thiruvananthapuram.
23. Exhibition in connection with Awareness-cum-Training Programme on Provisions of the Protection of Plant Varieties and Farmers Rights (PPVFRA) Act, 2001 on 26 October 2023 at ICAR-KVK, Namakkal, Tamil Nadu.
24. Huddle Global 2023 exhibition organized by Kerala Startup Mission during 16-18 November, 2023 at Adimalathura, Thiruvananthapuram.
25. International Conference on Environmental Pollution and Health: Governance for a Sustainable Future (ICEGSF 2023) during 22-24 November 2023 at Department of Environmental Sciences, University of Kerala.
26. National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems and Resilience during 28-29 November 2023 at ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram.
27. Navakeralasadas of Kazhakuttom Legislative Constituency on 12 December 2023 at Chempazhanthy Gurukulam Hall, Thiruvananthapuram.
28. Exhibition during the Product Launch-cum-Stakeholder Workshop on 'Strategies for Commercialising Biofortified Foods' on 18 December 2023 at Chennai.

Media Coverage

Sl. No.	Date	News Title	Name of Newspaper
1.	01 January 2023	Field day cum harvest festival of cassava var. Sree Athulya at Karur	Dinakaran Tamil daily
2.	18 January 2023	News about the Seminar-cum-training on arrowroot cultivation at Manjaly, Ernakulam	Kerala Kaumudi Daily
3.	19 January 2023	*Maracheeniyilayilninnu prakrithivathakam*	The Mathrubhumi Daily
4.	24 January 2023	Dr. G. Byju, CTCRI Director	Malayala Manorama Daily
5	24 January 2023	G. Byju appointed as CTCRI Director	The Hindu Daily
6.	04 February 2023	*Kizhangu vila gaveshana kedram vividha krishiyidangal sandarshichu* CTCRI team field visit at Russelpuram, Neyyatinkara	Malayala Manorama Daily
7.	04 February 2023	CTCRI team field visit at Russelpuram, Neyyatinkara	Kerala Kaumudi Daily
8.	10 February 2023	*Kaachil, verum 250 kilo* Yams 250 kg news	Malayala Manorama Daily
9.	19 February 2023	Harvest festival of rice at ICAR-CTCRI	The Hindu Daily
10.	28 February 2023	*Vaividhyam vilambi vaiga kaarshika pradarshanamela* News about VAIGA Exhibition	Malayala Manorama Daily
11.	02 March 2023	Global meet on Patent cooperation treaty at CTCRI	The Hindu Daily
12.	04 March 2023	MoU inked for agri-tech research	The Hindu Daily
13.	05 March 2023	Agri-tech research: Tuber crops Institute and DUK cooperate	Malayala Manorama Daily
14.	28 March 2023	CTCRI, MG University sign MoU on collaboration	The Hindu Daily
15.	28 March 2023	CTCRI, MG University signed MoU_	Mathrubhumi Daily
16.	30 March 2023	*Smaarttu krishi, iratti vilavu* News on smart farming	Malayala Manorama Daily
17.	27 April 2023	*Meelimoottaye thurathaan afrikkanvandu*	Malayala Manorama
18.	28 April 2023	*Maracheeniyile meelimoottaye thurathaan afrikkan vandu*	Mathrubhumi
19.	29 April 2023	*Meelimoottaye thurathaanethunnu afrikkayil ninnu vandu*	Kerala Kaumudi
20.	29 April 2023	ICAR-CTCRI sets up millet museum on its city campus	The Hindu
21.	29 April 2023	*CTCRI yil cherudhaanya museum*	Malayala Manorama Desabhimaani Janmabhumi

22.	06 May 2023	CTCRI developing food products using tuber-millet combo	The Hindu
23.	22 May 2023	CTCRI session on pest management in cassava	The Hindu
24.	23 May 2023	Brainstorming in cassava mealybug	Malayala Manorama
25.	25 May 2023	Brainstorming in cassava mealybug	The New Indian Express
26.	22 May 2023	Brainstorming in cassava mealybug	The Hindu
27.	23 May 2023	*Meelimuttakalude shalyam: vidagdharude yogaminnu*	Malayala Manorama
28.	25 May 2023	CTCRI to prepare policy document on management of mealybugs	The New India Express
29.	01 June 2023	Fungal disease in cassava-visit by CTCRI scientists	Malayala Manorama
30.	03 June 2023	*Kizhakkan mekhalayil kappaikku kumilrogam; aashanka*	Malayala Manorama
31.	04 June 2023	*Maracheeniyudelokam*	Desabhimani e- paper
32.	13 June 2023	CTCRI research team monitoring demonstration plots at Pollachi, Coimbatore	Dinamalar
33.	14 June 2023	Drone demonstration in Salem district	Digital Media
34.	15 June 2023	Awareness on modern agriculture	Dinakaran
35.	15 June 2023	'Rainbow diet' drive in Attappady to tackle malnutrition	The Hindu
36.	18 June 2023	*Malleeshvara vidyaanikethanil madurakkizhangu krishi*	Janmabhumi
37.	19 June 2023	*Attappadiyil rainbowdiettu prachaaranavumaayi CTCRI*	Malayala Manorama
38.	20 June 2023	Tuck into a tuber-based 'rainbow diet'	The Hindu (Thiruvananthapuram, Kolkata, Visakhapatnam, Chennai and Mumbai editions)
39.	21 June 2023	Training of farmers on the use of drones in agriculture at field level	Dinamani
40.	24 June 2023	*Maracheeniilayilninnu jaivakeedanaashini ctcri dhaaranaapathram oppuvachu*	Janmabhumi
41.	24 June 2023	*Maracheeniilayil ninnu jaivakeedanaashini ctcri dhaaranaapathram oppuvachu*	Deepika
42.	24 June 2023	Bio-pesticide from cassava leaves: CTCRI signs MoU	The New Indian Express
43.	26 June 2023	*Maracheeniyil ninnu moolyavardhitha uthpannangalumaayi karshakak koottaayma*	Desabhimani Pathanamthitta
44.	13 July 2023	*CtcriyumIITiyumdhaaranapathramoppittu*	Deshabhimani Daily Palakkad Edition
45.	13 July 2023	*ICAR-CTCRI, IIT Palakkad dhaaranaapathramoppuvachu*	Malayala Manorama Daily, Palakkad Edition
46.	13 July 2023	CTCRI and Palakkad IIT ink MOU for collaboration	The Hindu Daily, Palakadu Edition
47.	14 July 2023	Training of farmers on cultivation of new varieties of cassava	Dinakaran Daily
48.	17 July 2023	Smart farming technology of CTCRI lauded at national event	The Hindu Daily
49.	18 July 2023	*Mathiya kilangupayirgal vingnanigal thottakalaithuraiyinarudan kala aiyvu*	Dinakaran, Tamil Daily
50.	20 July 2023	*Maravallipayiraimathiyavingnanigalkuluvinaraiyvu*	Dinathanthi
51.	20 July 2023	*Maravallisagupadiathigarikkavingnanigalkuluaiyvu*	Dinamalar
52.	21 July 2023	*Kendra kizhanguvilagaveshanakendram jubilee niravil*	Malayala Manorama Daily
53.	21 July 2023	*Vajra jubilee niravil; kendrakizhanguvilagaveshanasthaapanam*	Kerala Kaumudi Daily
54.	22 July 2023	Central Tuber Crops Research Institute to release 3 crop varieties	The Hindu Daily
55.	22 July 2023	*Kendra kizhanguvilagaveshanakedram: vajra jubilee aagoshaminnu*	Mathrubhumi Daily
56.	23 July 2023	*Kendra kizhanguvilagaveshanakendramvajrajubileeaagoshan-galkkuthudakkam*	Mathrubhumi Daily
57.	23 July 2023	*Verurappichittuarupathandu: jubilee niravilkizanguvilagaveshanakendram*	Malayala Manorama Daily
58.	23 July 2023	*Chakkayudetherileri 'Fruit n Root' at the top of the Jackfruit*	Mathrubhumi, Aalappuzha

59.	23 July 2023	ICAR-CTCRI to focus on developing climate-resilient crop varieties	The Hindu Daily
60.	25 July 2023	Seminar on IPR to be held at NIIST on July 26	The Hindu Daily
61.	03 August 2023	Demonstration of nano urea spraying by 'drone' to farmers	Dinakaran
62.	03 August 2023	Drone use: Demonstration training for farmers	Dinathanthi
63.	05 August 2023	Training farmers on drone use in Cassava cultivation	Dinathanthi
64.	05 August 2023	Fertilizer spraying by drone to improve cassava cultivation	The Hindu, Tamil
65.	06 August 2023	Drones in agriculture: Demonstration held	The New Indian Express, Kanyakumari
66.	11 August 2023	*Puraskarathilmanamniranjuchaavara training centarilekuttikal*	Mathrubhumi daily
67.	11 August 2023	*Naadankrishiyudekaavalaal: vinodinukendraangeekaaram*	Malayala Manorama
68.	23 August 2023	SCSP program conducted at Salem district in Tamil Nadu	Dinamalar
69.	28 August 2023	SCSP program at Karur district in Tamil Nadu	Dinakaran
70.	29 August 2023	Training conducted at Karur district, Visvanathapuri village under SCSP	Kalai Kathir
71.	08 September 2023	District level seminar on Cassava cultivation and drone demonstration in Kanyakumari	Dinathanthi
72.	08 September 2023	Seminar on Cassava cultivation and value addition at Nagercoil	Dinamani
73.	09 September 2023	Training farmers on drone use	Dinathanthi
74.	09 September 2023	*Kendra kizhanguvilagaveshanasthaapanathildvidinadesheeya-simposeum*	Janayugam
75.	10 September 2023	*Dvidinadesheeyasimposeum*	Kerala Kaumudi
76.	11 September 2023	*Kizhanguvilagaveshanakedrathildesheeyaseminaar*	Malayala Manorama
77.	12 September 2023	Symposium on Plant health management	The Hindu
78.	12 September 2023	*Kendra kizhanguvilagaveshanakendrathildesheeya seminar*	Malayala Manorama
79.	12 September 2023	*Sasya aarogyaparipaalanam; simposeumnadathi*	Desabhimani
80.	12 September 2023	*Kendra kizhanguvilagaveshanakedramdesheeyashilpashaala*	Mathrubhumi
81.	19 September 2023	Newspaper coverage about input distribution at Pallikkal under SCSP programme	The Mathrubhumi daily
82.	22 September 2023	*Bhaarathamkaarshikavikasanathintesuvarnabhoomiyaayi: Dr. Sheela*	Janmabhumi
83.	22 September 2023	*Parashaalablokkupanchaayathintenethruthwathiluchakkadayil-nadannakisaan mela*	Desabhimani e-paper
84.	25 September 2023	Training on Modern cultivation of tuber crops in Navsari	Divya Basker, Gujarathi
85.	27 September 2023	Agro-advisory cum field visit at Manjaly, Ernakulam by field diagnostic team from CTCRI on 26 September 2023	The Mathrubhumi Kerala Kaumudi Mangalam daily
86.	06 October 2023	*Kaarshikaupakaranangalumnadilvasthukkalumnalki*	Malayala Manorama, Pathanamthitta
87.	06 October 2023	*Koorkkakrishisammelanaminnu*	Kerala Kaumudi
88.	06 October 2023	*Udghaadanamcheythu*	Kerala Kaumudi
89.	07 October 2023	*Koorkkakrishicrodeekaranasammelanam*	Desabhimani
90.	07 October 2023	Session on Chinese potato organised	The Hindu
91.	07 October 2023	Brainstorming meet held on cultivation of Chinese potato	The New Indian Express
92.	14 October 2023	Training of farmers on Production of new variety of cassava	Dinathanthi
93.	14 October 2023	Training on Cultivation of new varieties of cassava	Dinamalar
94.	26 October 2023	Seminar on Conservation and registration of crop varieties at Namakkal	Thinamalar
95.	28 October 2023	New varieties in Koonavelampatti near Rasipuram - Maravalli plant	Thinathanthi
96.	30 October 2023	Seminar on Crop variety protection	Dinakaran
97.	30 October 2023	Awareness seminar for farmers on Crop variety registration	Kalaikathir
98.	02 November 2023	Training course on Cassava cultivation techniques	Aishwaryaam
99.	09 November 2023	*Madurakkizhangukrishivilaveduppinorungi: rainbodayattucampainvijayathilekku*	Malayala Manorama, Paalakkad

100.	10 November 2023	CTCRI, IISR develop three biocapsules for farm sector	The Hindu
101.	15 November 2023	*Kizhanguvilagaveshanakedrathinuamgeekaaram*	Kerala Kaumudi
102.	15 November 2023	*Digital university ctcrigaveshanakendram*	Desabhimani
103.	25 November 2023	*Kedra kizhanguvilagaveshanakedrathildesheeyasammelanam*	Desabhimani
104.	26 November 2023	*Kaarshikasamskrithiyudeormakalunarthivrishchikakaarthika*	Malayala Manorama
105.	27 November 2023	*Dvidinadesheeyasammelanam*	Kerala Kaumudi
106.	29 November 2023	*Dvidinasammelanam*	Kerala Kaumudi
107.	29 November 2023	National Conference on tuber crops inaugurated at CTCRI	Indian Express
108.	29 November 2023	*Dvidinadesheeyasammelanamsamaapichu*	Janayugam
109.	30 November 2023	*Jaivakrishikku "vala'maayi bio capsule*	Malayala Manorama
110.	30 November 2023	3 Biocapsules to aid farming developed	Indian Express
111.	05 December 2023	CTCRI, Odisha Govt. to fight malnutrition in Keonjhar	The Hindu
112.	07 December 2023	*Loka mannudinamaacharichu*	Malayala Manorama
113.	12 December 2023	Restore India's intellectual heritage, says Governor	The Hindu
114.	22 December 2023	*Karshakarkkunadilvasthkkkalvitharanamcheythu*	Desabhimani
115.	22 December 2023	*Karshakarkkunadilvasthukkalnalki*	Malayala Manorama
116.	25 December 2023	Nutriseed villages to promote biofortified varieties established in Dhalai	Tripura Times
117.	25 December 2023	Nutriseed to promote biofortified varieties	North East Colours
118.	27 December 2023	*Maracheenikrishi :kadambanaadukarshakaresahaayik-kankizhanguvilagaveshanakedram*	Kerala Kaumudi

वर्ष 2023 के दौरान इस संस्थान में आयोजित राजभाषा कार्यान्वयन से संबन्धित कार्यक्रम

राजभाषा कार्यान्वयन समिति (राभाकास) की बैठक का आयोजन

इस संस्थान के निदेशक महोदय एवं अध्यक्ष राजभाषा कार्यान्वयन समिति, आईसीएआर सीटीसीआरआई, डॉ. जी. बैजु की अध्यक्षता में प्रत्येक तिमाही (16 मार्च, 30 जून, 26 सितंबर और 15 दिसंबर) को राजभाषा कार्यान्वयन समिति की बैठकों का आयोजन किया गया। इन बैठकों में राजभाषा के कार्यान्वयन से संबंधित विभिन्न बिंदुओं पर चर्चा की गई और लिए गए निर्णयों को लागू किया गया। प्रधान वैज्ञानिक एवं संपर्क अधिकारी डॉ. आशा देवी ए, और निजी सचिव एवं सदस्य सचिव (रा.भा.) श्री. पद्मकुमार एम. को संस्थान के राजभाषा गतिविधियों का उत्तरदायित्व सोंप दिया गया। श्री. पद्मकुमार एम. के सेवा-निवृत्ति होने पर डॉ. एस. शानवास, तकनीकी अधिकारी को सदस्य सचिव (रा.भा.) नामित किया गया। ओएल गतिविधियों में सहायता के लिए एक राजभाषा सहायक को अनुबंध के आधार पर नियुक्त किया गया है। इस साल की उपलब्धियाँ कुछ इस प्रकार थीं।

- पुस्तकालय में इस साल का हिन्दी के सामान्य पुस्तकें खरीदी गयी।
- विभिन्न हिंदी प्रतियोगिताओं के पुरस्कार विजेताओं के सेवा अभिलेखों में आवश्यक प्रविष्टियां स्थापना अनुभाग से किया जा रहा है। इसके अलावा सेवा पुस्तिकाओं में द्विभाषी रूप में प्रविष्टियां की जा रही है।
- आईसीएआर सीटीसीआरआई समाचार पत्रिका को द्विभाषी बनाने का निर्णय लिया गया और हिंदी अनुभाग ने जुलाई - सितंबर 2023 की तिमाही के लिए आईसीएआर-सीटीसीआरआई समाचार का हिंदी में अनुवाद किया।
- प्रतिदिन एक हिंदी शब्द सीखने के लक्ष्य को ध्यान में रखते हुए, प्रत्येक प्रभाग/अनुभाग मासिक आधार पर शब्दों का योगदान देता है।

नगर राजभाषा कार्यान्वयन समिति द्वारा वर्ष 2023 के दौरान आयोजित बैठकों में इस संस्थान के संपर्क अधिकारी (राजभाषा) एवं सदस्य सचिव (राजभाषा) ने भाग लिया।

हिन्दी कार्यशालाओं का आयोजन

18 जनवरी 2023 को 'राजभाषा - अधिनियम और नियम' विषय पर एक दिवसीय हिन्दी कार्यशाला का आयोजन किया गया। डॉ. शीला इम्मानुएल, निदेशक (प्र.) एवं अध्यक्ष (राभाकास), भाकृअनुप– केन्द्रीय कंद फसल अनुसंधान संस्थान, तिरुवनंतपुरम ने अध्यक्षता की और कक्षा का संचालन श्रीमती के.आर. रेन्जिनी, सहायक निदेशक (ओएल) और सदस्य सचिव, टोलिक-I, पीएमजी, तिरुवनंतपुरम ने किया। इसमें 28 अधिकारियों / कर्मचारियों को प्रशिक्षण दिया गया। दूसरी एक दिवसीय हिन्दी कार्यशाला 08 सितम्बर 2023 को "गूगल अनुवाद का उपयोग करके अनुवाद में व्यावहारिक प्रशिक्षण" विषय पर आयोजित की गई। डॉ. जी. सुजा, निदेशक (प्र.) ने अध्यक्षता की और डॉ. आशा देवी, प्रधान वैज्ञानिक एवं संपर्क अधिकारी (रा.भा.) ने कार्यशाला का संचालन किया। इस कार्यशाला में 33 अधिकारियों / कर्मचारियों को प्रशिक्षण दिया गया। तीसरी एक दिवसीय हिन्दी कार्यशाला "केंद्र सरकार के कार्यालयों में राजभाषा कार्यान्वयन की भूमिका" विषय पर दिनांक 20 अक्टूबर 2023 को आयोजित की गई। डॉ. जी. सुजा, निदेशक (प्र.) ने कार्यशाला का उद्घाटन किया। श्री. अनिल बी, उपनिदेशक, केंद्रीय हिन्दी निदेशालय, शिक्षा मंत्रालय, भारत सरकार, नई दिल्ली द्वारा क्लास लिया गया। इस कार्यशाला में 29 अधिकारियों / कर्मचारियों को प्रशिक्षण दिया गया। चौथी एक दिवसीय हिन्दी कार्यशाला "आपके कार्य क्षेत्र में राजभाषा का प्रयोग करने के आसान तरीके " विषय पर दिनांक 07 दिसम्बर 2023 को आयोजित की गई। डॉ. एम. आर. साहू, निदेशक (प्र.) ने कार्यशाला का उद्घाटन किया। श्री. टी. रंगराजन, सहायक निदेशक (राजभाषा), दक्षिण वायु कमान, आक्कुलम, तिरुवनंतपुरम द्वारा क्लास लिया गया। इस कार्यशाला में 35 अधिकारियों / कर्मचारियों को प्रशिक्षण दिया गया।

विशेष प्रोत्साहन योजना

हिंदी में अधिकतम कार्य के लिए प्रोत्साहन योजना पुरस्कार 2022 और 2023, श्री. एम. पद्मकुमार, निजी सचिव एवं सदस्य सचिव (रा.भा.) को प्राप्त हुआ। वर्ष 2022 में उन्होंने टोलिक-I से हिंदी में मौलिक कार्य करने के लिए प्रशंसा भी हासिल की।

हिन्दी पखवाड़ा समारोह

हिंदी पखवाड़ा समारोह 2022 का समापन समारोह 18 जनवरी 2023 को आयोजित किया गया जिसमें डॉ. शीला इम्मानुएल, निदेशक (प्र.) ने अध्यक्षता की और श्रीमती के.आर. रेन्जिनी, सहायक निदेशक (रा.भा.) और सदस्य सचिव, टोलिक-I, पीएमजी, तिरुवनंतपुरम मुख्य अतिथि थी। मुख्य अतिथि द्वारा विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कार वितरित किये गये।

संस्थान ने 14-28 सितंबर 2023 के दौरान आईसीएआर-सीटीसीआरआई के मुख्यालय और क्षेत्रीय स्टेशन, भुवनेश्वर, ओडिशा में कर्मचारियों के लिए विभिन्न प्रतियोगिताओं के साथ हिंदी पखवाड़ा 2023 मनाया और आधिकारिक कार्यों के लिए हिंदी भाषा के उपयोग के लिए जागरूकता पैदा की विभिन्न प्रतियोगिताओं का आयोजन भी इस अवसर पर किया गया। हिंदी पखवाड़ा समारोह 2023 का समापन समारोह 20 अक्टूबर 2023 को आयोजित किया गया था। डॉ. जी. सुजा, निदेशक (प्र.) ने अध्यक्षता की और श्री. अनिल बी., उपनिदेशक, केंद्रीय हिंदी निदेशालय, नई दिल्ली मुख्य अतिथि थे। इस अवसर पर हिंदी पखवाड़ा 2023 के दौरान विभिन्न प्रतियोगिताओं के विजेतावों के लिए पुरस्कार वितरण किया गया।

Important Events

Sl. No.	Name of the event	Date
1.	Tuber Crops Day at Regional Station, Bhubaneswar	18 January 2023
2.	Webinar on Innovations in Agricultural Marketing- Experiences of NIAM and Strategies for Tuber Crops	09 February 2023
3.	Farmer Innovator Meet	24 February 2023
4.	MoU signed with Digital University of Kerala (DUK)	02 March 2023
5.	International Seminar on Patent Cooperation Treaty (PCT)	03 March 2023
6.	Celebration of International Women's Day	08 March 2023
7.	Live Web Telecast of the Inauguration of International Millet Conference by Hon'ble Prime Minister and Stakeholders Interface on Millets for Food and Nutrition	18 March 2023
8.	Biofortified Sweet potato and Millet Food Festival	23 March 2023
9.	MoU signed with MG University	27 March 2023
10.	Second Meeting of the IX Research Advisory Committee	12-13 April 2023
11.	49th Meeting of Annual Institute Research Council	17-20 April 2023
12.	Establishment of Millets Museum at ICAR-CTCRI	28 April 2023
13.	23rd Annual Group Meeting of the All India Coordinated Research Project on Tuber Crops	10-12 May 2023
14.	Brainstorming Meeting on Mealybugs in Cassava	23 May 2023
15.	Training Programme on Tuber Crops Seed Village	02 June 2023
16.	H.H. Sree Visakham Thirunal Endowment Lecture	05 June 2023
17.	Interaction Meeting with Officials of KAU Reforms Commission	20 July 2023
18.	Foundation Day (Diamond Jubilee) Celebrations of ICAR-CTCRI	22 July 2023
19.	Inauguration of New Infrastructure on Climate Controlled Plant Growth Facility	22 July 2023
20.	Farmers' Seminar on Cassava Cultivation and its Value addition, Demonstrations on Drone Applications in Agriculture	07 September 2023
21.	National Symposium on Plant Health Management: Current Trends and Novel Mitigation Strategies	11-12 September 2023
22.	Training Programme on Natural Farming	05 October 2023
23.	Brainstorming on Chinese potato for Empowering Stakeholders: Challenges and Strategies	06 October 2023
24.	Training on PPVFRA for the benefit of farmers, students and other stakeholders	26 October 2023
25.	National Training Programme on Advances in Quality Planting Material Production of Tropical Tuber Crops	20-22 November 2023
26.	National Conference on Tropical Tuber Crops for Sustainability, Tradition, Agri-Food Systems & Resilience (NCTTC 4 STAR 2023)	28-29 November 2023
27.	World Soil Day 2023	05 December 2023
28.	Viksit Bharat @ 2047- Voice of Youth at Raj Bhavan	11 December 2023
29.	Product-Launch cum Stakeholders Workshop on Strategies for Commercialising Biofortified Foods	18 December 2023
30.	Training on Soil, Plant and Water Analyses for Efficient Nutrient Management	18-22 December 2023
31.	Farmers Workshop cum Awareness Programmes on Nutriseed Villages to Promote Biofortified Varieties in Dhalai, Tripura	23 December 2023
32.	Rainbow Diet Campaign Launched in Assam	29 December 2023

Weather Data 2023

ICAR-CTCRI, Headquarters, Thiruvananthapuram, Kerala

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Min.	Max.	FN	AN		
January	22.14	30.02	90.49	66.57	18.54	2
February	22.54	30.64	90.27	64.58	10.67	2
March	24.60	31.93	85.49	65.56	13.72	1
April	25.88	32.71	87.31	69.91	78.74	6
May	26.14	32.40	87.82	71.54	136.91	6
June	25.26	31.23	87.09	74.28	73.41	5
July	24.77	30.43	89.18	74.49	139.95	11
August	25.35	31.59	87.19	68.46	20.07	2
September	24.45	29.96	92.71	78.20	384.54	22
October	24.38	30.16	93.21	76.43	504.43	18
November	23.81	31.04	93.71	75.24	179.58	10
December	24.50	31.94	91.19	70.35	57.14	3

ICAR-CTCRI, Regional Station, Bhubaneswar, Odisha

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Min.	Max.	FN	AN		
January	16.40	29.50	88	46	0.00	0
February	18.40	32.40	90	35	0.00	0
March	21.40	34.20	91	51	48.50	3
April	24.70	37.20	90	52	92.20	3
May	26.40	37.80	88	57	103.70	6
June	27.10	37.90	89	64	142.30	9
July	26.80	33.30	93	79	215.50	14
August	26.20	33.10	91	74	488.70	11
September	25.20	32.90	93	76	448.20	14
October	23.50	33.00	86	60	52.70	3
November	20.30	30.90	87	51	18.50	2
December	16.10	27.70	87	50	21.30	1

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