वार्षिक प्रतिवेदन
Annual Report
2022

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद)

श्रीकार्यम, तिरुवनंतपुरम 695 017, केरल, भारत

ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

Sreekariyam, Thiruvananthapuram 695 017, Kerala, India

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Diamond Jubilee of ICAR-CTCRI

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From The Director

The population of India is expected to grow to 1.62 billion and the demand for food grains is estimated to increase to 360 million tons by 2050. The likely gap in demand-supply would be partially bridged by tropical tuber crops like cassava and sweet potato, which are cheap energy sources. Moreover, when climate change continues to disrupt agricultural production, challenging our ability to feed a growing population, tuber crops come in handy, bestowed with resilience to global warming and prospects for better returns under adverse edaphic and climatic conditions. Tropical tuber crops are versatile crops with transforming roles from providing a substantial part of the world's food-cum-feed supply to diverse industrial applications and nutritional attributes. In the context of ICAR-CTCRI celebrating its 60 years of service, I take stock of the research accomplishments, technologies and developmental programmes for the year 2022 featured in the form of Annual Report.

The germplasm was enriched with 79 new collections and overall, 5588 accessions are being conserved for valued traits. Two cassava genotypes with better-fried chips quality and five genotypes for N and K use efficiency; two sweet potato genotypes with high carotenoids and anthocyanin and five genotypes suitable for processing; three high yielding bushy white yam clones; five non-acrid elephant foot yam hybrid lines; two promising arrowroot lines and two yam bean lines for high yield and quality were identified.

In order to face the complex climate change challenges, the agrifood systems involving tuber crops are getting strengthened with productive, profitable and biologically efficient intercropping system of taro with vegetable cowpea; nature-based solutions like organic packages for intercropping system of elephant foot yam with cucumber/ amaranthus and cassava-groundnut system; reduction of chemical fertilizers by zone-specific site specific nutrient management (SSNM) involving customized fertilizers, which resulted in 17-23% increase in yield, environmental protection and reduction in global warming potential and INM involving nutrient use efficient cassava variety, Sree Pavithra enabling 75% saving of NPK fertilizers. The fertigation schedule developed in taro with 25% saving of N and K nutrients and 83% higher cormel yield would intensely facilitate 'Per Drop More Crop', the mission-mode programme of Govt. of India.

Biorational management of cassava mealybug, identification of phytochemical constituents from the root extract of *Ipomoea mauritiana* with insecticidal activity against sweet potato weevil, management of collar rot in elephant foot yam and taro leaf blight using new generation fungicides, confirmation of pathogenicity of cassava root rot were some of the other significant findings. Production of thermoplastic starch sheets from cassava, development of cassava starch phosphate carbamate with high water

absorption capacity, commercialization and patent filing of power operated size based Chinese potato grader, development of a prototype tractor operated Chinese potato harvester, a modified continuous type cassava peeler and frozen yogurt from biofortified sweet potato would make faster and longer strides for value chain to elevate the status of these crops.

A mobile app *'Krishi Krithya'* for e-Crop based smart fertigation system for tuber crops, women empowerment index in Chinese potato, a workflow for the analysis of whole genome sequence data of cassava were also developed. To better align on-station research for development, service and delivery to its stakeholders, ICAR-CTCRI continued its efforts by conducting out-reach programmes like NEH, SCSP and TSP, besides 476 OFTs/FLDs. Sustained focus was given to the two flagship programmes of Govt. of India,'*Mera Gaon Mera Gaurav'* and 'Swachh Bharat Abhiyan Mission', which could create tremendous impact in the society.

I am very happy to inform that ICAR-CTCRI bagged the 14th Rank among 93 ICAR Institutes for the combined years 2019-20 and 2020-21.The scientific credibility and quality of the research outcomes are evidenced from 247 publications, including 54 research papers in high impact international and national journals. The legacy and impact of R&D programmes of tropical tuber crops will continue for many years! Thanks to the collaborative functional linkages with CGIAR institutes like CIP, CIAT; Govt. of India organizations/schemes 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 extend my sincere and profound thanks to Dr. Himanshu Pathak, Secretary (DARE) & Director General (ICAR); Dr. Anand Kumar Singh, DDG (Hort. Sci.), ICAR and Dr. Sudhakar Pandey, ADG (FVS & MP), ICAR, for their valuable guidance and support. I profusely thank Dr. M.N. Sheela, Former Director (A), ICAR-CTCRI for her able leadership during the period.

I thank all the staff for serving this national Institute with diligence and commitment to make this year scientifically momentous. I appreciate the efforts made by the Chief Editor and Editors in documenting this Annual Report in high standard.

G. Byju
Director

10 May 2023

विशिष्ट सारांश

प्रतिवेदित वर्ष के दौरान 42 संस्थान वित्तपोषित परियोजनाओं तथा 27 बाहरी वित्त पोषित परियोजनाओं के तहत नए संग्रहणों के साथ संरक्षित आनुवंशिक संपदा, विमोचित की गई किस्मों; प्रक्रमों (प्रोसेसस), नयाचारों यानी प्रोटोकॉल्स, प्रौद्योगिकियों, खेती करने की विधियों, उच्च मूल्य वाले कंपाउंडों तथा सस्योत्तर मशीनरियों का विवरण नीचे दिया गया है:

1. कुल 5588 वंशावलियों को फील्ड जीन बैंक में अनुरक्षित एवं संरक्षित किया गया जिनमें कसावा की 1216 वंशावलियां, शकरकंद की 1110 वंशावलियां, रतालू की 1121 वंशावलियां, खाद्य अरबी की 683 वंशावलियां, लघु कंद फसलों की 207 वंशावलियां तथा क्षेत्रीय केंद्र से 1251 संग्रहण शामिल थे। कंद फसलों के बहत्तर (72) नए संग्रहणों, यानी कसावा (8), शकरकंद (7), रतालू (13), खाद्य अरबी (46) और लघु कंद फसलों (5) को जर्मप्लाज्म बैंक में जमा कराया गया।

2. कसावा वंशक्रमो की पहचान निम्न वांछित विशेषकों व गुणों के साथ की गई (i) सीएमडी लक्षण मुक्त विदेशी वंशावलियां (25); (ii) बेहतर फ्राइड चिप्स गुणवत्ता वाले वंशक्रम (16-5 और देशज वंशक्रम, मन्ना); (iii) उच्च उपज (60.48 टन प्रति हैक्टे. के साथ KBH-2006/18 और 48.42 टन प्रति हैक्टे. के साथ 8S-501-2) तथा पोषक तत्व उपयोग दक्ष वंशक्रम (उच्च नाइट्रोजन उपयोग दक्षता के लिए KBH18 एवं 15S-409; पोटेशियम उपयोग दक्षता के साथ वंशक्रम 8S-501-2, 15S-409 एवं KBH18)।

3. शकरकंद वंशक्रमों की पहचान निम्न वांछित विशेषकों के साथ की गई, (i) बेहतर पाक गुणवत्ता (38/46); (ii) उच्च कैराटिनोइड एवं एंथोसाइनिन तत्व (9.5 मि. ग्रा. प्रति 100 ग्रा. ताजा वजन यानी FW आधार पर कुल कैराटिनोइड तत्व के साथ वंशक्रम 110/28 और 60 मि. ग्रा. प्रति 100 ग्रा. ताजा वजन आधार पर एंथोसाइनिन एवं 14.5 मि. ग्रा. प्रति 100 ग्रा. ताजा वजन आधार पर कुल कैरोटिनोइड के साथ वंशक्रम 38/15 तथा 8 मि. ग्रा. प्रति 100 ग्रा. ताजा वजन आधार परएंथोसाइनिन तत्व); उच्च उपज (31.20 टन प्रति हैक्टे. के साथ सफेद गुदा वाला हाइब्रिड SPH-60; 26.29 टन प्रति हैक्टे. के साथ संतरी गुदा वाला SPH-21 हाइब्रिड; और 27.45 टन प्रति हैक्टे. के साथ बैंगनी गुदा वाला हाइब्रिड S-1401 तथा प्रसंस्करण के लिए उपयुक्त (S-27, पालक्काड़ लोकल, श्री अरूण, इंदिरा मधुर, EC321693).

4. उच्च कंद उपज वाले बड़ा रतालू वंशक्रमों (46.91 टन प्रति हैक्टे. के साथ DaH-10-130 एवं 40.24 टन प्रति हैक्टे. के साथ DaH-10-41); उच्च उपज वाले सफेद रतालू वंशक्रम (59.30 टन प्रति हैक्टे. के साथ DRS-1047) और उच्च उपज वाले झाड़ीदार सफेद रतालू क्लोनों (38.27 टन प्रति हैक्टे. के साथ DrD-1095, 35.80 टन प्रति हैक्टे. के साथ DrD-1038; और 35.16 टन प्रति हैक्टे. के साथ DrD-1112) की पहचान की गई।

5. पांच गैर-एक्रिड जिमीकंद हाइब्रिड वंशक्रमों (H-102-2015, H-107-2015, H-843/2-2017, H-6-7-2017 एवं H-6-34-2017) की पहचान की गई। एक उच्च उपज वाले अरारोट वंशक्रम (42.26 टन प्रति हैक्टे. के साथ M-3) और उच्च शुष्क पदार्थ तत्व के साथ एक अन्य वंशक्रम (33. 25% राइजोम शुष्क पदार्थ तत्व के साथ M-2) की पहचान की गई। एक उच्च उपज वाले याम बीन वंशक्रम (38.64 टन प्रति हैक्टे. के साथ वंशक्रम 3 x 8) तथा आसानी से उपयोग किए जाने वाले सर्वाधिक कार्बोहाइड्रेट (48.14%) एवं प्रोटीन तत्व (2.27 मि. ग्रा.) के साथ एक वंशक्रम (DPH-10) की पहचान की गई।

6. टैनिया की दो किस्मों, यानी IGSGTN-1 (TTn14-1) को छत्तीसगढ़, मणिपुर एवं केरल राज्यों हेतु केंद्रीय विमोचन के लिए; ii. XaMTS लोकल (TTn1 4-5) को केरल में विमोचन के लिए और स्टोलोन टैरो (*कोलोकेसिया एस्क्यूलेंटा* वैरा. *स्टोलोनीफेरम* (एल.) स्कॉट.) की तीन किस्मों अर्थात i. CAUST-2 को मणिपुर में विमोचन के लिए; ii. BCST-14 को पश्चिम बंगाल, असम एवं मणिपुर राज्यों में केंद्रीय विमोचन के लिए; iii. AAUST-2 को असम में विमोचन के लिए एआईसीआरपी (कंद फसलें) द्वारा संस्तुत किया गया।

7. पूर्ण जीनोम पुनःअनुक्रमण के माध्यम से दो अंतःजात कसावा वंशक्रमों (8S-501 एवं 9S-127) की उच्च गुणवत्ता प्रारूप जीनोम असेम्बली ने 8S-501 और 9S-127 वंशक्रमों में क्रमशः 7,789,154 एवं 7,130,986 SNPs तथा 943,104 एवं 1,104,776 इनडेल्स की मौजूदगी इंगित की। जीनोम आधारित सिन्टेनी और कोलिनेरटी विश्लेषण में यह पाया गया कि कसावा में *MeMADS* बॉक्स जीन दोहरीकरण एवं डायवर्जेंस के माध्यम से उदगमित हुए। 23 *MeMADS* बॉक्स जीनों को 53 *miRNAs* के संभावित लक्ष्यों के रूप में पाया गया।

8. सब्जी लोबिया (1:1 अनुपात) के साथ अरबी के अंतर-फसलीकरण के लिए कृषि विधियों का पैकेज विकसित किया गया, जो कि काफी उपयोगी, लाभप्रद और जैविक रूप से प्रभावकारी था। खीरा और चौलाय जैसी सब्जी फसलों के साथ जिमीकंद के अंतर-फसलीकरण के लिए जैविक कृषि विधियों का पैकेज विकसित किया गया। जिमीकंद की घनकंद अर्थात कॉर्म समतुल्य उपज तब सर्वाधिक पाई गई जब उसे प्रथम वर्ष में 75% जैविक + 25% अजैविक (28.28 टन प्रति हैक्टे.) सामग्रियों के साथ तथा दूसरे वर्ष में 100% जैविक (33.29 टन प्रति हैक्टे) के साथ चौलाय फसल के तहत अंतर-फसल के रूप में उगाया गया।

9. कसावा-मूंगफली प्रणाली के लिए कृषि विधियों का जैविक पैकेज विकसित किया गया। 25% जैविक + 25% अजैविक + *बीजामृत, घना जीवामृत* एवं *जीवामृत* के तहत कसावा-मूंगफली प्रणाली सबसे अधिक उपजशील एवं लाभकारी थी। कसावा किस्म श्री रक्षा से जैविक प्रक्रिया के तहत लगातार छठे वर्ष में काफी अधिक उपज (20.51 टन प्रति हैक्टे.), उच्च लाभ (रु. 583,305 प्रति हैक्टे.) और लाभःलागत यानी बीःसी अनुपात (3.46) प्राप्त किया गया।

10. खरपतवार नियंत्रण भूआवरणीय छिद्रिल मैट को अरबी की खेती में एक प्रभावकारी खरपतवार प्रबंधन तकनीक के रूप में पाया गया, क्योंकि इसका उपयोग किए जाने से खरपतवार समष्टि काफी कम हो गई, जबकि दूसरी ओर उच्च उपज स्थिरता सूचकांक (0.78) और उच्च लाभःलागत अनुपात (2.76) प्राप्त किया गया। अरबी में, धान भूसी पलवार के साथ 74,000 पादप प्रति हैक्टे. के रोपण घनत्व के कारण न्यून खरपतवार शुष्क वजन (9.90 ग्रा. प्रति वर्ग मी.), उच्च उपज (25.84 टन प्रति हैक्टे.) और उच्च लाभःलागत अनुपात (3.05) प्राप्त हुआ।

11. अरबी में उर्वरीकरण अनूसूची विकसित की गई। N, P_2O_5 एवं K_2O संयोजन का 50% की दर से 60:25:75 कि. ग्रा. प्रति हैक्टे. अनुपात में 90 डीएपी के भीतर प्रयोग को, 90-120 डीएपी के दौरान 25% की दर से प्रयोग को तथा 120-150 डीएपी के दौरान शेष उर्वरक का 25% की दर से प्रयोग को अरबी की खेती में इष्टतम एवं लाभप्रद पाया गया जिसके कारण नाइट्रोजन और पोटेशियम पोषक तत्वों की 25% बचत हुई तथा मृदा अनुप्रयोग की तुलना में 83% अधिक घनकंद उपज प्राप्त हुई।

12. एस एस एन एम के साथ उर्वरक सर्वश्रेष्ठ प्रबंधन विधियों को कसावा, जिमीकंद, बड़ा रतालू, सफेद रतालू और शकरकद की खेती में काफी लाभकारी पाया गया, क्योंकि एस एस एन एम के लिए की गई वर्तमान सिफरिश की तुलना में, उपज 17-23% अधिक उपज प्राप्त हुई।

13. किस्म भू कृष्णा की कलमों व बेलों का 45 से. मी. की मेड़ ऊंचाई और 90 से. मी. पंक्ति दर पंक्ति अंतराल पर रोपण किए जाने से कंद की उच्चत्तर विपणन योग्य उपज (14.09 टन प्रति हैक्टे.), सकल लाभ (रु. 2,81,700 प्रति हैक्टे.) और शुद्ध लाभ (रु. 2,02,100 प्रति हैक्टे.) तथा उच्च लाभःलागत अनुपात (3.54) प्राप्त किया गया।

14. कसावा की खेती में विशिष्ट उर्वरक के रूप में $N:P_2O_5:K_2O$:Mg:Zn:B संयोजन का 8:11:21:3.84:0.84:0.315 अनुपात में 500 कि. ग्रा. प्रति हैक्टे. की दर से प्रयोग किए जाने से काफी अधिक कंद उपज (39.25 टन प्रति हैक्टे.) प्राप्त की गई। एन यू ई जीनप्ररूपों/किस्मों में से, श्री पवित्रा ने 25% NPK का प्रयोग किए जाने से जो कंद उपज (32.50 टन प्रति हैक्टे.) प्राप्त की गई, वह पीओपी के तहत H-1687 (35.05 टन प्रति हैक्टे.) जीनप्ररूप के बराबर थी।

15. रतालू को डिब्बों में उगाकर उसके त्वरित बहुगुणन के लिए प्रोट्रे विधि विकसित की गई। बड़ा रतालू किस्म श्री निधि ने 20 ग्रा. उत्थित प्रोट्रे पादपों के 20 मिनीसेट का प्रयोग करके 0.51 से 1.2 कि. ग्रा. प्रति पादप के दायरे में उपज के साथ ग्रो बैग में निरंतर रूप से बेहतर प्रदर्शन किया। मूल्यांकन किए गए पांच मीडिया में से, मृदा : नारियल जटा : वर्मीकम्पोस्ट के 1:1:1 अनुपात में प्रयोग से उच्चतम औसत कंद उपज प्राप्त की गई। बड़ा रतालू की दो ग्रंथि वाली कलमों में काफी अधिक अंकुरण (89.97%) हुआ। उत्पादित की गई जड़ों की औसत संख्या आईबीए उपचार में तथा उसके बाद पीजीपीआर मिक्स-1 में सर्वाधिक थी।

16. कसावा, शकरकंद, जिमीकंद और चाइनीज पोटेटो के गुणवत्तात्मक रोपण सामग्री के उत्पादन के लिए 80 एकड़ क्षेत्रफल को कवर करते हुए पच्चीस बीज ग्रामों को केरल,

तमिलनाडु, ओडिशा तथा आन्ध्र प्रदेश में स्थापित किया गया। केरल, तमिलनाडु, आन्ध्र प्रदेश और ओडिशा (84.60 एकड़ क्षेत्रफल) से छियासी किसानों को कंद फसलों के गुणवत्तात्मक रोपण सामग्री उत्पादन के लिए विकेंद्रीकृत बीज बहुगुणकों के रूप में पंजीकृत किया गया है।

17. कसावा के 1,33,000 तने, जिमीकंद के 31 टन, बड़ा रतालू के 32.5 टन, सफेद रतालू के 3 टन, छोटे रतालू के 3.5 टन, अरबी के 2.5 टन तने, शकरकंद की 14,60,000 कलमें, चाइनीज पोटेटो की 50,000 कलमें तथा याम बीन की 200 कि. ग्रा. कलमें उत्पादित की गई।

18. भाकृअअनुप-सीटीसीआरआई के टीएसपी कार्यक्रम के तहत ओडिशा के पांच जिलों से 450. जनजातीय किसानों को बड़ा रतालू की 8000 कि. ग्रा., जिमीकंद की 8500 कि. ग्रा., अरबी की 7000 कि. ग्रा., याम बीन की 150 कि. ग्रा. रोपण सामग्रियों, शकरकंद की 9,00,000 कलमें तथा कसावा के 5000 तनों की रोपण सामग्री वितरित की गई।

19. एससीएसपी कार्यक्रम के तहत, कसावा, बड़ा रतालू और जिमीकंद की उन्नत किस्मों पर तमिलनाडु के मंगलूर ब्लॉक तथा केरल के परकोड ब्लॉक में 140 प्रदर्शन आयोजित किए गए। 124 किसानों को कंद फसलों की उन्नत किस्मों की रोपण सामग्रियों, कृषि औजार एवं यंत्रों का वितरण किया गया। इक्कीस आउटरीच कार्यक्रम आयोजित किए गए जिनसे 1246 किसान तथा अन्य हितधारक लाभान्वित हुए।

20. 0.8% की दर से *श्रेया* तथा 5 दिनों के बाद 1% की दर से *नेन्मा* और कीटरोगजनक कवक (ई पी एफ) एवं *परप्यूरियोसीलियम लाइलासिनम* का 20 ग्रा. प्रति ली. (1×10^8 CFU) की दर से प्रयोग सहित कसावा मीलीबग (*फेनाकोकस मानिहोटी*) के लिए बायोरेशनल प्रबंधन विकसित किया गया।

21. जीसीएमएस का प्रयोग करके *आइपोमोइया मौरिशिएना, आई. बटाटस* और *आई. पाल्मेटा* के मिथेनोलिक जड़ अर्क से भिन्न पादप रासायनिक संघटकों की पहचान की गई। *आई. मौरिशिएना* में मौजूद क्विनिक अम्ल की पहचान शकरकंद घुन के विरूद्ध कीटनाशक गतिविधि के साथ प्रमुख घटकों में से एक के रूप में की गई।

22. जिमीकंद की खेती में ग्रीवा सड़न और अरबी पत्ती अंगमारी रोग के प्रबंध के लिए डाइफेनोकोनाजोल (0.1%) और प्रोफाइलेक्टिक छिड़काव के रूप में क्रमशः कवकनाशक, फैमोक्साडोन + सायमोक्सानिल के संयोजन का प्रयोग करने तथा 15 दिनों के अंतराल पर इनके तीन छिड़काव करने की सिफारिश की गई।

23. कसावा जड़ सड़न रोग के साथ *फ्यूसेरियम फैल्सिफॉर्मे* के साहचर्य की पुष्टि आरएनए पॉलीमिरेस (आरपीबी 2) की दूसरी सबसे बड़ी सबयूनिट का अनुक्रमण करके तथा वियुक्तों (आइसोलेट्स) के अनुलेखन दीर्घीकरण कारक अर्थात ट्रांसलेशन इलोन्गेशन फैक्टर (TEF-1α) जीन के द्वारा की गई।

24. 15 मिनटों तक कसावा की कलमों को 55.30°C तापमान उपचार से संक्रमित की गई कलमों में कसावा किर्मीर विषाणु अर्थात मोजेक वायरस को नियंत्रित व समाप्त करने में सहायता मिली। *ट्राइकोडर्मा* वियुक्तों का उपचार किए जाने से विषाणु भार घट गया, जैसा कि कंट्रोल में 12.66 की तुलना में Cq. के 34.41 मान से स्पष्ट था। Cq. मान विषाणु के संकेंद्रण से विपरीत आनुपातिक है।

25. तिरुवनंतपुरम, केरल में एक मृदा नमूने से कीटरोगजनक सूत्रकृमि, *हेटरोरहाबडिटिस* प्रजा. के एक वियुक्त यानी आइसोलेट की पहचान की गई।

26. कसावा स्टार्च और बैगेस/केला रेशा कम्पोजिट्स से थर्मोप्लास्टिक स्टार्च शीटों के उत्पादन के लिए प्रक्रम (प्रोसेस) स्थितियों का इष्टतमीकरण किया गया।

27. जल पूर्वोपचार अर्थात वाटर रिमिडिएशन एवं अन्य हाइड्रोजेल अनुप्रयोगों के लिए उच्च जल अवशोषक क्षमता (91-94 $g\,g^{-1}$) के साथ कसावा स्टार्च फॉस्फेट कार्बामेट के संश्लेषण हेतु प्रक्रम विकसित किया गया।

28. बिजली चालित आकार आधारित चाइनीज पोटेटो ग्रेडर के लिए पेटेंट आवेदन दाखिल किया गया जिसके वाणिज्यकरण का कार्य मैसर्स स्टोनहाट टेक्नोलॉजीज़, कोयंबटूर, तमिलनाडु को सौंपा गया।

29. एक प्रोटोटाइप ट्रेक्टर चालित चाइनीज पोटेटो फसल कटाई यंत्र अर्थात हार्वेस्टर तथा लघु श्रेणी के प्रसंस्करण के लिए एक संशोधित निरंतर प्रक्रति का कसावा छिलका उतराई यंत्र विकसित किया गया।

30. कैरोटीन और एंथोसाइनिन समृद्ध शकरकंदों से प्रशीतित योगर्ट विकसित किया गया, जो मानव आंत स्वास्थ्य में सुधार लाने हेतु प्रोबायोटिक तथा प्रिबायोटिक गुणधर्मों को संयोजित व एकीकृत करता है।

31. सेलम जिले में किए गए अग्रपंक्ति प्रदर्शनों (एफ एल डी) के दौरान यह पाया गया कि कसावा किस्म श्री अतुल्या की

उपज, स्थानीय किस्मों की तुलना में, 2.23 के लाभःलागत अनुपात के साथ 14.19% अधिक थी, जबकि पुदुक्कोट्टई जिले में श्री अतुल्या की उपज 1.94 के लाभःलागत अनुपात के साथ 9.65% अधिक थी। आंध्र प्रदेश के पूर्वी गोदावरी जिले में सीएमडी प्रतिरोधी किस्म श्री रक्षा पर किए गए प्रदर्शनों में यह पाया गया कि स्थानीय किस्मों की तुलना में इसकी उपज सिंचित स्थितियों के तहत 12.50% अधिक थी (2.7 के लाभःलागत अनुपात के साथ), जबकि बारानी यानी वर्षासिंचित स्थितियों के तहत यह 14.81% (2.20 के लाभःलागत अनुपात के साथ) अधिक थी। तेन्कासी जिले के अंतर्गत दस किसानों के खेतों में चाइनीज पोटेटो की खेती में एस एस एन एम पर किए गए ऑन-फार्म परीक्षणों (ओएफटी) के दौरान यह पाया गया कि श्री धरा किस्म वाले फसल भूखंड में एस एस एन एम उपचार किए जाने से 2.96 के लाभःलागत अनुपात के साथ, किसानों की विधि की तुलना में, 14.61% उपज अधिक प्राप्त की गई,

32. पांच जैवप्रबलित एवं उच्च उपज वाली शकरकंद किस्मों के प्रदर्शन का मूल्यांकन करने हेतु तेरह ऑन फार्म परीक्षण (अट्टपाडी-8; कल्लकुरिची-5) आयोजित किए गए। छात्रों द्वारा कसावा पास्ता की सेंसरी स्वीकारिता से यह पाया गया कि सामान्य आकृति व संरचना (M=7.04), रंग (M=6.89) और टेक्सचर व बनावट (M=6.73) के आधार पर, गेहूं आधारित पास्ता का स्कोर काफी उच्च था, जबकि अरोमा व सुगंध के कारण कसावा पास्ता का स्कोर उच्च (M=6.06) था।

33. ओडिशा के गंजम जिले के अंतर्गत शकरकंद की खेती में समग्र सशक्तिकरण सूचकांक पुरुषों के संबंध में 0.76 था, जबकि महिलाओं के संबंध में 0.57 था। चाइनीज पोटेटो की उन्नत किस्म पर प्रभाव मूल्यांकन तमिलनाडु में 200 किसानों के बीच/मध्य किया गया, जिसमें यह पाया गया कि 38% किसानों ने ''श्री धरा किस्म को अंगीकृत किया, जिससे उन्हें 25% की अतिरिक्त उपज एवं आय प्राप्त हुई।

34. शकरकंद किस्म श्री भद्रा में सिंचाई एवं उर्वरक अनुप्रयोग के लिए ई-क्रॉप आधारित स्मार्ट कृषि प्रौद्योगिकी का वैधीकरण किया गया। कसावा के पूर्ण जीनोम अनुक्रम डेटा के विश्लेषण के लिए एक वर्कफ्लो विकसित किया गया।

35. ई-क्रॉप आधारित स्मार्ट कृषि प्रणाली ने किसानों के लिए एडवाइजरियां सशजित कीं जिनका किसानों द्वारा नियमित अंतरालों पर अनुसरण किया जाना अपेक्षित था। स्मार्ट खेती (एस एफ) के तहत शकरकंद की उपज, किसानों की पारंपरिक कृषि विधियों (टी एफ) की तुलना में, 218% अधिक थी, और कसावा, जिमीकंद तथा केला के संबंध में उपज एस एफ के तहत टी एफ विधियों की तुलना में क्रमशः 187, 218 एवं 152% अधिक थी।

36. कसावा से तले हुए स्नैक फूड्स और तली हुई चिप्स के विनिर्माण पर दो प्रौद्योगिकियों के लाइसेंस केरल में दो कंपनियों व फर्मों को दिए गए हैं।

37. भाकृअनुप-सीटीसीआरआई' कंद फसलों पर पीएच. डी. कार्यक्रमों व उपाधियों के लिए एक अनुमोदित अनुसंधान केंद्र है। प्रतिवेदित अवधि के दौरान, संस्थान ने बी. एससी./बी.टेक. छात्रों को प्रशिक्षण एक्सपोज़र का अवसर प्रदान किया, एम. एससी. छात्रों को प्रोजेक्ट वर्क में मार्गदर्शन दिया तथा पीएच. डी. छात्रों का तकनीकी मार्गदर्शन किया। कुल छात्रों की संख्या 137 थी।

38. देश के विभिन्न भागों से कुल 749 किसानों, 315 छात्रों तथा 727 पदाधिकारियों को भाकृअनुप-सीटीसीआरआई द्वारा प्रशिक्षण प्रदान किया गया।

39. भारतीय कृषि अनुसंधान परिषद के अंतर्गत सभी संस्थानों की वर्ष 2019-20 और 2020-21 की संयोजित रैंकिंग सूची में, भाकृअनुप-सीटीसीआरआई ने 14वां स्थान प्राप्त किया।

40. संस्थान ने वर्ष के दौरान कुल 247 प्रकाशनों को प्रकाशित किया जिनमें 54 शोध पत्र, 32 सिम्पोजियम व संगोष्ठी शोध पत्र, 5 पुस्तकें, 25 पुस्तक अध्याय, 5 तकनीकी बुलेटिन, 31 तकनीकी फोल्डर/ लीफलेट/ पम्फलेट, 58 लोकप्रिय आलेख, 22 पाठ्यक्रम/ प्रशिक्षण नियमावलियां, 4 संस्थान प्रकाशन, 3 रेडियो वार्ताएं, 8 टीवी. कार्यक्रम शामिल हैं।

Executive Summary

The genetic wealth conserved with newer collections, varieties released, processes, protocols, technologies, methods, high value compounds and post-harvest machinery developed under 42 Institute projects as well as 27 externally aided projects are given below.

1. A total of 5588 accessions, comprising 1216 cassava, 1110 sweet potato, 1121 yams, 683 edible aroids, 207 minor tuber crops and 1251 collections from Regional Station were maintained and conserved in the field gene bank. Seventy nine new collections of tuber crops, cassava (8), sweet potato (7), yams (13), edible aroids (46) and minor tuber crops (5) were added to the germplasm.

2. Cassava lines having the following desirable traits were identified (i) CMD symptom-free exotic accessions (25) (ii) lines having better-fried chips quality (16-5 and landrace, *Manna*) (iii) high yield (KBH-2006/18 with 60.48 t ha^{-1} and 8S-501-2 with 48.42 t ha^{-1}) and (iv) nutrient use efficient lines (KBH18 and 15S-409 for N use efficiency; 8S-501-2, 15S-409 and KBH18 for K use efficiency).

3. Sweet potato lines having the following desirable traits were identified (i) good culinary quality (38/46) (ii) high carotenoids and anthocyanin (110/28 with 9.5 mg 100 g^{-1} FW total carotenoids and 60 mg 100 g^{-1} FW anthocyanin and 38/15 with 14.5 mg 100 g^{-1} FW total carotenoids and 8 mg 100 g^{-1} FW anthocyanin) (iii) high yield (SPH-60, white flesh hybrid with 31.20 t ha^{-1}; SPH-21, orange flesh hybrid with 26.29 t ha^{-1} and SPH-31, purple flesh hybrid with 27.45 t ha^{-1}) and (iv) suitable for processing (S-27, Palakkad local, S-1401, Sree Arun, Indira Madhur and EC321693).

4. Greater yam lines with high tuber yield (DaH-10-130 with 46.91 t ha^{-1} and DaH-10-41 with 40.24 t ha^{-1}); high yielding white yam line (DRS-1047 with 59.30 t ha^{-1}) and high yielding bushy white yam clones (DrD-1095 with 38.27 t ha^{-1}, DrD-1038 with 35.80 t ha^{-1} and DrD-1112 with 35.16 t ha^{-1}) were identified.

5. Five non-acrid elephant foot yam hybrid lines were identified (H-102-2015, H-107-2015, H-843/2-2017, H-6-7-2017 and H-6-34-2017). A high yielding arrowroot line (M-3 with 42.26 t ha^{-1}) and another line with high dry matter content (M-2 with 33.25%) were identified. A high yielding yam bean line (3 x 8 with 38.64 t ha^{-1}) and a line with highest readily usable carbohydrate (48.14%) and protein (2.27 mg) (DPH-10) contents were identified.

6. Two varieties of tannia i. IGSGTN-1 (TTn14-1) for central release for the states of Chhattisgarh, Manipur and Kerala; ii. XaMTS Local (TTn14-5) for release in Kerala and three varieties of stolon taro (*Colocasia esculenta* var. *stoloniferum* (L.) Schott.) i. CAUST-2 for release in Manipur; ii. BCST-14 for central release for the states of West Bengal, Assam and Manipur; iii. AAUST-2 for release in Assam were recommended by AICRP TC.

7. High quality draft genome assembly of two inbred cassava lines (8S-501 and 9S-127) through whole-genome re-sequencing revealed the presence of 7,789,154 and 7,130,986 SNPs as well as 943,104 and 1,104,776 In Dels in 8S-501 and 9S-127, respectively. Genome based synteny and collinearity analysis revealed that the *MeMADS* box genes in cassava were evolved through gene duplication and

divergence. Twenty three *MeMADS* box genes were found to be potential targets of 53 *miRNAs*.

8. Package of practices for intercropping taro with vegetable cowpea (1:1) was developed, which was productive, profitable and biologically efficient. Organic package of practices for intercropping elephant foot yam with vegetables such as cucumber and amaranthus were developed. The corm equivalent yield of elephant foot yam was highest when intercropped with cucumber under 75% organic + 25% inorganic (28.28 t ha^{-1}) in the first year and with amaranthus under 100% organic (33.29 t ha^{-1}) in the second year.

9. Organic package of practices for cassava-groundnut system was developed. Cassava-groundnut system under 75% organic + 25% inorganic + *Beejamrit, Ghanajeevamrit* and *Jeevamrit* was the most productive and remunerative. Cassava variety Sree Reksha continued to produce significantly higher yield (20.51 t ha^{-1}), higher profit (₹ 5,83,305 ha^{-1}) and B:C ratio (3.46) in the sixth consecutive year under organic mode.

10. Weed control ground cover perforated mat proved to be an effective weed management technique in taro with significantly lower weed population, significantly higher yield stability index (0.78) and higher B:C ratio (2.76). In taro, planting density of 74,000 plants ha^{-1} along with paddy straw mulching resulted in lower weed dry weight (9.90 g m^{-2}), higher yield (25.84 t ha^{-1}) and B:C ratio (3.05).

11. Developed fertigation schedule in taro. Application of 60:25:75 kg ha^{-1} of N, P_2O_5 and K_2O @ 50% within 90 DAP, 25% during 90-120 DAP and the rest 25% during 120-150 DAP was optimum and economical for fertigation in taro with 25% saving of N and K nutrients and 83% higher cormel yield over soil application.

12. Fertilizer Best Management Practices by SSNM proved to be significantly superior in cassava, elephant foot yam, greater yam, white yam and sweet potato by enhancing yield to the extent of 17-23% over present recommendation.

13. Planting Bhu Krishna vines on 45 cm ridge height and at 90 cm row to row spacing resulted in significantly higher marketable tuber yield (14.09 t ha^{-1}), gross (₹ 2,81,700 ha^{-1}) and net (₹ 2,02,100 ha^{-1}) returns as well as B:C ratio (3.54).

14. Customized fertilizer with a composition of N:P_2O_5:K_2O:Mg:Zn:B @ 8:11:21:3.84:0.84:0.315 ratio applied @ 500 kg ha^{-1} produced significantly highest tuber yield (39.25 t ha^{-1}) in cassava. Among the NUE genotypes/variety, Sree Pavithra at 25% NPK resulted in a tuber yield (32.50 t ha^{-1}) on par with H-1687 under PoP (35.05 t ha^{-1}).

15. Developed protray method for accelerated multiplication of yams through container growing system. Greater yam var. Sree Nidhi performed consistently better in grow bag with yield ranging from 0.51 to 1.2 kg per plant using minisett of 20 g raised protray plants. Among the five media evaluated, soil + coir pith + vermicompost in 1:1:1 ratio produced the highest mean tuber yield. Two node vine cuttings of greater yam showed significantly highest sprouting (89.97%). The mean number of roots produced was the highest in IBA treatment followed by PGPR Mix-1.

16. Twenty five seed villages were established for quality planting material production of cassava, sweet potato, elephant foot yam and Chinese potato in Kerala, Tamil Nadu, Odisha and Andhra Pradesh covering an area of 80 acres. Eighty six farmers from Kerala, Tamil Nadu, Andhra Pradesh and Odisha (covering 84.60 acres) have been registered as decentralized seed multipliers for quality planting material production of tuber crops.

17. Quality planting material of 1,33,000 stems of cassava, 31 tons of elephant foot yam, 32.5 tons of greater yam, 3 tons of white yam, 3.5 tons of lesser yam, 2.5 tons of taro, 14,60,000 vine cuttings of sweet potato, 50,000 vine cuttings of Chinese potato and 200 kg of yam bean were produced.

18. Planting material of 8000 kg of greater yam, 8500 kg of elephant foot yam, 7000 kg of taro, 150 kg of yam bean, 9,00,000 vine cuttings of sweet potato and 5000 stems of cassava were distributed to 450 tribal farmers from five districts of Odisha under ICAR-CTCRI-TSP programme.

19. Under SCSP programme, 140 demonstrations on improved varieties of cassava, greater yam and elephant foot yam were carried out in Parakode block of Kerala and Mangalur block of Tamil Nadu. Planting materials of improved varieties of tuber crops, inputs, farm tools and implements were distributed to 124 farmers. Twenty one outreach programmes were conducted for the benefit of 1246 farmers and other stakeholders.

20. Developed biorational management of cassava mealybug (*Phenacoccus manihoti*) involving *Shreya* at 0.8% followed by *Nanma* at 1% after 5 days and entomopathogenic fungi (EPF), *Purpureocillium lilacinum* @ 20 g l^{-1} (1 x 10^8 CFU).

21. Identified different phytochemical constituents from the methanolic root extract of *Ipomoea mauritiana, I. batatas* and *I. palmata* using GCMS. Quinic acid present in *I. mauritiana* was identified as one of the major components with insecticidal activity against sweet potato weevil.

22. Application of difenoconazole (0.1%) and combination fungicide, famoxadone + cymoxanil, as prophylactic spray and later on three sprays at 15 days interval as soon as the disease is noticed are recommended for the management of collar rot in elephant foot yam and taro leaf blight respectively.

23. Association of *Fusarium falciforme* with cassava root rot was confirmed by sequencing second largest subunit of RNA polymerase (RPB2) and the translation elongation factor (*TEF-1α*) gene of the isolates.

24. Treatment of cassava setts at 55.30°C for 15 min could eliminate the cassava mosaic virus in infected cuttings. Treatment with *Trichoderma* isolates showed reduction in virus load as evident from Cq value of 34.41 as against 12.66 in control. The Cq value is inversely proportional to virus concentration.

25. An isolate of an entomopathogenic nematode, *Heterorhabditis* sp. was identified from a soil sample in Thiruvananthapuram, Kerala.

26. Optimized process conditions for production of thermoplastic starch sheets from cassava starch and bagasse/banana fibre composites.

27. Developed process to synthesize cassava starch phosphate carbamate with high water absorption capacity (91-94 g g^{-1}) for water remediation and other hydrogel applications.

28. Patent application filed for power operated size based Chinese potato grader and it was commercialized to M/s Stonehat Technologies, Coimbatore, Tamil Nadu.

29. Developed a prototype tractor operated Chinese potato harvester and a modified continuous type cassava peeler for small scale processing.

30. Developed frozen yogurt from carotene and anthocyanin rich sweet potatoes, which combines probiotic as well as prebiotic properties to improve human gut health.

31. FLDs conducted in Salem district revealed that the yield of cassava variety Sree Athulya was 14.19% higher than the local varieties with a B:C ratio of 2.23 and in Pudukottai district the yield of Sree Athulya was 9.65% higher than the local varieties with a B:C ratio of 1.94. Demonstrations on CMD resistant variety Sree Reksha in East Godavari district of Andhra Pradesh revealed that the yield was 12.50% higher (with a B:C ratio of 2.7) under irrigated conditions and 14.81% higher (with a B:C ratio of 2.20) under rainfed conditions than the local varieties. OFTs on SSNM in Chinese potato conducted in ten farmers' fields in Tenkasi district showed that the yield of SSNM treated plot of Sree Dhara gave 14.61% higher yield with a B:C ratio of 2.96 than the farmers' practice.

32. Thirteen on-farm trials (Attapadi-8; Kallakurichi-5) involving five biofortified and high yielding varieties of sweet potato were conducted to assess its performance. Sensory acceptability of cassava pasta by students, indicated that wheat pasta scored significantly higher for general appearance (M=7.04), colour (M=6.89) and texture (M=6.73), while cassava pasta for its aroma (M=6.06).

33. Overall empowerment index in sweet potato was 0.76 for men and 0.57 for women in Ganjam district of Odisha. Impact assessment on improved variety of Chinese potato conducted among 200 farmers in Tamil Nadu revealed that 38% of the farmers adopted 'Sree Dhara' which gave an additional yield and income of 25%.

34. Validated e-Crop based smart fertigation technology in sweet potato. Developed a workflow for the analysis of whole genome sequence data of cassava.

35. E-Crop based smart farming system generated the advisories for farmers to practice at regular intervals. Sweet potato tuber yield under smart farming (SF) was 218% over traditional farming (TF) practices and for cassava, elephant foot yam and banana the yields under SF were 187, 218 and 152% over the corresponding TF yields respectively.

36. Two technologies on fried snack foods and fried chips from cassava were licensed to two firms in Kerala.

37. ICAR-CTCRI is an approved Research Centre for undertaking Ph.D. programmes on tuber crops. During the period, the Institute has offered exposure training to B.Sc./B.Tech. students, project work of M.Sc. students, imparted technical guidance to Ph.D. students, totaling to 137.

38. A total of 749 farmers, 315 students and 727 officials from different parts of the country were imparted training by ICAR-CTCRI. The Institute participated in 10 exhibitions.

39. ICAR-CTCRI bagged the 14th Rank among all ICAR Institutes in the combined list of Ranking of Institutes of Indian Council of Agricultural Research for the year 2019-20 and 2020-21 (combined).

40. Institute had 247 publications: Research papers: 54; Symposia: 32; Books: 5; Book chapters: 25; Technical bulletins: 5; Technical folders/leaflets/pamphlets: 31; Popular articles: 58; Course/training manuals: 22; Institute publications: 4; Radio talk: 3 and TV programmes: 8.

Introduction

Headquarters, Thiruvananthapuram (48.19 ha)


Regional Station, Bhubaneswar (20 ha)

ICAR-CTCRI (1963-2022)

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 in July 1963 with its headquarters (HQ) at Sreekariyam, Thiruvananthapuram, Kerala. It has one Regional Station (RS) at Bhubaneswar, Odisha. 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 Golden Jubilee

in 2013 and 60 years of concerted research have led to the development of several sustainable production, protection and processing technologies for tuber crops, besides release of 68 improved varieties. The target group of most of the technologies being marginal and resource poor farmers, adequate emphasis is also given for on-farm 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 5588. The pioneering role of ICAR-CTCRI 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 68 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 are promising and acceptable to farmers as well as industries. The three latest cassava varieties, Sree Reksha, Sree Sakthi and Sree Suvarna are resistant to cassava mosaic disease (CMD) and are high yielding. 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. Four varieties in yams viz., Sree Nidhi, Sree Haritha, Sree Swetha and Sree Hima were also recently released. 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 to 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 (INM, SSNM and organic management), 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.

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 post harvest 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.

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 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 development programmes implemented successfully and have greatly helped to increase livelihood security of the farmers and other stakeholders across the country.

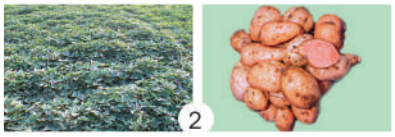
The ICAR-CTCRI bagged the Sardar Patel Outstanding Institution Award for the year 2005 instituted by the ICAR for outstanding contributions made in the improvement of tropical tuber crops and development of lowcost production technologies. The Institute also bagged many national and international recognitions 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 combined list of Ranking of Institutes of Indian Council of Agricultural Research for the year 2019-20 and 2020-21 (Combined) for the significant research and extension achievements.

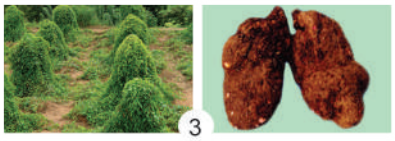
The Institute has conducted more than 30 national and international symposia/seminars/ workshops. The Institute is well equipped to conduct basic, strategic and applied research with its state-of-art laboratories. The infrastructural facilities of the Institute have increased during the X and XII Plan 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. 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.

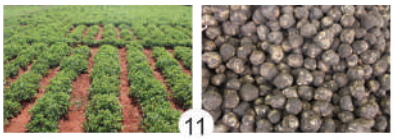
The Institute has established a full-fledged Local Area Network connecting various divisions, sections, administration, accounts and farm sections of ICAR-CTCRI through a strong fiber optic backbone. The main building of the Institute has CCTV facility and the entire campus is now wi-fi enabled through 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.

Mandate Crops

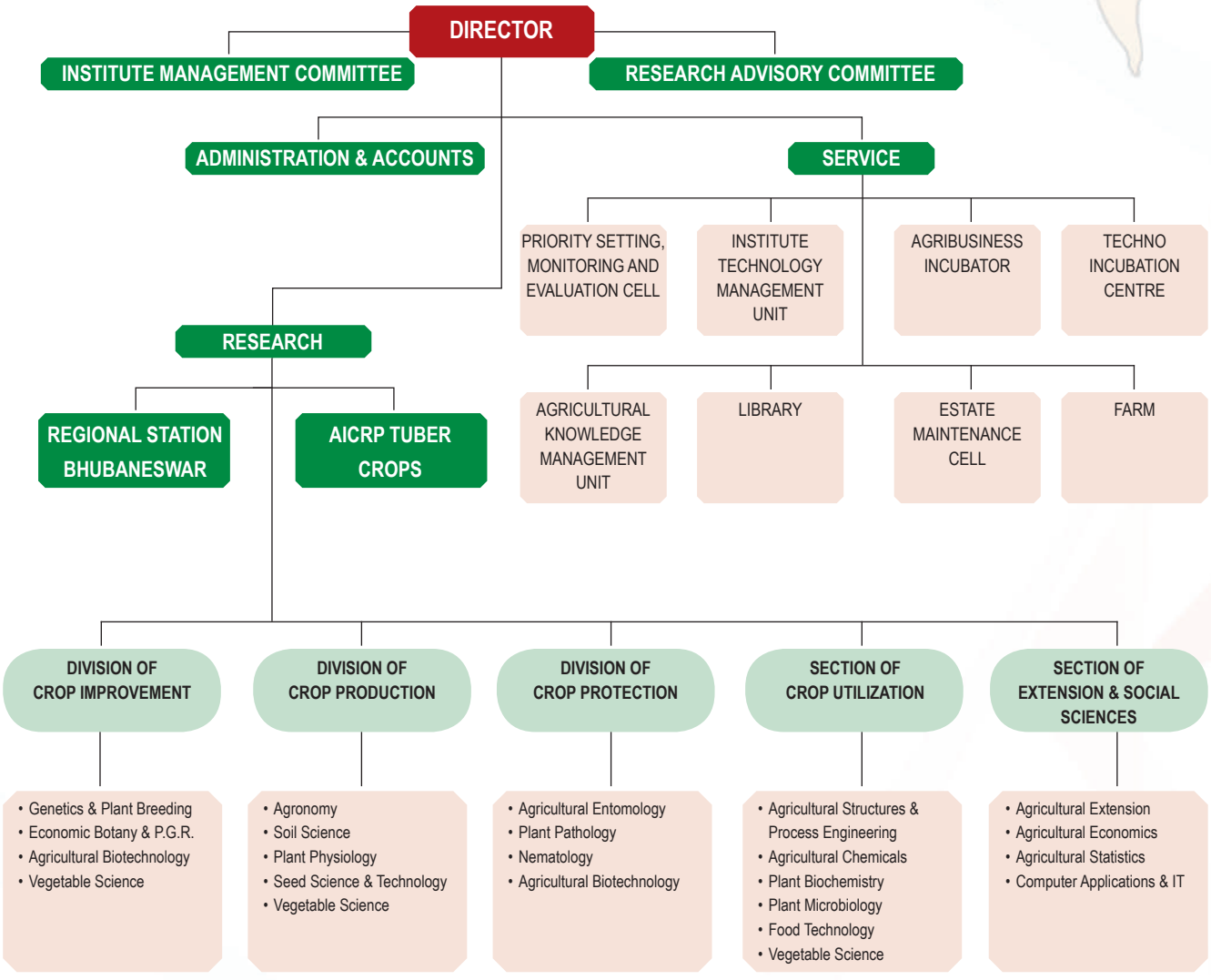




1. Cassava: *Manihot esculenta* Crantz, Euphorbiaceae
2. Sweet potato: *Ipomoea batatas* (L.) Lam., Convolvulaceae
3. Greater yam: *Dioscorea alata* L., Dioscoreaceae
4. White yam: *Dioscorea rotundata* Poir., Dioscoreaceae
5. Lesser yam: *Dioscorea esculenta* (Lour.) Burk., Dioscoreaceae
6. Elephant 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 (2022)

Category	Sanctioned	In position	Vacant
RMP	1	0	1
Scientific staff	44	43	1
Technical staff	47	31	16
Administrative staff	30	22	8
Skilled support staff	38	19	19
Total	**160**	**115**	**45**

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	0.00	0.00	0.00
	B. Building - 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, E.R. Harish, T. Makeshkumar, A.N. Jyothi, H. Kesava Kumar, J. Sreekumar, T. Krishnakumar, R. Arutselvan, M. Nedunchezhiyan, T.P. Sujatha (from 29.08.22)
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, T. Makeshkumar, A. Asha Devi, G. Byju, G. Suja, K. Susan John, A.N. Jyothi, N. Krishna Radhika, C. Visalakshi Chandra, J. Sreekumar, K.M. Senthilkumar, E.R. Harish, D. Jaganathan, T. Krishnakumar, P. Prakash, T.P. Sujatha (from 29.08.22)
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	M.N. Sheela, K.M. Senthilkumar, J. Sreekumar, A.N. Jyothi, 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, A.N. Jyothi, J. Sreekumar
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, Shirly Raichal Anil, R. Saravanan, N. Krishna Radhika, J. Sreekumar, C. Visalakshi Chandra

5.	**Project 5:** Gene editing of Indian cassava varieties to produce high value waxy starch	N. Krishna Radhika	K.I. Asha, M.N. Sheela, Shirly Raichal Anil, K.M. Senthilkumar
6.	**Project 6:** Breeding and evaluation for development of high yielding nutritionally enriched, photo-insensitive, processable and multipurpose sweet potato	Shirly Raichal Anil	C. Visalakshi Chandra, S. Sunitha, E.R. Harish, R. Saravanan, A.N. Jyothi, J. Sreekumar
7.	**Project 7:** Harnessing the genetic potential of wild *Ipomoea* spp. through wide hybridization for improvement of sweet potato	L.K. Bharathi	Shirly Raichal Anil, Kalidas Pati, K.M. Senthilkumar, E.R. Harish, T. Makeshkumar
8.	**Project 8:** 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
9.	**Project 9:** Genetic improvement for drought tolerance in sweet potato and high yielding, disease tolerant nutritionally rich lines in taro	V.B.S. Chauhan	Kalidas Pati, R. Arutselvan, M. Nedunchezhiyan K. Laxminarayana
10.	**Project 10:** 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
11.	**Project 11:** Developing breeder seed standards and precocity of genetic vigour for tropical tuber crops	P. Murugesan	Shirly Raichal Anil, R. Muthuraj, Kalidas Pati, E.R. Harish, R. Arutselvan, P. Sethuraman Sivakumar
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, T. Krishnakumar, R. Saravanan, Sanket J. More
2.	**Project 2:** Weed management in tropical tuber crops	J. Suresh Kumar	M. Nedunchezhiyan, S. Sunitha, Sanket J. More, G. Byju, P. Prakash
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	G. Byju, Kalidas Pati
5.	**Project 5:** Fertilizer best management practices in tropical tuber crops	G. Byju	G. Suja, D. Jaganathan
6.	**Project 6:** Sustainable nutrient management in tropical tuber crops	K. Laxminarayana	M. Nedunchezhiyan, Kalidas Pati, M.N. Sheela, J. Suresh Kumar, A.N. Jyothi

7.	**Project 7:** Long term integrated nutrient management in tropical tuber crops	K. Susan John	V. Ramesh, R. Muthuraj, S.S. Veena, T. Makeshkumar, K. Sunilkumar, Sanket J. More, J. Suresh Kumar
8.	**Project 8:** Soil carbon quality and conservation studies in tropical tuber crops	V. Ramesh	S. Sunitha, P. Prakash
9.	**Project 9:** Climate change adaptation and mitigation in tropical tuber crops	Sanket J. More (till 12.08.22) V. Ramesh (from 13.08.22)	G. Byju, G. Suja, S. Sunitha, R. Muthuraj, V. Ramesh, D. Jaganathan, J. Suresh Kumar, R. Saravanan, P. Prakash, K. Susan John
10.	**Project 10:** Physiological studies related to climate change in tropical tuber crops	R. Saravanan	J. Suresh Kumar, G. Byju, Sanket J. More, Shirly Raichal Anil, K.I. Asha, J. Sreekumar
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 minor tuber crops	R. Muthuraj	G. Byju, G. Suja, V. Ramesh, K. Sunilkumar, T. Makeshkumar, M.N. Sheela, K.I. Asha, R. Saravanan, K. Susan John, E.R. Harish, M. Nedunchezhiyan, D. Jaganathan, T. Krishnakumar, Shirly Raichal Anil, V.B.S. Chauhan, H. Kesava Kumar, S.S. Veena
2.	**Project 2:** Investigations on rapid multiplication of yams and aroids	K. Sunilkumar	G. Suja, T. Makeshkumar, S. Sunitha, R. Muthuraj, J. Suresh Kumar, E.R. Harish, M.L. Jeeva, M. Nedunchezhiyan, G. Byju, H. Kesava Kumar, S.S. Veena
V	**HORTCTCRISIL 202001301469 Mega Project 5: Development of innovative technologies for the intensification of pest management in tuber crops through biorational approaches**	**C.A. Jayaprakas**	
1.	**Project 1:** Development of biorational control measures for the management of insect pests of tuber crops	C.A. Jayaprakas	E.R. Harish, H. Kesava Kumar, B.G. Sangeetha
2.	**Project 2:** Management of important pests and documentation of emerging pests in tuber crops	E.R. Harish	C.A. Jayaprakas, B.G. Sangeetha, R. Arutselvan
3.	**Project 3:** Characterization of insect resistance genes in sweet potato and related *Ipomoea* species against sweet potato weevil infestation	B.G. Sangeetha	C.A. Jayaprakas, Shirly Raichal Anil
4.	**Project 4:** 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, R. Arutselvan

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, G. Byju, A. Asha Devi, 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
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, A. Asha Devi, V.S. Santhosh Mithra, R. Arutselvan, 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, T. Makeshkumar, Kalidas Pati, K. Laxminarayana, E.R. Harish, M. Nedunchezhiyan, H. Kesava Kumar
VII	**HORTCTCRISIL 202001501471 Mega Project 7: Development and refinement of post-harvest handling, storage and processing techniques for minimization of losses in tropical tuber crops and production of value added products**	**M.S. Sajeev**	
1.	**Project 1:** Non-conventional applications of cassava starch in construction and building materials	M. S. Sajeev	T. Krishnakumar, A.N. Jyothi
2.	**Project 2:** Development and functional characterization of modified starches of cassava and lesser known tropical tuber starches for industrial application	A.N. Jyothi	M.S. Sajeev, T. Krishnakumar, M.N. Sheela, A. Asha Devi, P. Prakash
3.	**Project 3:** Design and development of pre- and post-harvest machineries/storage systems in tuber crops	T. Krishnakumar	M.S. Sajeev, C. Pradeepika
4.	**Project 4:** 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, G. Byju, S.S. Veena, C. Visalakshi Chandra, R. Saravanan, T. Krishnakumar
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, P. Prakash, V.S. Santhosh Mithra, G. Byju, P. Sethuraman Sivakumar, G. Suja, R. Muthuraj, H. Kesava Kumar, M.N. Sheela, P. Murugesan, T. Krishnakumar, M. Nedunchezhiyan
2.	**Project 2:** Upscaling tuber crops technologies for promoting food and nutritional security	P. Sethuraman Sivakumar	K. Laxminarayana, P. Prakash, Sheela Immanuel, K.Sunilkumar, M. Nedunchezhiyan, R. Muthuraj, D. Jaganathan, H. Kesava Kumar, R. Arutselvan, Sanket J. More, T. Krishnakumar, L.K. Bharathi, B. Shanmughasundaram, M. Elavarasan
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, P. Sethuraman Sivakumar, T. Krishnakumar, M.N. Sheela, V. Ramesh
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	Sheela Immanuel, P. Prakash, T. Makeshkumar, M.N. Sheela, K. Susan John, K.M. Senthilkumar

Developmental Projects

Sl. No.	Project title	PI(s)	Co-PI(s)	Funding agency	Budget (₹ in lakhs)
1.	ICAR-CTCRI TSP : Livelihood improvement of tribal farmers through tuber crops technologies	M. Nedunchezhiyan K. Laxminarayana (Nodal Officer)	Kalidas Pati V.B.S. Chauhan R. Arutselvan K. Hanume Gowda	ICAR, New Delhi	40.00
2.	ICAR-CTCRI-SCSP: Empowerment of tuber crops farmers through sustainable use of resources and tuber crops technologies	V. Ramesh G. Byju (Nodal Officer)	M.N. Sheela M.S. Sajeev S.S. Veena D. Jaganathan H. Kesava Kumar J. Suresh Kumar T. Krishnakumar	ICAR, New Delhi	62.00

3.	ICAR-CTCRI NEH: Scaling up biofortified tuber crops through 'Rainbow Diet Approach' in the North Eastern Hills Region	P. Sethuraman Sivakumar Sheela Immanuel (Nodal Officer)	K. Laxminarayana M. Nedunchezhiyan H. Kesava Kumar M.S. Sajeev P. Prakash T. Krishnakumar R. Arutselvan V.B.S. Chauhan	ICAR, New Delhi	15.00

Externally Aided Projects

Sl. No.	Project title	PI(s)	Co-PI(s)	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 2022-23: 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 2022-23: 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 2022-23: 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 2022-23: 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 2022-23: 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 2022-23: 12.75
7.	ICAR-Bioversity International & CIAT Alliance collaborative project on Germplasm exchange, improvement and testing advanced clean seed technology in cassava (*Manihot esculenta* Crantz)	M.N. Sheela S. Sunitha T. Makeshkumar	G. Byju K.I. Asha K.M. Senthilkumar P. Murugesan R. Muthuraj	ICAR-Bioversity International & CIAT Alliance	Total: 43.23 2022-23: 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 2022-23 13.85
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 2022-23 50.23
10.	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: 116.81 2022-23 17.93
11.	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 2022-23 55.42

12.	Radiation technology for quality improvement of tuber crops and management of its byproducts	C. A. Jayaprakas	E.R. Harish R. Saravanan H. Kesava Kumar B.G. Sangeetha	Department of Atomic Energy, Bhabha Atomic Research Centre (BARC)	40.95
13.	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	25.60
14.	Establishment of Plant Health Clinic (PHC) at ICAR-CTCRI Regional Station, Odisha	R. Arutselvan	Kalidas Pati V.B.S. Chauhan	National Horticulture Mission (NHM), Directorate of Horticulture, Govt. of Odisha	25.00
15.	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 2022-23 24.00
16.	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 2022-23 8.78
17.	AICRP on Post-harvest Engineering and Technology	M.S. Sajeev	T. Krishnakumar	ICAR, New Delhi	7.20
18.	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 2022-23 9.50
19.	IP & TM scheme: National Agricultural Innovation Fund (NAIF) component II: 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 2022-23 28.50

20.	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
21.	Improving rural agrosystem through horticultural crops based smart farming technologies	V.S. Santhosh Mithra	G. Byju J. Sreekumar D. Jaganathan	State Horticulture Mission, Govt. of Kerala	24.50
22.	Smart cassava farms: Validation and upscaling of AI & an IoT device	V.S. Santhosh Mithra	G. Byju J. Sreekumar D. Jaganathan	Kerala State Planning Board, Govt. of Kerala	34.76
23.	Soil health management in coconut based cropping systems involving tuber crops for enhanced yield and income	D. Jaganathan	G. Byju, G. Suja	Coconut Development Board, Kochi, Kerala	Total: 33.00 2022-23 10.00
24.	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 2022-23 14.40

Research Highlights

Institute Projects

Crop Improvement

Conservation and utilization of germplasm of tuber crops for sustaining production

Cassava

A total of eight new landraces were collected from Thrissur, Kerala. One thousand two hundred and sixteen accessions comprising 545 indigenous, 315 exotic, 115 landraces and 241 breeding lines were planted during 2021-22 in the field gene bank (FGB) at ICAR-CTCRI, Thiruvananthapuram, for maintenance, characterization and preliminary evaluation (Fig. 1).

Fig. 1. Cassava germplasm field view

Three hundred and ten exotic accessions were morphologically characterized for 43 (31 qualitative +12 quantitative) above ground vegetative, flower and fruit characters as well as biotic stresses. These accessions were characterized during the 3rd, 6th and 9th month growth stages.

At the 3rd month, young stem colour and colour of apical leaves showed variation ranging from light green to purple (Fig. 2). Apical leaf pubescence varied from glabrous (215), moderate (51) to high in 44 accessions.

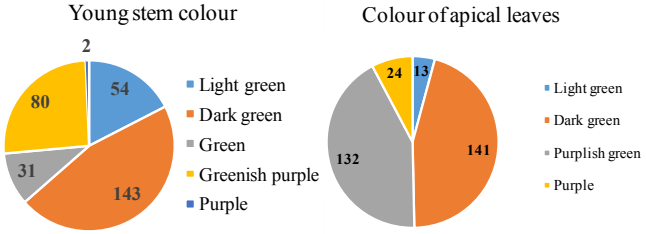


Fig. 2. Variability in the colour of young stem and apical leaves

At the 6th month, leaf colour was dark green in majority of the accessions (295). Leaf retention was maximum in 140 accessions. Leaf vein colour varied from green (178), reddish-green in less than half of the lobe (72), reddish-green in more than half of the lobe (37) to all red in 23 accessions. Length of the central leaf lobe ranged from 9 to 24.50 cm, whereas, the width ranged from 2.10 to 4 cm (178), 4.10 to 6 cm (129), 0 to 2 cm (2) and 6.10 to 8 cm (1). The ratio of lobe length to lobe width ranged from 2.25 to 6.67 cm. The shape of the central leaf lobe was lanceolate (299), elliptical lanceolate (6), straight (2), pandurate (2) and ovoid (1). Prominent number of leaf lobes ranged from 3 to 9. Leaf lobe margin was smooth in 283 and winding in 27 accessions. Orientation of petiole showed many variations (Fig. 3). Petiole colour showed variations from red, green, greenish red, yellowish green, reddish green and purple (Fig. 3). Petiole base colour varied from green (112), purple (58), purplish green (57), light purple (51), greenish purple (20) to light green (12). Petiole middle colour varied from green (111), purple

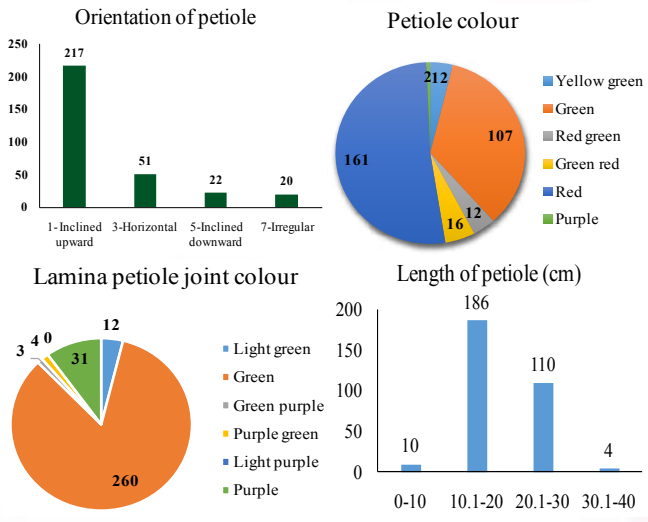


Fig. 3. Variability in petiole characters

(59), greenish purple (57), light purple (39), purplish green (32) to light green in 12 accessions. Petiole top colour varied from green (112), greenish purple (61) to light purple (46), purple (41), purplish green (38) and light green (12). Lamina petiole joint colour was green to purple (Fig. 3). Length of petiole ranged from 8 to 38 cm (Fig. 3).

Among the 310 accessions, at the 9th month stage, the plant height ranged from 140 cm to 400 cm (Fig. 4) while, the stem base perimeter ranged from 4.50 to 19 cm. Height to first branching ranged from 17 cm to 248 cm (Fig. 4). The level of branching ranged from 0 to 7. The shape of the plant varied from compact (134), open (11), umbrella (158) to cylindrical (7). Branching habit also showed good variation (Fig. 4). Branching angle was between 0 to 65˚ in which a maximum of 205 accessions were in the range of 20-40˚.

Flowering was recorded in 301 accessions, while fruiting and seed set was observed in 298 accessions. Among the 298 fruiting accessions, fruit colour varied from light green to dark green. Leaf scar was prominent (308) to semi-prominent (2). The stem cortex colour varied from orange (1), light green (93) to dark green (216), while stem epidermis colour varied from cream (65), light brown (116), dark brown (116) to orange (13) accessions. The colour of the stem exterior ranged from orange (6), golden (1), light brown (60), silver (136), grey (45) to dark brown (62). Distance between leaf scars was short ≤ (8 cm) for all the 310 cassava accessions. The growth habit of the stem was straight (301) and zig-zag (9). The number of leaf lobes varied from 1 to 9. The colour of the end branches of the adult plant varied from green to purple. The length of stipules varied from long to short and stipule margin was entire and split.

The cassava mosaic disease incidence scores were used for identification of many disease-free plants at the 3rd, 6th and 9th month stages. Pooled data of the scores at the three stages indicated that 25 accessions were completely free from the disease (Fig. 5 and Table 1). Leaf brown spot disease scores ranged from 0 to high, where, high disease incidence was observed in 172 accessions, 126 with medium symptoms, and low in 12 accessions.

Ascending hierarchical cluster analysis based on 43 above ground morphological traits grouped the 310 accessions of cassava into six distinct clusters with 18 sub-clusters. Cluster 1 with 129 accessions represented the biggest

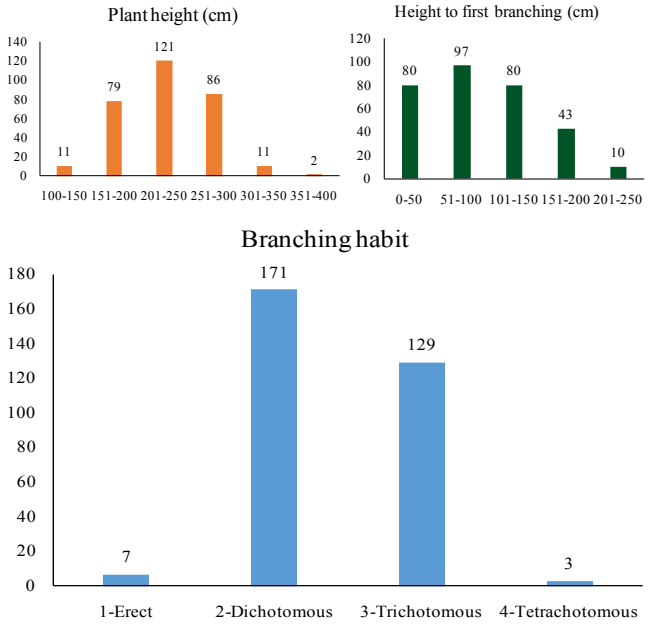


Fig. 4. Variability in plant height, height to first branching and branching habit

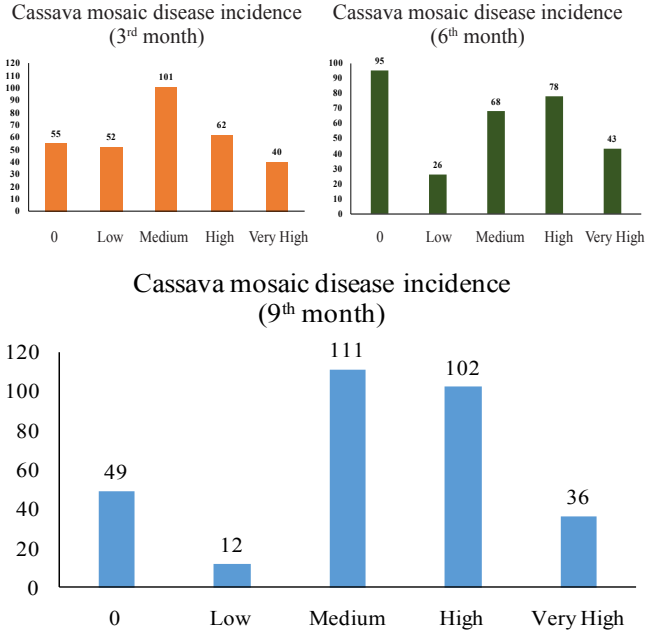


Fig. 5. Cassava mosaic disease incidence at different growth stages (3rd, 6th and 9th month)

one with maximum number of accessions from CE-8 to CE-482A, whereas Cluster 6 with 21 accessions from CE-372 to CE-478A having 3 sub clusters was the most divergent one. No two accessions were similar in the grouping.

Table 1. Promising accessions identified in cassava

Character	Number of accessions evaluated	Number of promising accessions	Promising accessions
CMD symptom free	310	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-403, CE-428, CE-456 and CE-594A

Sweet potato

Out of a total of seven accessions collected, one new landrace was collected from Punalur, Kerala, which was cream-fleshed with good cooking quality, two from Meghalaya, one from Adimali, Kerala and three from Thiruvananthapuram, Kerala. One thousand one hundred and ten accessions of sweet potato were maintained in the FGB during 2022-2023 at ICAR-CTCRI, Thiruvananthapuram for maintenance and characterization.

Ninety three accessions/pre-breeding lines were characterized for 26 vegetative and storage root characters based on CIP descriptors. The recorded data were subjected to statistical analysis using Multivariate statistical package (MVSP 3.1). UPGMA cluster analysis separated these accessions into two principal clusters at a Euclidean distance of 1.2. PC1 accounted for 25% of the variation. Predominant vine colour, leaf lobe shape, leaf lobe number and petiole pigmentation were the highly loaded variables contributing to variation in PC1. Leaf lobe number, leaf lobe shape, shape of central leaf lobe, petiole pigmentation, predominant skin colour and predominant flesh colour were the traits with high values in PC1, PC2 and PC3. Hence, these characters are important in distinguishing the accessions. Yield varied from 16 to 733 g plant^{-1}. Eight accessions did not show tuberization. Out of the tuberizing ones, 4 were white, 3 cream, 10 pale orange, 40 orange, 14 dark orange and 2 purple-fleshed. Forty six accessions had starch below 10%, 22 between 11 and 20% and 5 above 20%. In this set, highest starch content observed was 22.70% (Table 2).

Table 2. Promising accessions identified in sweet potato

Character	Number of accessions evaluated	Number of promising accessions	Promising accessions
High starch	93	5	105/6, 125/20, 7/2, 107/16 and 351/25

Yams

A total of 13 accessions of yams were collected, including three from Tripura, five from Kerala, three from Tamil Nadu, and one each from Maharashtra and Odisha. It included six greater yam, five lesser yam and three wild yam accessions (Fig. 6). These accessions were planted in the field for characterization as per DUS guidelines. One thousand one hundred and twenty one accessions of yams, comprising greater yam (600), white yam (158), lesser yam (222), potato yam (6) and wild yams (135) were maintained in the FGB at ICAR-CTCRI, Thiruvananthapuram. The distribution map of greater yam accessions was prepared based on passport data (Fig. 7).

Fig. 6. New collections: A: Lesser yam; B: Greater yam

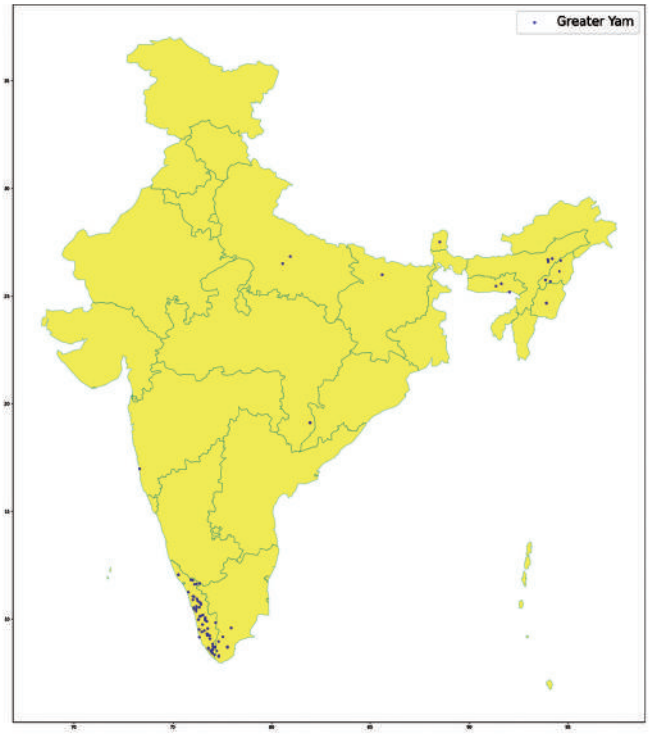


Fig. 7. Geographical distribution of greater yam accessions

Under morphological characterization, 421 greater yam accessions were evaluated for nine tuber traits. Tuber yield ranged from 0.11 (Da-61) to 5.26 kg plant^{-1} (Da-811). Five percent of the accessions were high yielding (>4.01 kg plant^{-1}). The tuber length ranged from 34 cm (Da-14) to 181 cm (Da-6) and tuber girth ranged from 12 cm (Da-14) to 99 cm (Da-604). Twenty promising accessions with high yield (>4 kg plant^{-1}) were identified (Table 3). The digital documentation of the greater yam accessions based on key morphological traits was carried out. Besides, 32 greater yam accessions were characterized using six SSR primers.

Among white yam, 158 accessions were evaluated for tuber traits. The tuber yield ranged from 0.26 (Dr-344) to 6.68 kg plant^{-1} (Dr-20). Eight tuber characters of 123 white yam accessions were recorded. Six accessions produced high yield (>4 kg plant^{-1}). The tuber length ranged from 13 (Dr-116) to 60 cm (Dr-140) and tuber girth ranged from 13 (Dr-96) to 60 cm (Dr-15). Seven accessions produced high tuber yield per plant (>4 kg plant^{-1}) (Table 3). In lesser yam, the tuber yield per plant ranged from 0.08 kg (CTDE-215) to 3.89 kg (CTDE-27).

Edible aroids

A total of 46 accessions were collected, comprising 28 taro (which includes three bunda type from Tripura; 12 voucher samples of eddoe type from Kovvur, Andhra Pradesh; four each from Meghalaya and Kerala; three from Tamil Nadu and one each from Tripura and Odisha); six elephant foot yam (three from Tripura; two from Kerala and one from Tamil Nadu); eight tannia (four from Kerala; two from Tamil Nadu and one each from Meghalaya and Tripura); three *karunakizhangu* (two from Tamil Nadu and one from Kerala) and one *Alocasia* (from Kerala) for conservation in the FGB (Fig. 8). Six hundred and eighty three edible aroid germplasm comprising 429 taro, 203 elephant foot yam, 48 tannia and 3 *Alocasia* are being maintained in the FGB, ICAR-CTCRI, Thiruvananthapuram.

Under molecular characterization, five tannia accessions were used for standardizing eight tannia SSR markers

Table 3. Promising accessions identified in yams

Character	Crop	Number of accessions evaluated	Number of promising accessions	Promising accessions
High yield	Greater yam	421	20	Da-9, Da-12, Da-18, Da-60, Da-63, Da-206, Da-234, Da-255, Da-367, Da-372, Da-379, Da-492, Da-501, Da-519, Da-817, Da-821, DaH-166, DaH-9/196, TCR-142 and TCR-226
	White yam	158	7	Dr-20, Dr-130, Dr-350, Dr-15, Dr-140, Dr-13 and Dr-130

Fig. 8. New aroid collections

having number of observed alleles per locus more than two. Various parameters like varied DNA concentration (10-40 ng μl^{-1}), varied $MgCl_2$ concentration of Taq buffer (1.5, 2.0 and 3.0 mM), varied primer concentration (0.2, 0.3, 0.4 µg) and different annealing temperatures were done. The product was resolved in 2% agarose gel and polymorphism was observed in the selected primers. These primers will be used for characterization of the tannia germplasm.

Under evaluation of germplasm, 203 elephant foot yam accessions were evaluated for flowering and five lines were identified viz., AD/Sa/2022-1, AD/2022-1, AmH-13-C, TEy22-8 and Gajendra (Fig. 9).

Preliminary yield evaluation of 47 elephant foot yam accessions was carried out and it was observed that the yield ranged from 6.71 (Am-48) to 31.40 t ha^{-1} (BCA-4). Two accessions, BCA-4 and Am-39 were statistically superior to Gajendra (26.70 t ha^{-1}), whereas, AmH-dwarf, SP x Athira and ADSK/2021-1 yielded on par. Edible aroid photo database was updated with tuber photos of 25 accessions, comprising 22 taro and one each of tannia, *karunakizhangu* and *Alocasia*.

Fig. 9. Flowering lines of elephant foot yam

Minor tuber crops

A total of five minor tuber crops accessions, comprising two each of Chinese potato (Kovilpatti, Tamil Nadu and Idukki, Kerala) and Canna (Dindigul, Tamil Nadu), and one yam bean (ICAR-NBPGR) were collected. Two hundred and seven accessions comprising 110 Chinese potato, 53 yam bean, 6 *Canna edulis*, 25 *Curcuma angustifolia* (East Indian arrowroot), 12 arrowroot (*Maranta arundinacea*) and one *Curcuma zedoaria* were maintained in the FGB at ICAR-CTCRI, Thiruvananthapuram.

Chinese potato

Under morphological characterization, the two group of Chinese potato representing local types from Kovilpatti (IC641834) and Vandamedu (Idukki) (IC641831) were assessed for qualitative characters. The general view of plant, leaf, stem and tuber characters are given in Fig. 10 and Fig. 11.

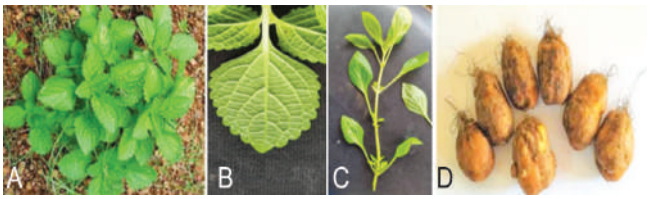


Fig. 10. Kovilpatti collection (IC641834);
A: Plant view; B: Leaf; C: Stem; D: Tuber

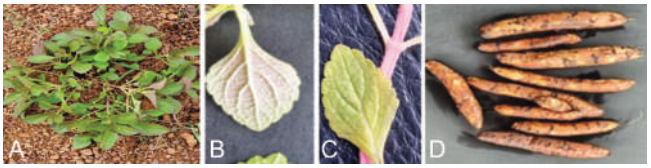


Fig. 11. Idukki collection IC641831;
A: Plant view; B: Leaf; C: Stem; D: Tuber

In the germplasm, morphological characterization of 26 accessions of Chinese potato along with the variety Sree Dhara (Fig. 12-14) was done using NBPGR descriptors for seven qualitative and 16 quantitative traits. These data were subjected to Cluster analysis, Pearson Correlation Coefficient analysis and Principal Component Analysis

Fig. 12. Field view of Chinese potato crop

Fig. 13. Round tubers

Fig. 14. Elongated tubers

(PCA). Cluster analysis grouped the 27 entries into three major clusters with sub-clusters. Pearson correlation coefficient analysis showed maximum genetic variability between Sree Dhara and TCR-136 (0.7649) and the least similarity (-0.8599) between TCR-136 and TCR-110. The PCA revealed that characters like tuber flesh colour, pigmentation of the peduncle, tuber skin colour and tuber shape contributed more towards the genetic variability among the accessions of Chinese potato.

Under molecular characterization, 26 accessions of Chinese potato along with the variety Sree Dhara was characterized using 10 ISSR and eight SSR markers. The results revealed high overall polymorphisms of 97.82 and 72.72% respectively.

Based on 10 ISSR markers, the UPGMA cluster grouped the 27 accessions into three principal clusters and amongst these, ASA-7 was identified as a divergent line. In Pearson correlation coefficient analysis, TCR-120 and ASA-10 showed maximum genetic similarity (0.8325) whereas, the least similarity (-0.3492) was obtained between SAASV-20 and TCR-111, intra-specifically.

In the case of eight SSR markers, a total of 11 scorable bands were produced, of which, eight were polymorphic. Cluster analysis grouped these accessions into three major clusters. In Pearson correlation coefficient analysis of SSR markers, the correlation coefficient ranged from -0.7826 to 1, revealing less genetic variability among the accessions. Mantel's test showed a positive correlation proving that the ISSR and SSR markers along with morphological data can be used to identify variability in this potentially important underutilized crop.

Yam bean

The yam bean accession (IC635945) introduced from ICAR-NBPGR through Material Transfer Agreement (MTA) along with RM1 variety were characterized for 17 characters as per DUS guidelines of PPV&FRA and documented (Fig. 15 and Fig. 16).

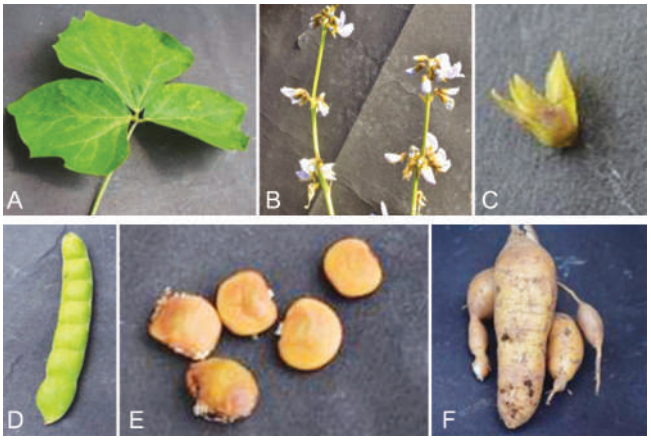


Fig. 15. Distinct characters of variety RM-1

A: Leaf shape; B: Inflorescence; C: Sepel stalk; D: Pod; E: Seed; F: Tuber

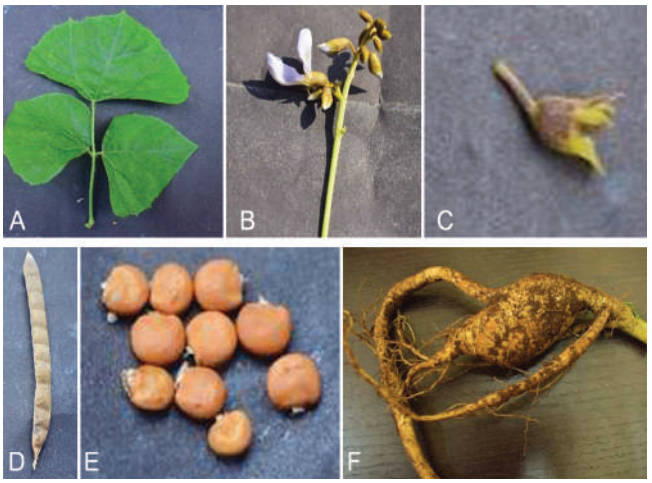


Fig. 16. Distinct characters of Andaman germplasm IC635945
A: Leaf shape; B: Inflorescence; C: Sepel stalk;
D: Pod; E: Seed; F: Tuber

For studying the genetic diversity using molecular markers, 67 SSR markers from soybean were used to assess cross species transferability of soybean SSR to yam bean in 140 yam bean accessions. Of the 67 SSR markers tested, 15 showed interspecies transferability. Jaccard's similarity coefficient and dendrogram were generated using NTSYS-pc. The 15 primers produced a total of 3928 bands with numbers of alleles per marker ranging from 1 to 2. The 140 yam bean cultivars were classified into two main clusters and two sub clusters. YBBL-13 formed a cluster separate from the rest, and was followed by YB-564, which differed from the rest in the second-level clusters. A total of 21 terminal sub-clusters were formed, characterizing the 140 yam bean accessions. These 15 soybean SSR primers can be used to explore the diversity of yam bean species and can aid in the preservation of wild yam bean species and accession.

Ten yam bean accessions (DPH-10, DUS 8X9, L19, LNo.3, EC100546, DPH63, DPH6, DPH20, RM1 and RM2) were evaluated for proximate composition of the tuber flour. These were checked for various nutritional components. The results showed that the moisture level of the tubers ranged from 83 to 96%, with LNo.3 having the highest moisture content (95.32%) and DPH-20 the lowest (83.42%). The amount of readily usable carbohydrate in the *P. erosus* flours ranged from 20 to 50%, with DPH-10 having the highest (48.14%) and L19 having the lowest carbohydrate content (22.87%). The protein level of all the yam bean types tested ranged from 1 to 2.5 mg per 100 g of sample, with DPH-10 having the highest (2.27 mg) and DPH-20 the lowest protein content (1.02 mg) (Table 4).

Table 4. Promising accessions identified in yam bean

Character	Number of accessions evaluated	Number of promising accessions	Promising accessions
Readily usable carbohydrate	10	1	DPH-10
Protein level	10	1	DPH-10

The structural features of *yam bean mosaic virus* (YBMV) (coat protein) (CP) were predicted using 3D modeling and molecular dynamics simulations. Results showed that ARG124, ARG155, and TYR151 towards the inner side of the virion and THR122, GLN125, SER92, and ASP94 towards the outer side could provide essential insights into the structure and function of the CP. The results can be used to develop new strategies for controlling YBMV and other plant viruses and improve resistance of crops to virus infection.

Queensland arrowroot (*Canna edulis*)

Two accessions of *C. edulis* (CTCRI-Canna-PM1 and PM2) were assessed for 37 characters as per DUS guidelines. The distinct differences with regard to capsule colour, flower and seed presence in the capsule were documented (Fig.17 and Fig. 18). Canna-PM2 had distinct parthenocarpic green capsule and large rhizome with 16.50% starch.

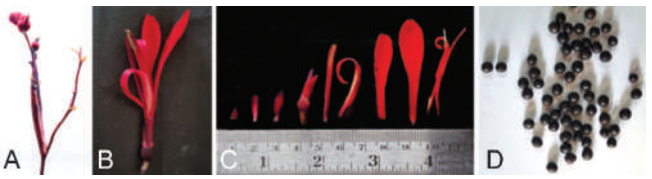


Fig. 17. CTCRI-Canna-PM1; A: Capsule; B: Flower; C: Petals;
D: Seed

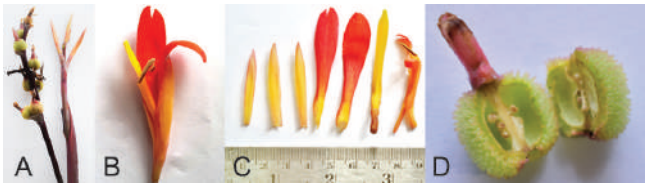


Fig. 18. CTCRI-Canna-PM2; A: Capsule; B: Flower; C: Petals; D: Parthenocarpic capsule

Germplasm conservation and evaluation at Regional Station

At the Regional Station, ICAR-CTCRI, Bhubaneswar, germplasm of different tuber crops comprising 1251 accessions are being maintained in the FGB. It includes cassava (113), sweet potato (380), yams (51), taro (510), elephant foot yam (40), tannia (1), *Alocasia* (3), Chinese potato (5), yam bean (146) and arrowroot (2).

In vitro conservation of tuber crops

At the headquarters, *in vitro* cultures conserved included released, pre-release and exotic lines, comprising 18 cassava, 22 sweet potato, 28 yams, 2 taro and 2 minor tuber crops. Apart from this, three accessions of cassava (CE-28A, CE-38, CE-48) using nodal segments and two of taro (C-553 and C-167) using young sprouts were newly initiated under *in vitro* for conservation.

At the Regional Station, 500 released, pre-release, and exotic line cultures were kept under *in vitro*. These cultures included 10 released varieties of cassava, 11 varieties of sweet potato, 5 varieties of taro, 4 varieties of yam, 2 varieties of elephant foot yam and 4 varieties of Chinese potato.

Gene bio-prospecting for novel traits in tuber crops

The antibacterial effects of methanolic extract of *Curcuma angustifolia* accessions were reported in Chhattisgarh Tikhur-1 variety and IC641835 (IGBT), a collection from Chhattisgarh. The minimal inhibitory concentration (MIC) was analyzed for three accessions from Chhattisgarh, which are maintained in the FGB and compared with a standard antibiotic drug, gentamicin. The methanol extract of *C. angustifolia* Chhattisgarh Tikhur-1 variety had a MIC at 400 µg, whereas IC641835 showed MIC at 800 µg. The standard drug, gentamicin had MIC at 200 µg. As the extract used is crude and unrefined, isolation of a pure compound in future can be a more effective drug towards *Staphylococcus aureus*. The genetic variability analysis was carried out among the five *C. angustifolia* accessions from various locations using four selected SSR markers. The dendrogram revealed that Chhattisgarh Tikhur-1 variety and accession from Idukki had 100 per cent similarity and accession from FGB and Nedumangad had 100 percent similarity.

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

The seedlings developed through pyramiding of resistance from multiple sources were evaluated for tuber yield, dry matter content and culinary quality. The highest tuber dry matter content was recorded in 20S-1 (49.30%), followed by 15S-409 (49%). Four genotypes viz., 17S-123, 8N-113, 15S-101 and 17S-247 also contained high dry matter (>45%). Four genotypes viz., 15S-351, 17S-48, 17S-120 and 17S-247 showed good culinary quality. Ten genotypes were evaluated for fried chips quality, of which 16-5 and landrace, *Manna*, had better-fried chips quality.

Thirty cassava genotypes were evaluated for nutrient use efficiency, and selection indices were worked out that ranged from 130.91 (17S-247) to 460.75 (KBH-2006/18). Based on the selection index, five genotypes were selected and evaluated in replicated yield trial. The highest tuber yield was recorded in the genotype KBH-2006/18 (60.48 t ha^{-1}), followed by 8S-501-2 (48.42 t ha^{-1}). The N use efficiency was highest for the genotype KBH-2006/18 (20.04 kg tuber/kg N uptake), followed by 15S-409 (14.50 kg tuber/kg N uptake), 8S-501-2 (13.31

kg tuber/kg N uptake) and 16-5 (12.67 kg tuber/ kg N uptake). The genotype, 8S-501-2 exhibited high efficiency for K (47.81 kg tuber/kg K uptake), followed by 15S-409 (39.93 kg tuber/kg K uptake), KBH18 (39.10 kg tuber/kg K uptake) and Sree Pavithra (32.48 kg tuber/ kg K uptake).

Whole genome resequencing of ICAR-CTCRI cassava elite breeding lines 8S-501 and 9S-127

A high-quality draft genome assembly of two inbred cassava lines, 8S-501 and 9S-127, was developed through whole-genome resequencing. These elite breeding lines were developed at ICAR-CTCRI and are widely used in cassava breeding programmes. Analysis of these draft genome sequences revealed the presence of 7,789,154 and 7,130,986 SNPs in 8S-501 and 9S-127 respectively (Fig. 19). Comparative analysis showed the presence of 1,104,776 and 943,104 InDels in 8S-501 and 9S-127 respectively (Fig. 20). The SNPs and InDels identified in this study will be utilized for the identification and development of molecular markers linked to important agronomic traits including high starch, profuse flowering and CMD resistance. The high-quality draft assembly would be helpful for mining SSRs and the development of molecular markers for marker-assisted backcross breeding in cassava.

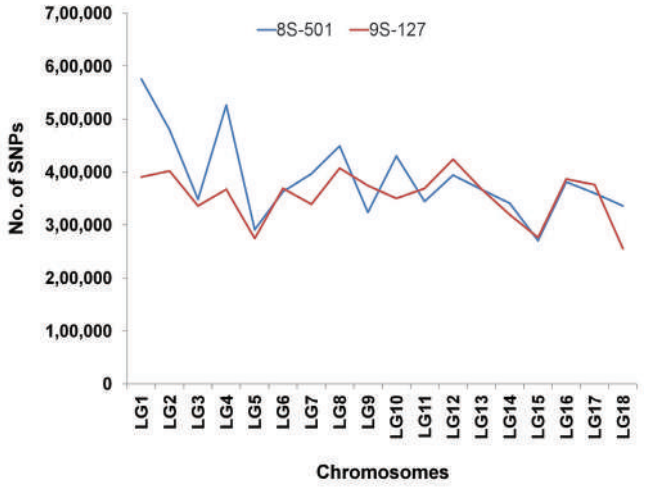


Fig. 19. Chromosomal distribution pattern of SNPs

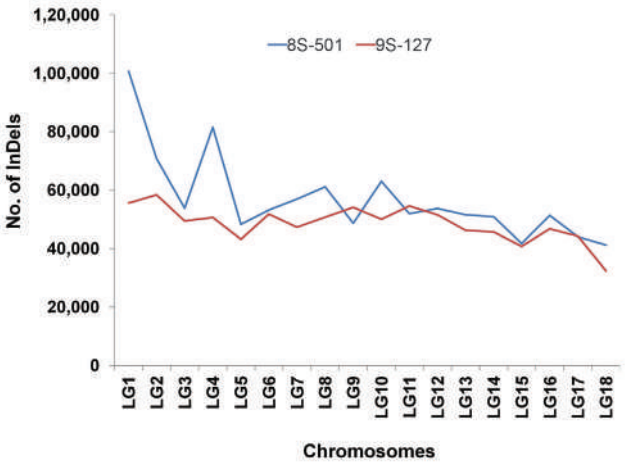


Fig. 20. Chromosomal distribution pattern of InDels

Yams

Fig. 21. Tuber of SD-15

In yams, the evaluation trials were planted during April 2022 at ICAR-CTCRI, Thiruvananthapuram as a rainfed crop. In the advanced yield trial of greater yam entries, DaH-10-130 produced the highest tuber yield (46.91 t ha^{-1}), followed by DaH-10-41 (40.24 t ha^{-1}). In the advanced yield trial of white yam entries, DRS-1047 yielded the highest (59.30 t ha^{-1}). Among the bushy white yam clones evaluated, DrD-1095 produced the highest tuber yield (38.27 t ha^{-1}), followed by DrD-1038 (35.80 t ha^{-1}) and DrD-1112 (35.16 t ha^{-1}). About 1.20 tons of planting material of the pre-release variety SD-15 (Fig. 21) that produced tuber yield of 43.62 t ha^{-1} under non-trailing conditions, was multiplied. Transcriptome analysis of the dwarf variety, Sree Swetha and tall variety, Sree Haritha was undertaken to study the expression of dwarfing genes in white yam.

Arrowroot

In arrowroot, fourth year advanced yield trial of seven arrowroot genotypes planted in RBD in three replications for yield and yield attributes showed that the tuber yield ranged from 37.78 to 42.26 t ha^{-1}. The genotype M-3 was significantly superior, with an yield of 42.26 t ha^{-1} (Fig. 22). It was also observed that all the genotypes yielded above 35 t ha^{-1}. The highest single plant rhizome weight was produced in M-6 and M-5 (1.19 kg) and the lowest in M-3 (1.03 kg). The entries M-7, M-4, M-2 and M-1 had single plant rhizome weight above 1 kg. The number of rhizomes per plant ranged from 17 (M-3) to 20 (M-6, M-4). The single rhizome weight was highest in M-7 (130.56 g) and lowest in M-5 (105.0 g). All the entries produced single rhizome weight above 100 g. Single rhizome length x girth was highest in M-7 (28 x 9.33 cm) and the lowest in M-3 with 23.78 x 8.94 cm. Rhizome length alone was high in M-7 (28 cm) and lowest in M-5 (22.94 g), while rhizome girth was highest in M-5 (9.78 g) and lowest in M-3 (8.94 g). The average dry matter content of rhizomes of all the genotypes was above 30%, which ranged from the lowest of 30.50% in M-4 to 33.25% in M-2 (Fig. 22 and Fig. 23).

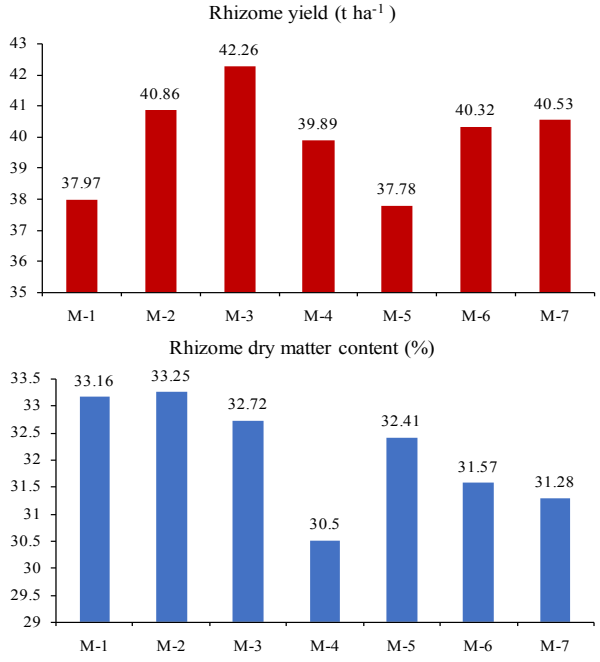


Fig. 22. Rhizome yield (t ha^{-1}) and dry matter content (%) of arrowroot genotypes

Fig. 23. Promising genotypes identified in arrowroot for A: Rhizome yield; B: Dry matter

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

For CMD resistant mapping study, 325 F_1 seedlings were developed by crossing Sree Jaya and 9S-127. These seedlings were evaluated for CMD and SSR marker studies. The CMD screening done in this population identified 185 resistant seedlings and segregated them in a 1:1 ratio. For identification of the hybrid nature of the F_1 seedlings, DNA of ten randomly selected plants was isolated, and the SSR36 and SSR42 primers confirmed the true hybridity. In the new CMD resistant population (CMD resistant lines: 9S-127, Sree Padmanabha, 8S-501, PDP CMR-1; Susceptible lines: Sree Jaya and H-226), 350 resistant hybrid seedling lines were identified from 80 cross combinations. The first clonal generation (C_1) of the selected seedlings was planted for further characterization.

Starch mapping population

The parents, Sree Vijaya and 9S-127 were used to develop 125 starch mapping populations. Fifty randomly selected seedlings were used for dry matter estimation. The dry matter ranged from 27.76 to 52.05% in the hybrids and parents (Sree Vijaya: 37%, 9S-127: 49.20%). Starch content ranged from 13.88 to 33.46% (Sree Vijaya: 20.50%, 95-127: 30.90%). From this population, 10 progenies consisting of low and high dry matter lines were selected for DNA isolation and starch gene-specific marker studies.

Drought tolerant population

Five drought-tolerant lines (H-226, 9S-127, 8S-501, PDP CMR-1, CR43/11) were crossed with seven drought

susceptible genotypes (Sree Padmanabha, M-4, CI-130, CI-448, FB-1, H-97, Vellayani Hraswa), and 252 CMD seedlings were identified from 44 cross combinations. The yield of the harvested seedling progenies ranged from 0.5-4 kg plant^{-1} in both CMD and drought tolerant populations (Fig. 24). The selected C_1 clonal generation were planted for further evaluation.

Fig. 24. Hybrid seedling (F_1) tuber yield of CMD resistant and drought tolerant crosses

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

Fifteen cassava genotypes comprising nutrient-use efficient genotypes and cassava germplasm accessions were evaluated for PPD tolerance till 15 days after harvest. Genotypes such as CI-905, CE-535 and CE-546 were tolerant to PPD up to seven days after harvest.

Seedling (F_1) evaluation

The seedling progenies and parents such as CO 1, Sree Padmanabha and 9S-127 were evaluated for major agronomic traits at 3, 6 and 9 months after planting, yield, dry matter content and PPD tolerance. The total number of tubers per plant ranged from 4 to 8 (parents) and 2 to 15 (progenies); commercial-sized tubers ranged from 2 to 6 (parents) and 2 to 9 (progenies). The mean yield recorded for seedling progenies was 4.48 kg plant^{-1}, with the highest yield of 7.38 kg plant^{-1}. The plant height ranged from 159.4 to 347.4 cm. The mean PPD score of progenies was 2.75, and there were progenies with tolerance to PPD seven days after harvest. The dry matter content of progenies ranged from 28.92 to 35.22% (Fig. 25).

Fig. 25. High tolerance for PPD observed in F_1 clonal progenies

First clonal (F_1) evaluation (F_1C_1)

The F_1 clonal progenies of crosses made during 2019-20 were planted in field for evaluation of yield and PPD tolerance. The tuber yield per plant ranged from 0.34 to 5.92 kg with an average of 1.57 kg. The number of tubers per plant ranged from 3 to 11 tubers. The F_1 clonal progenies showed wide segregation for PPD tolerance and CMD score of the clonal progenies was 1.13.

Second clonal (F_1) evaluation (F_1C_2)

The number of tubers per plant ranged from 2 to 27 tubers and tuber yield per plant ranged from 1.04 to 4.54 kg with an average of 1.37 kg. The F_1 clonal progenies showed wide segregation for PPD tolerance from low to high tolerance (Fig. 26). The average CMD score of the clonal progenies was 2.16. The cooking quality of

Fig. 26. Field view of the second clonal progenies and PPD tolerance observed in the progenies

the clonal progenies was assessed and genotypes with excellent cooking quality were identified. The mean dry matter content recorded was 31.27%. The second clonal progenies were replanted in replicated trials for Preliminary Yield Trial (PYT). The parental polymorphism study between the parents contrasting for PPD was done with 35 and out of this, 10 new polymorphic markers were identified.

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

Synteny and collinearity analysis revealed that the *MeMADS* box genes in cassava were evolved through gene duplication and divergence (Fig. 27). The miRNA target prediction

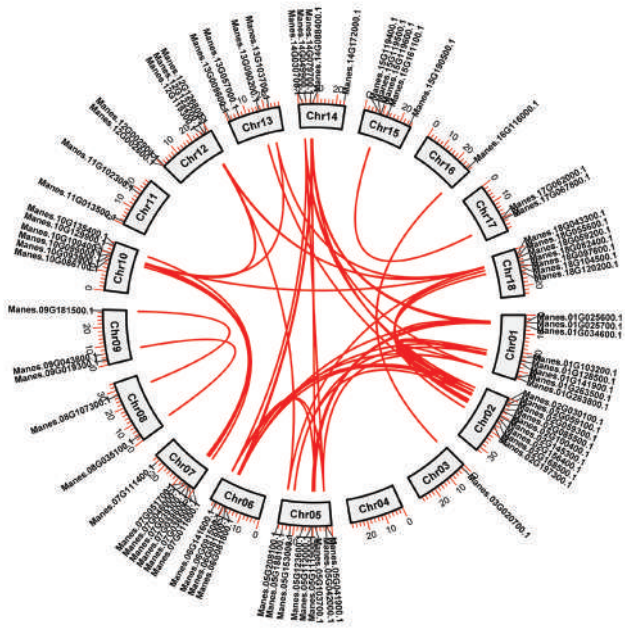


Fig. 27. Synteny relationship of *MeMADS* family members in cassava

showed 23 *MeMADS* box genes as potential targets of 53 miRNAs. Eighteen and sixteen miRNAs were known to regulate the expression of *MeMADS14* and *MeMADS63* respectively. The expression of *MeMADS16* was regulated by *mes-mirR2275,* whereas the expression of *MeMADS2* and *MeMADS3* were regulated by *mes-mirR2275*. The *mes-mirR396* regulates the expression of seven genes viz., *MeMADS14, MeMADS30, MeMADS36, MeMADS41, MeMADS56, MeMADS63 and MeMADS68*. This study showed that *MeMADS-box* genes were evolved through duplication and divergence in cassava. Expression of selected set of tuber specific *MeMADS box* genes are under progress.

Gene editing Indian cassava varieties to produce high value waxy starch

To develop a gene editing construct targeting *gbss* gene, four primers incorporating the guide sequence targeting *gbss* gene at two sites have been synthesized and four primer mixture of the guides along with the vector pCBC-DT1T2 was PCR amplified. For standardizing the regeneration potential of cassava accessions after transformation, *in vitro* cultures and FEC of cassava accessions 9S-127, 8S-501 and H-226 were multiplied and maintained. Cassava var. H-226 showed highest regeneration potential after transformation, in comparison to the accessions 9S-127 and 8S-501.

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

The hybrid seeds from controlled crosses were germinated and raised in the polybags during the previous years. These seedling tubers were evaluated based on flesh colour and dry matter. The purple-fleshed hybrids identified were evaluated during the last three years in different seasons and the compiled data indicated significant difference for yield between hybrids and between season as well as hybrids and season (Table 5). The cooking quality of the boiled storage root of the above hybrids was evaluated for consistency, undesirable colour, texture, sweetness and taste as per IPGRI descriptors. The hybrid, 38/46 was identified as the best with good culinary quality. The other promising yielders containing both anthocyanin and β-carotene viz., 110/28 (with 9.5 mg 100 g^{-1} FW of total carotenoids and 60 mg 100 g^{-1} FW of anthocyanin) and 38/15 (with 14.5 mg 100 g^{-1} FW of total carotenoids and 8 mg 100g^{-1} FW of anthocyanin) (Fig. 28 and Fig. 29) also showed good cooking quality. The selected lines were identified for on-farm trials in various locations in Kerala.

In the advanced yield trial of 26 orange-fleshed hybrids evaluated during kharif 2022, 43/83 was the highest yielder with a yield of 52.90 t ha^{-1} and starch content of 22.59%. In the preliminary yield trial of another 30 orange-fleshed hybrids, the highest yielder was 642/6 with a yield of 33 t ha^{-1}. In the evaluation trial of 14

Table 5. Yield of sweet potato genotypes

Hybrids	Yield over the different seasons (t ha^{-1})						Average
	Jan-April 2020 S1	July-Oct 2020 S2	Nov 2020-Feb 2021 S3	Sep-Dec 2021 S4	Dec 2021-March 2022 S5	April-Aug 2022 S6	
Bhu Krishna	11.46	9.03	8.68	13.89	15.28	10.42	11.46^{def}
38/15	27.78	10.42	4.17	26.04	9.72	27.08	17.53^{bc}
38/46	21.53	29.51	3.12	27.78	18.40	14.58	19.16^{abc}
38/57	7.08	31.25	1.39	6.25	3.33	14.58	10.65^{efg}
93/8	15.97	10.42	17.36	17.71	19.10	14.58	15.86^{cde}
110/28	26.04	6.94	15.62	31.60	38.19	12.50	21.82^{ab}
110/14	17.36	55.56	34.72	17.36	9.73	14.58	24.89^{a}
114/13	7.22	0.00	6.25	15.62	13.31	12.50	9.15^{fgh}
114/54	5.56	32.29	5.56	8.68	5.21	7.29	10.76^{defg}
114/15	0.67	12.15	1.39	15.62	1.74	3.12	5.78^{fghi}
114/11	0.00	2.43	1.04	3.47	1.25	0.00	1.37^{i}
114/39	0.62	10.49	0.69	0.00	1.04	2.29	3.68^{hi}
125/20	16.87	37.50	2.08	14.24	17.36	10.42	16.41^{bcd}
163/2	3.12	14.58	0.00	0.00	2.50	3.12	5.28^{ghi}

LSD (0.05): Accession= 4.34; Accession x Season=10.63

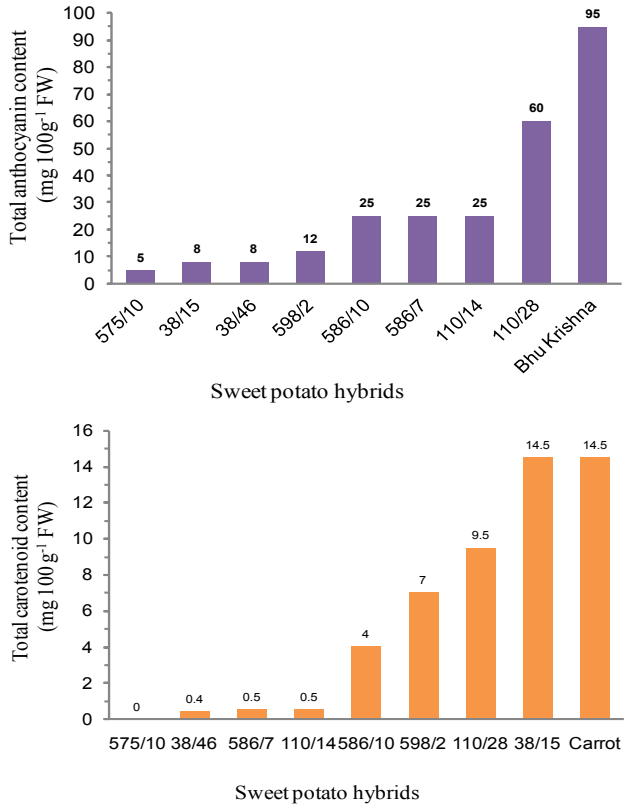


Fig. 28. Anthocyanin and carotenoid content in the selected accessions containing both anthocyanin and β-carotene

Fig. 29. Selected promising hybrids of sweet potato

promising anthocyanin rich accessions evaluated during kharif 2022, 38/15 was the highest yielder with a yield of 30.95 t ha^{-1}.

In the experiment on breeding for processing traits, 12 sweet potato genotypes of varying flesh colour (germplasm accessions, breeding lines and improved varieties) were evaluated for two seasons. The dry matter content varied from 24.76 (S-346) to 37.23% (S-1401); total starch from 18.70 (S-1248) to 23.52% (Sree Arun); total sugar from 1.57 (S-1248) to 4.95% (Sree Arun); peel loss from 10.65 (S-346) to 19.41% (S-1258) and flour yield from 26.60 (Sree Varun) to 41.87% (Palakkad local). Genotypes such as S-27, Palakkad local, S-1401, Sree Arun, Indira Madhur, EC 321693 were suitable for processing. Controlled hybridization of parental lines selected for processing traits was done and the seedlings were raised. The open pollinated seeds from isolated plots were collected, germinated and seedlings were established. The germination percentage of hybrid seeds was 81.81%.

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

Exploration missions were conducted in targeted areas and eight wild species of *Ipomoea* including *I. trifida* and *I. mauritiana* were collected for utilization in the wide hybridization programme. The collected wild species of *Ipomoea* were planted and conserved at ICAR-CTCRI, Thiruvananthapuram. At the Regional Station of ICAR-CTCRI, Bhubaneswar, 100 pollinations were attempted between *I. batatas* (var. Kanjangad local) and *I. trifida*. The fruit set was poor (4%) in the crossed plants and seed was developed in only one fruit. The seed was sown for germination.

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

Thirteen sweet potato hybrid lines viz., four white flesh (SPH-65, SPH-19, SPH-61 and SPH-60), four orange flesh (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 planted during October 2021 at the Regional Station, Bhubaneswar, for evaluation of yield and other qualitative traits for the second year and harvested during February 2022. Among the white flesh hybrid, highest yield was in SPH-60 (31.20 t ha^{-1}), followed by SPH-65 (26.20 t ha^{-1}), SPH-19 (24.50 t ha^{-1}) and SPH-61 (18.49 t ha^{-1}).

Among the orange flesh hybrids, highest yield was obtained from SPH-21 (26.29 t ha^{-1}), followed by SPH-40 (25.90 t ha^{-1}), SPH-52 (25.18 t ha^{-1}) and SPH-44 (24.83 t ha^{-1}). Out of the purple flesh hybrids, highest yielder was SPH 31 (27.45 t ha^{-1}), followed by SPH-15 (21.65 t ha^{-1}), SPH-14 (20.07 t ha^{-1}), SPH-29 (18.66 t ha^{-1}) and SPH-30 (17.55 t ha^{-1}). The highest amount of anthocyanin was in SPH-31(137.69 mg 100 g^{-1} dry weight basis), followed by SPH-15 (98.44 mg 100 g^{-1} dry weight basis). In addition, SPH -31 may be used for juice, jam, halwa (sweet) preparations and other purposes. The highest β-carotene content was in SPH-52 (12.33 mg 100 g^{-1} dry weight basis), followed by SPH-44 (10.26 mg 100 g^{-1}) and SPH-21 (8.46 mg 100 g^{-1}) (Fig. 30).

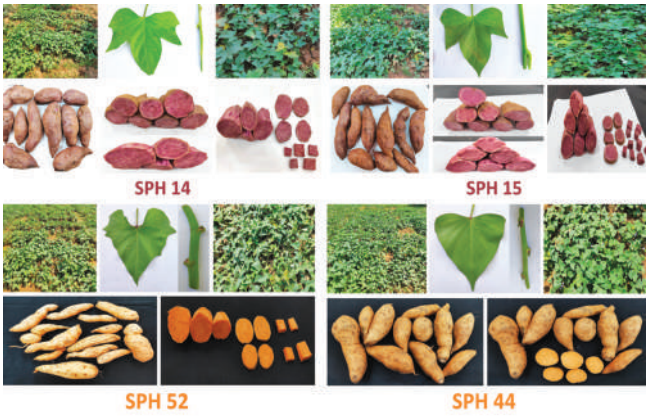


Fig. 30. Selected purple and orange-flesh sweet potato

Yam bean

In yam bean, highest yielder was hybrid 3 x 8 (38.64 t ha^{-1}), followed by 3 x 9 (35.26 t ha^{-1}) (Fig. 31). Seeds were harvested for best yam bean hybrids for multilocation trials (MLT) in different parts of Odisha. Yam bean lines were evaluated for nutrient content like P, K, Mn, Zn, Fe, Cu and Mg and the ranges are as follows,

Fig. 31. Best yam bean hybrid lines

P: 2170-2930 ppm; K: 3210-3520 ppm; Mn: 60.50-86.30 ppm; Zn: 10.50-12.60 ppm; Fe: 249.60-281.40 ppm; Cu: 13.90-15.50 ppm and Mg: 290.30-319.80 ppm.

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

Sweet potato

Sweet potato genotypes for drought tolerance viz., DB/21/57, RS-III-3, B × 7, SP-123 and S-162 were planted along with checks, Bhu Sona, Bhu Krishna and Kishan for evaluation in two replications. Highest number of tubers per plant was recorded in DB/21/57 (5.85), followed by RS-III-3, B × 7, and SP-123 (5.0) and Bhu Krishna (4.5). Greatest tuber length was recorded in RS-III-3 (15.25 cm), followed by SP-123 (14.30 cm), B × 7 (13.50 cm) and S-162 (13.32 cm). Highest tuber weight per plant was recorded in B × 7 (352.60 g), followed by RS-III-3 (325.33 g), SP-123 (298.50 and DB/21/57 (280.30). Highest yield per plant was in B × 7 (1.76 kg), followed by D/21/57 (1.64 kg), RS-III (1.63 kg) and Kishan (0.99 kg) (Fig. 32). Drought tolerant genotypes namely, DB/21/57, RS-III-3, B × 7, SP-123 and S-162 were also planted in crossing block along with high yielding and nutritionally rich varieties such as Bhu Sona, Bhu Krishna and Kishan (Fig. 32). Crosses were made and F_1 seeds were collected for further evaluation.

Fig. 32. Tubers of drought tolerant genotypes with check varieties

Taro

Clonal generation (C_3) of seven taro F_1 crosses viz., 18×TCR-369, Nycle × 224, 12 × TCR-369, 12 × TCR-429, 12 × IC022067, TCR-369 × TCR-429 and TCR-813 × IC419746 were planted in July 2021 at Regional Station, ICAR-CTCRI and harvested in January 2022. Clones of all the crosses were evaluated for their nutritional traits (Table 6).

Table 6. Nutritional traits of clonal generations of taro

Sl. No.	Nutritional trait	Genotype (Maximum)	Next best genotypes
1.	DPPH assay (%)	18×TCR-369 (69.39)	12 × TCR-429 (61.67) 12 × IC022067 (60.33)
2.	CUPRAC assay (µmol trolox g^{-1})	18×TCR-369 (32.75)	12 × IC022067 (29.50) 12 × TCR-429 (29.66)
3.	Phenolic (mg gallic acid g^{-1})	18×TCR-369 (7.69)	12 × TCR-429 (7.03) 12 × IC022067 (6.90)
4.	Sugar (%)	12 × TCR-369 (2.73)	12 × TCR-429 (2.10) TCR-813 × IC419746 (1.67)
5.	Starch (%)	12 × TCR-369 (58.86)	TCR-813 × IC419746 (51.33)
6.	Protein (%)	12 × IC022067 (17.43)	12 × TCR-369 (16.20) Nycle × 224 (14.67)

7.	Phosphorous (mg 100 g^{-1})	12 × TCR-429 (417.64)	12 × IC022067 (389.63) 12 × TCR-369 (350.2)
8.	Potassium (mg 100 g^{-1})	12 × IC022067 (1236.83)	12 × TCR-429 (1185.67) 12 × TCR-369 (1087.50)
9.	Iron (mg 100 g^{-1})	12 × TCR-429 (16.05)	12 × TCR-369 (15.19) 12 × IC022067 (13.96)
10.	Copper (mg 100 g^{-1})	Nycle × 224 (1.47)	TCR-813 × IC419746 (1.10) 18×TCR-369 (0.90)
11.	Zinc (mg 100 g^{-1})	Nycle × 224 (14.23)	18×TCR-369 (12.50) TCR-813 × IC419746 (9.03)
12.	Manganese (mg 100 g^{-1})	Nycle × 224 (6.78)	TCR-813 × IC419746 (5.30) 18×TCR-369 (4.93)

Similarly, these clones were planted in July 2022 and leaves collected during September were subjected to the above analysis and it was observed that the leaves had more antioxidant (86.33% DPPH assay and 83.13 µmol trolox g^{-1} CUPRAC assay) activities, total phenolics (67.34 mg gallic acid g^{-1}), crude protein (19.30 g 100 g^{-1}) and Fe (17.67 mg 100 g^{-1}) compared to corms.

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

Fourteen taro accessions were subjected to artificial screening for identification of taro leaf blight resistant lines. However, none of the lines showed resistance. Under AYT1, 11 entries were evaluated with Sree Rashmi as the local check. The taro accession from Nicobar Islands gave the highest cormel yield of 12.80 t ha^{-1} and total yield of 21.80 t ha^{-1}.

Under the genetic improvement programme of elephant foot yam, a total of 20 hybrid corms from a cross between ADS/2019-1 as female parent and Puttur local I as male parent were planted and harvested during January-February 2022. The yield of corms ranged from 6 to 129 g $plant^{-1}$. Among the 45 hybrid corms selected and carried forward from previous crosses, H-102-2015, H-107-2015, H-843/2-2017, H-6-7-2017 and H-6-34-2017 were non-acrid; H-107-2015 and H-6-34-2017 (Fig. 33 and Fig. 34) had smooth petiole; while H-102-2015, H-843/2-2017 and H-6-7-2017 had slightly rough petiole.

Fig. 33. H-107-2015

Since the roughness of the petiole surface is an indication of acridity, corms from smooth to slightly rough petiole plants were assessed for cooking quality.

During the period under report, five elephant foot yam accessions flowered and these were used for hybridization purpose. The crosses made between AD/Sa/2022-1, a landrace collected from Thiruvananthapuram, with stored pollens of a high yielder, Am-141 did not produce any seeds. The accession AD/2022-1 flowered and the fresh pollen was used to pollinate TEy22-8 and Gajendra (2 nos.). Selfing was also attempted but was unsuccessful. Of the three crosses, only one cross with Gajendra ♀ x AD/2022-1 ♂ was successful and produced fertile seeds (Fig. 35). About 200 seeds were obtained and these were planted for germination studies.

Fig. 34. H-6-34-2017

Under yield evaluation trial of elephant foot yam, 11 accessions were carried forward to AYT1 based on two years' preliminary yield evaluation data with Sree Padma

Fig. 35. A pollinated elephant foot yam flower and various stages of fruit and seed set

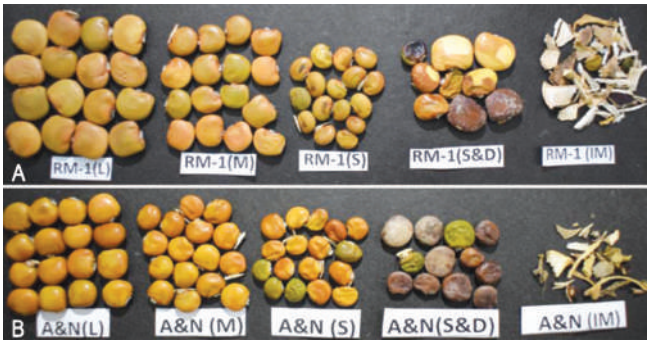


Fig. 36. Seed size variation (large, medium and small), A: Yam bean RM-1; B: Andaman & Nicobar germplasm

as the local check. Under AYT1, Am-39 (28.68 t ha^{-1}) and AmH dwarf (27.12 t ha^{-1}) were superior to Sree Padma, whereas, three accessions (Peermade local, Am-141 and AmH 13-B) were on par. For standardization of *in vitro* micropropagation protocol in tannia, axillary and apical buds from an accession, Sreekariyam local were tried. MS media supplemented with BA (1 mg l^{-1}) was good with the formation of two shoots.

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

Laboratory and field experiments were undertaken on precocity, genetic vigour and seed quality traits of cultivated variety of yam bean (*Pachyrhizus erosus*). The seeds of experimental materials namely RM-1 and Andaman germplasm (IC No.635945) were studied for seed size variation (Fig. 36).

Overall, the investigation performed on seed descriptor study indicated that RM1 had large seed, which was reflected in terms of higher values on seed thickness, length and width of the seeds. Seed hardness test (texture analysis) was standardized using the instrument Texture analyzer (Stable micro system (TA × T plus). Standard germination and field emergence study indicated that there was no difference in seed quality between laboratory and field emergence. There were varietal differences with respect to abnormal, ungerminated and hard seededness from the freshly harvested seeds. In the International Seed Testing Association (ISTA) seed health test, the saprophytic fungus namely, *Rhizopus*, *Penicillium, Aspergillus flavus, Aspergillus niger* and *Macrophomina phaseolina* were observed in both the experimental materials (Fig. 37). The high percentage of presence of *Macrophomina phaseolina* with respect to Andaman Islands germplasm in seed health test needs to be further investigated as it has more pathogenicity.

Rhizopus | *Penicillium* | *Aspergillus flavus* | *Aspergillus niger* | *Macrophomina phaseolina*

Fig. 37. Microscopic view of fungus observed in ISTA seed health test

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

Studies on intercropping in taro: A field experiment was conducted at the Regional Station of ICAR-CTCRI, Bhubaneswar, Odisha, for the second consecutive season to confirm the effect of intercropping vegetable crops in taro on yield potential, 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 (19.48 t ha^{-1}), followed by taro + okra (16.28 t ha^{-1}). The land equivalent ratios (LER) for T_3, T_6 and T_7 were >1, indicating their higher biological efficiency (Fig. 38). The treatment taro + vegetable cowpea resulted in greater LER, higher gross (₹ 2,92,200 ha^{-1}) and net returns (₹ 1,69,700 ha^{-1}). The B:C ratio was highest (2.52) in sole okra, followed by taro + vegetable cowpea (2.38).

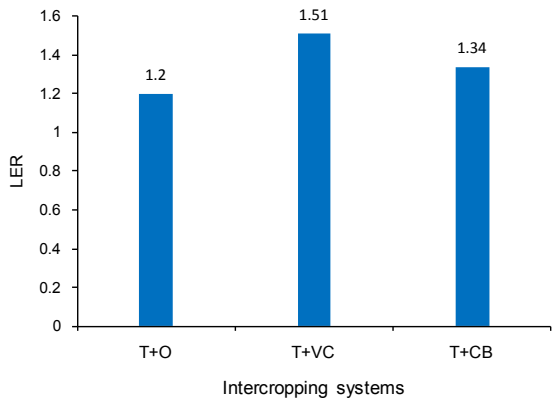


Fig. 38. Effect of taro + vegetable intercropping system on LER

Organic farming of tuber crops based cropping systems

Organic farming of elephant foot yam based cropping systems: A field experiment in split plot design with elephant foot yam (var. Gajendra) + vegetables (amaranthus, okra and cucumber) in main plots and five managements viz., 100% organic, 75% organic + innovative practices (3% *Panchagavya* + 10% 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 was carried out for two seasons (Fig. 39). In the first year, the corm yield of elephant foot yam was unaffected due to vegetable intercrops or management options. The yields of vegetables were significantly affected by management options. The vegetable intercrops performed better under either of the organic practices. The treatment 75% organic + 3% *Panchagavya* + 10% cow urine resulted in highest yield of vegetables (11.00 t ha^{-1}) on par with 100% organic (10.97 t ha^{-1}) and 75% organic + 25% inorganic (9.91 t ha^{-1}). However, the effect of vegetable x management interaction was not significant for yield of vegetables, corm yield of elephant foot yam as well as corm equivalent yield. The yields of amaranthus (9.98 t ha^{-1}) and cucumber (14.80 t ha^{-1}) were the higest in 100% organic and that of okra in 75% organic + 3% *Panchagavya* + 10% cow urine (10.93 t ha^{-1}). The corm yield of elephant foot yam and the corm equivalent yield was the highest when intercropped with cucumber under 75% organic + 25% inorganic (28.28 t ha^{-1}). There was no significant effect of management options on soil properties. But the population of fungi was significantly higher under 100% organic and 75%

Elephant foot yam + amaranthus | Elephant foot yam + okra | Elephant foot yam + cucumber | A single harvest of vegetables

Fig. 39. Organic farming of elephant foot yam + vegetables (second season)

organic + 25% inorganic. The pH, organic C, available P, secondary and micronutrient status of soil, count of bacteria and actinomycetes and dehydrogenase and acid phosphatase activities were enhanced under 100% or 75% organic. The available N and K status were higher under PoP, where chemical fertilizers were used.

In the second year, the corm yield of elephant foot yam was significantly higher due to intercropping with amaranthus (19.12 t ha^{-1}) and cucumber (17.19 t ha^{-1}), but remained unaffected by management options. The yields of vegetable intercrops were the highest under 75% organic + 25% inorganic (16.21 t ha^{-1}), on par with 50% organic + 50% inorganic (15.67 t ha^{-1}) (Fig. 40).

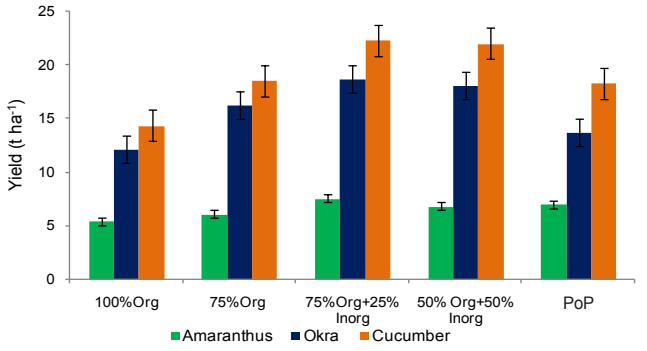


Fig. 40. Yield of vegetable intercrops under different management options (second season)

The corm yield of elephant foot yam (27.16 t ha^{-1}) and the corm equivalent yield (33.29 t ha^{-1}) were highest when intercropped with amaranthus under 100% organic.

Vertical farming of tropical tuber crops

Standardization of nutrient solution for hydroponics based vertical farming of sweet potato: The second season experiment was conducted with the variety Sree Kanaka using substrate-based hydroponics/ dripponics using cocopeat, perlite, vermiculite and their combinations. Two sets of nutrient stocks were prepared to standardize the growth and yield. Crop grew successfully up to 100 days. The vine yield was 0.39-0.78 kg $plant^{-1}$ in different combinations of inert media (Fig. 41).

Fig. 41. Experimental unit of hydroponics in sweet potato (var. Sree Kanaka)

Another experiment was also conducted to check the efficiency of the prepared hydroponic nutrient stocks under circulating hydroponics (NFT), and non-circulating and passive hydroponics (in pots) for growth and yield of spinach. These hydroponic systems gave 3-4 times higher yield than conventional soil-based production.

Urban farming of tropical tuber crops: The first season experiment on standardization of growing media for sweet potato was conducted during September-December, 2022 (Fig. 42 and Fig. 43). The experiment was laid out in CRD with ten treatments using soil, vermicompost, perlite, cocopeat, vermiculite and their combinations along with farmers' practice as check. The crop was grown in UV stabilized 600 gauge with

Fig. 42. View of urban farming experiment in sweet potato

Fig. 43. Sweet potato with tubers and roots in urban farming

a size of 40x24x24 cm poly bags. The vegetative growth parameters, average number of primary branches (2.33), secondary branches (26.3) and number of leaves per plant (329) were higher in the treatment, soil + vermicompost + cocopeat in 1:1:1 ratio. The average yield per plant/bag (0.84 kg) was higher in the treatment soil + vermicompost + perlite in 1:1:1 ratio. The experiment is planted for the second season for confirmative results.

Weed management in tropical tuber crops

Integrated weed management in taro

In the field experiment taken up for the third consecutive season to find out the effect of integrated weed management (IWM) in taro on yield and economics, use of weed control ground cover perforated mat (nursery men mat) (120 gsm) was the most effective. This treatment promoted growth with higher sprouting percentage (78.70, 95.37 at 1 and 3 MAP respectively), number of shoots per plant (4.54) and leaf area index (1.14 at 4 MAP). In addition, the weed density (8.01) and dry weight of the weeds (2.99 g m^{-2}) were also significantly lower in this treatment. Weed flora consisted of *Cynodon 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. and *Atylosia scarabaeoides* (L.) Benth. Weed control ground cover perforated mat resulted in significantly higher yield of corms (7.63 t ha^{-1}), cormels (19.05 t ha^{-1}), total yield (26.68 t ha^{-1}), higher gross (₹ 4,76,250) and net returns (₹ 2,77,539 ha^{-1}) and B:C ratio (2.40).

Biointensive weed management in taro

A field experiment on biointensive weed management in taro (var. Muktakeshi) was laid out in split plot design with two plant density in main plots [55,500 plants ha^{-1} (60 x 30 cm) (P_1) and 74,000 plants ha^{-1} (45 x 30 cm) (P_2)] and six mulching treatments in sub plots [sunnhemp live mulching (M_1), daincha live mulching (M_2), cowpea live mulching (M_3), paddy straw mulching (M_4), hand weeding (M_5) at 30, 60 and 90 days after planting (DAP) and control (M_6)] for the second season at Regional Station, Bhubaneswar, Odisha. Plant density of 74,000 plants ha^{-1} resulted in lower weed dry weight, higher yield (1.67 t ha^{-1}), greater gross (₹ 2,27,300 ha^{-1}) and net returns (₹ 1,35,900 ha^{-1}). Paddy straw mulching resulted in significantly lower weed dry weight (12.0 g m^{-2}) and higher yield (24.31 t ha^{-1}), followed by hand weeding at 30, 60 and 90 DAP (26.50 g m^{-2}). In addition, significantly higher gross (₹ 3,28,700 ha^{-1}) and net returns (₹ 2,20,100 ha^{-1}) and B:C ratio (3.02) were also obtained in paddy straw mulching. Among the interactions, planting density of 74,000 plants ha^{-1}along with paddy straw mulching resulted in lower weed dry weight (9.90 g m^{-2}) and greater taro yield (25.84 t ha^{-1}), gross (₹ 3,50,400 ha^{-1}) and net returns (₹ 2,35,600 ha^{-1}) as well as B:C ratio (3.05).

Water and nutrient management in tropical tuber crops through precision approaches

Water management studies in sweet potato

The field experiment to standardize a suitable irrigation schedule in sweet potato was conducted during January to April 2022 for the third season with eight treatments in RBD replicated thrice. The treatments comprised of

drip irrigation @ 50 (T_1), 75 (T_2), 100 (T_3), 125 (T_4) and 150% CPE (T_5); sprinkler irrigation @ 5 mm (T_6); furrow irrigation @ 5 mm (T_7) and a rainfed control (T_8). The growth parameters during initial growth stages viz., length of vines, number of leaves and leaf area were more with lower irrigation levels, but increased with increase in irrigation levels towards later stages. Harvest index increased with increase in irrigation levels up to T_4 (0.51), then declined for rest of treatments (Fig. 44). The tuber yield showed significant variation among irrigation treatments. The tuber yield was highest in T_4 (23.23 t ha^{-1}), closely followed by T_3 (22.79 t ha^{-1}). Sprinkler and furrow irrigations resulted in tuber yields of 13.68 and 13.54 t ha^{-1} respectively.

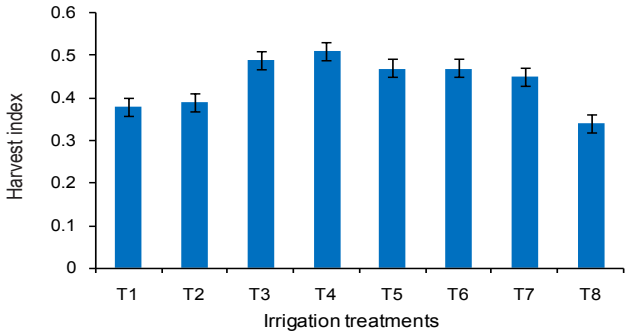


Fig. 44. Harvest indices of sweet potato under different irrigation treatments

Fertigation studies in taro

Fertigation studies in taro (Fig. 45) were carried out for the third season in split plot design with four levels of nutrients in main plots (NPK @ 60:25:75 (M_1); 60:25:100 (M_2); 80:25:100 (M_3); 80:25:125 (M_4) kg ha^{-1}) and three schedules of fertilizer application in sub plots [50% N and K before 60 DAP; 25% 60-120 DAP; 25% 120-150 DAP (S_1); 50% N and K before 90 DAP; 25% 90-120 DAP; 25% 120-150 DAP (S_2) and 25% N and K before 60 DAP; 50% 60-120 DAP; 25% 120-150 DAP (S_3)]. Taro variety Muktakeshi was planted during December 2021 and fertigation was given as per schedule at weekly intervals. The crop was harvested during May 2022. The effect of treatments on corm and cormel yield is presented in Fig. 46. The interaction effects of M_2S_3 and M_3S_2 produced the highest cormel yield (17.60 t ha^{-1}). However, there was no significant interaction among the main plot and sub plot treatments.

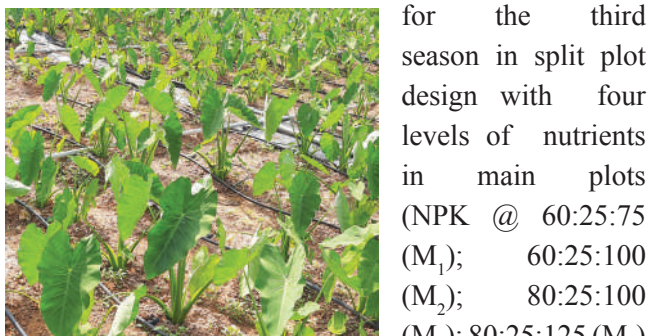


Fig. 45. Taro under drip fertigation

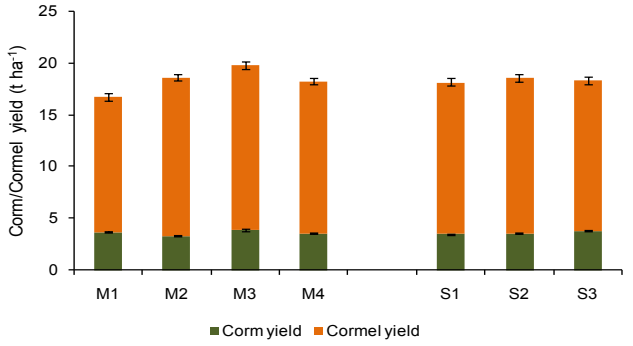


Fig. 46. Yield of taro under different fertigation treatments

Water saving techniques in cassava

Field experiment on water saving techniques in cassava was initiated during February to September 2022 with drip irrigation at 50% cumulative pan evaporation (CPE) along with eight water saving treatments viz., porous ground cover mulching (T_1), bio-mulching (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 plus ground cover mulching (T_7), organic cultivation practices (T_8) and drip irrigation at 50% as control (T_9). Three other 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. Cassava variety, Sree Vijaya was planted during February 2022 and harvested during August 2022. Porous ground cover mulching with drip irrigation at 50% CPE resulted in the highest tuber yield (67.04 t ha^{-1}), which was on par with the other water saving measures viz., soil application of pusa hydrogel, pusa hydrogel along with ground cover mulching and also with furrow irrigation. Rainfed crop produced 29.13

t ha^{-1} of tuber yield. Ground cover mulching resulted in 51.60% increase in tuber yield as compared to irrigation at 50% CPE without any water saving measures. Ground cover mulching also resulted in 48.70% increase in tuber yield and 50% saving in irrigation water as compared to drip irrigation at 100% CPE (Fig. 47).

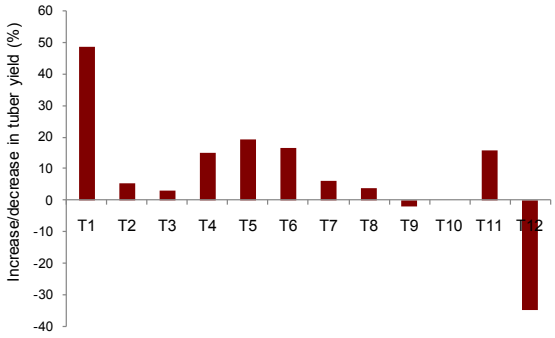


Fig. 47. Percentage increase/decrease in cassava tuber yield compared to 100% irrigation (T_{10})

Drip irrigation and fertigation management in greater yam

A field experiment was conducted for the second 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.

Increasing the levels of irrigation increased the yield of greater yam (Fig. 48). The treatment I_3 resulted in higher tuber yield of 36.20 t ha^{-1}, which was followed by I_2 with 34.20 t ha^{-1}. Among fertigation, the treatment F_3 resulted in significantly higher tuber yield of 34.70 t ha^{-1} (Fig. 49). The treatment I_3F_3 resulted in higher tuber yield, water use efficiency, gross returns and net returns (₹ 5,66,600 and ₹ 3,65,800 ha^{-1} respectively) and B:C

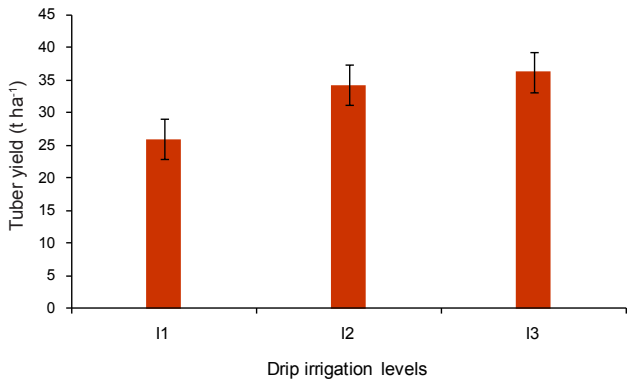


Fig. 48. Effect of levels of drip irrigation on the yield of greater yam

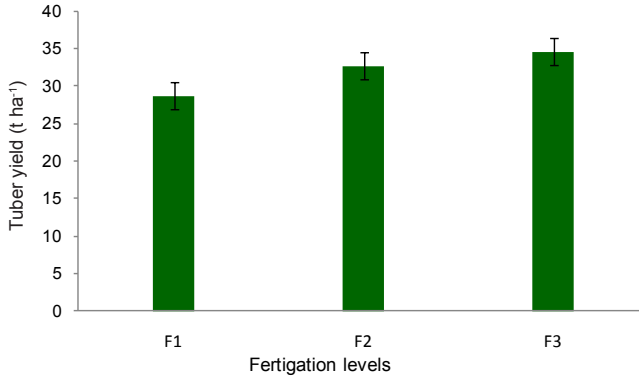


Fig. 49. Effect of levels of fertigation on the yield of greater yam

ratio (2.82) on par with I_2F_3 and I_3F_2. The treatment I_3F_1 resulted in higher nitrogen and potassium use efficiencies (564 kg kg^{-1}). Higher phosphorus use efficiency was noticed in the treatment I_3F_3 (630 kg kg^{-1}).

Scaling up and scaling out of SSNM for sustainable tuber crops production and soil health

Five on-station experiments were conducted. FBMP by SSNM proved to be significantly superior than the present recommendation (PR) (Cassava : SSNM – 30.60 t ha^{-1} & PR – 25.50 t ha^{-1} ; 20% increase; Elephant foot yam : SSNM – 37.50 t ha^{-1} & PR – 30.50 t ha^{-1} ; 23% increase; Greater yam : 24.00 t ha^{-1} & PR – 20.20; 19% increase; White yam : SSNM – 22.80 t ha^{-1} & PR – 19.50 t ha^{1}; 17% increase; Sweet potato: SSNM – 18.3 t ha^{-1} & PR – 15.5 t ha^{-1} ; 18% increase).

Farmer participatory SSNM trials were conducted in 210 farms spread across 3 panchayats in Pathanamthitta

district, Kerala. On average, the SSNM treatments resulted in 22% higher tuber yield in cassava. Elephant foot yam and yam are to be harvested.

Sustainable nutrient management in tropical tuber crops

INM in greater yam + maize system

Effect of integrated use of inorganic and organic sources on yield, proximate composition and soil quality in greater yam + maize system: Significantly highest tuber yield (25.16 t ha^{-1}) was obtained for integrated application of FYM @ 16 t ha^{-1} in combination with NPK @ 40:30:50 kg ha^{-1} and $MgSO_4$ @ 25 kg ha^{-1} with a yield response of 60% over control, which was on par with FYM @ 16 t ha^{-1} + NPK @ 40:30:50 kg ha^{-1} + $ZnSO_4$ @ 10 kg ha^{-1} (24.66 t ha^{-1}). Significantly highest starch (18.57%), total sugars (2.27%) and dry matter (27.94%) were recorded for integrated application of FYM @ 16 t ha^{-1} + NPK @ 80:60:100 kg ha^{-1} + $MgSO_4$ @ 25 kg ha^{-1}.

Balanced application of NPK @ 80:60:100 kg ha^{-1} resulted in the highest N use efficiency (94 kg tubers kg^{-1} N), integrated application of FYM @ 16 t ha^{-1} + NPK @ 40:30:50 kg ha^{-1} + $MgSO_4$ @ 25 kg ha^{-1} showed highest P use efficiency (153 kg tubers kg^{-1} P) and K use efficiency was maximum for application of vermicompost @ 5 t ha^{-1} + NPK @ 40:30:50 kg ha^{-1} (85 kg tubers kg^{-1} K). The soil pH was significantly enhanced to 6.81 due to integrated use of FYM @ 16 t ha^{-1} + NPK @ 40:30:50 kg ha^{-1} + $MgSO_4$ @ 25 kg ha^{-1} from the initial value of 5.93. Highest organic C content (0.672%) and available S (22.59 mg kg^{-1}) and significantly highest available N, P and K were observed due to integrated application of FYM @ 16 t ha^{-1} + NPK @ 40:30:50 kg ha^{-1} + $MgSO_4$ @ 25 kg ha^{-1}. The available micronutrients, Fe, Mn, Zn and Cu contents exceeded the critical limits in all treatment combinations. Integrated application of FYM @ 16 t ha^{-1} + NPK @ 40:30:50 kg ha^{-1} + $MgSO_4$ @ 25 kg ha^{-1} showed higher dehydrogenase activity (1.11 µg TPF g^{-1} h^{-1}), fluorescein diacetate hydrolysis assay (FDA) (5.92 µg g^{-1} h^{-1}) and acid phosphatase activity (62.87 µg PNP g^{-1} h^{-1}), whereas addition of super optimal (150%) doses of NPK, (FYM @ 16 t ha^{-1} + NPK @ 120:90:150 kg ha^{-1}) resulted in highest alkaline phosphatase activity (47.42 µg PNP g^{-1} h^{-1}).

Soil enzyme activities and tuber yield had significant relationship with total fungi and bacteria. Thus, application of organic manure combined with half of the recommended doses of inorganic chemical fertilizers and either $MgSO_4$ or $ZnSO_4$ helped to augment the crop yields, proximate composition and sustain the soil fertility.

Screening nutrient efficient genotypes of sweet potato

Screening of elite sweet potato genotypes for physiological efficiency: Results of the field experiment on nutrient use efficient genotypes of sweet potato evaluated with 90 elite genotypes during kharif season of 2021-22 revealed that Sree Bhadra resulted in significantly highest tuber yield (28.26 t ha^{-1}). Highest vine yield (35.22 t ha^{-1}) was recorded in SB 573/3. The starch content on fresh weight basis ranged from 14.06 to 19.56% (mean 16.63%), total sugars ranged from 2.04 to 3.12% (mean 2.79%) and dry matter ranged from 23.56 to 29.83% (mean 25.66%). The harvest index varied from 0.219 to 0.595 with a mean of 0.434. Highest harvest index was recorded in the genotype SB 106/45 (0.595), followed by 112 (0.585), RSIII-2 (0.583), DPS-34(0.575), Bhu Krishna (0.572) and B x 7 (0.57).

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

Nutrient management for naturally biofortified sweet potato varieties: A field experiment was laid out during rabi season of 2021-22 to study the effect of various nutrient management practices on yield and proximate composition of biofortified sweet potato varieties. The highest tuber yield (11.28 t ha^{-1}) and dry matter content (26.42%) was recorded in Bhu Sona. Highest starch content (21.45%) was recorded in the variety Bhu Ja and total sugars in the variety Bhu Krishna (2.97%).

Integrated application of FYM @ 5 t ha^{-1} along with NPK @ 50:25:50 kg ha^{-1} resulted in highest tuber yield (11.46 t ha^{-1}) on par with FYM @ 5 t ha^{-1} + NPK @

75:25:75 kg ha^{-1} (10.76 t ha^{-1}) and FYM @ 5 t ha^{-1} + NPK @ 100:37.5:100 kg ha^{-1} (10.53 t ha^{-1}). Among the fertility gradients, maximum starch content (20.91%) was observed with the application of FYM @ 5 t ha^{-1} + NPK @ 50:25:50 kg ha^{-1}. Combined application of FYM @ 5 t ha^{-1} + NPK @ 75:25:75 kg ha^{-1} resulted in highest dry matter (26.66%) and sugar (2.95%) contents.

Highest soil organic C (0.571%) was observed due to the application of FYM @ 5 t ha^{-1} + NPK @ 75:25:75 kg ha^{-1}. The available P was highest (> 50 kg ha^{-1}) in all the individual treatments. Significantly highest available K (229.3 kg ha^{-1}) was noticed due to combined application of FYM @ 5 t ha^{-1} + NPK @ 100:37.5:100 kg ha^{-1}. Higher soil enzyme activities with respect to dehydrogenase (1.582 µg TPF h^{-1} g^{-1}), fluorescein diacetate hydrolysis assay (2.356 µg g^{-1} h^{-1}), urease (303.2 µg NH_4-N $g^{-1}h^{-1}$), acid phosphatase (69.36 µg PNP g^{-1} h^{-1}) and alkaline phosphatase (49.76 µg PNP g^{-1} h^{-1}) activities were observed for conjoint application of FYM @ 5 t ha^{-1} + NPK @ 50:25:50 kg ha^{-1}.

Land configuration effects on biofortified sweet potato varieties: An experiment was conducted 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, tubers suitable for processing, harvest index and economics. The variety Bhu Krishna produced significantly higher marketable tuber yield (13.88 t ha^{-1}), gross (₹ 2,77,600 ha^{-1}) and net (₹ 1,97,700 ha^{-1}) returns as well as B:C ratio (3.47). 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 (14.09 t ha^{-1}), gross (₹ 2,81,700 ha^{-1}) and net (₹ 2,02,100 ha^{-1}) returns as well as B:C ratio (3.54). Among the land configurations, anthocyanin and β-carotene content were higher at 30 cm ridge height (60 cm row to row spacing). Higher total β-carotene was noticed in Bhu Sona variety, irrespective of land configurations.

Long term integrated nutrient management in tropical tuber crops

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

This experiment was initiated in 2020 as the fourth phase of the long term fertilizer experiment (LTFE) which is in progress at ICAR-CTCRI, Thiruvananthapuram since 1977. The major objective was to study the sustainability of the successful technologies/scientific information on INM practices in cassava from different nutrient management experiments including LTFE. The experiment was conducted with 20 treatments replicated thrice in RBD. The treatments were broadly grouped under four categories. Nutrient management approaches: Blanket recommendation (PoP), soil test based fertilizer cum manurial recommendation for major (STBFR), secondary (STBFR Mg) and micronutrients (STBFR Zn, STBFR B), soil and plant test based customized fertilizers (CF), low input nutrient management strategy (LINMS) and absolute control. Organic manure sources as substitute to farmyard manure (FYM): FYM, green manuring *in situ* with cowpea, crop residue incorporation and ash along with FYM. Nutrient use efficient (NUE) genotypes/varieties in reducing chemical fertilizer use: Sree Pavithra, 7III E3-5, CI-905 and CI-906 as planting material with 25% recommended dose of NPK. Plant nutrients: P, K, Ca, Zn, Si through soil and foliar application for the management of cassava mosaic disease (CMD).

The results of the second season experiment revealed that among the different nutrient management approaches, CF ($N:P_2O_5:K_2O$:Mg:Zn:B @ 8:11:21:3.84:0.84:0.315 ratio and applied @ 500 kg ha^{-1}) resulted in significantly highest tuber yield (39.25 t ha^{-1}), followed by PoP (NPK @ 100:50:100 kg ha^{-1} + FYM @ 12.5 t ha^{-1}) (35.05

t ha^{-1}). The STBFR (FYM @ 5 t ha^{-1} + NPK @ 63:0:37 kg ha^{-1}) (27.05 t ha^{-1}) was on par with STBFR along with Mg (28.50 t ha^{-1}), Zn (24.95 t ha^{-1}), B (22.95 t ha^{-1}) independently and LINMS (25.15 t ha^{-1}). Absolute control without any manures and fertilizers produced an yield of 20.65 t ha^{-1} (Fig. 50). LINMS resulted in

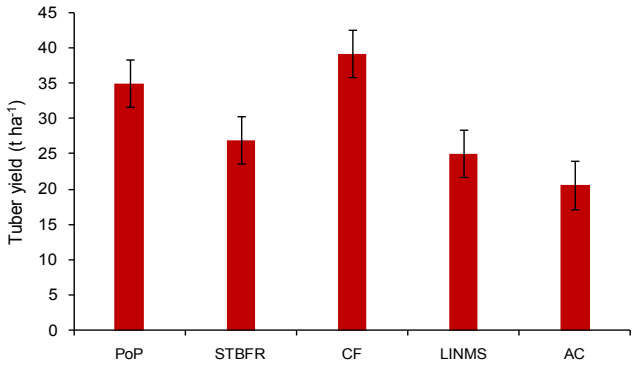


Fig. 50. Tuber yield under different nutrient management practices in cassava

significantly highest cyanogenic glucoside content in tubers (93.20 µg g^{-1}) and PoP, significantly the lowest (34.10 µg g^{-1}). Treatments exerted significant influence on the status of available N, P, K, Ca, Mg, Zn and B in soil. The PoP resulted in significantly the highest soil available N (169.8 kg ha^{-1}). Soil available P was significantly higher in PoP (141.2 kg ha^{-1}) and was on par with LINMS (117.7 kg ha^{-1}). LINMS resulted in significantly higher soil available K (219.3 kg ha^{-1}), on par with PoP (209.9 kg ha^{-1}).

Organic manure sources to substitute FYM, viz., green manuring *in situ* with cowpea (28.33 t ha^{-1}) and residue of the crop itself (22.50 t ha^{-1}) produced yield on par with FYM (25.83 t ha^{-1}). Ash along with FYM (20.75 t ha^{-1}) was on par with crop residue. Ash + FYM resulted in a significantly higher soil pH (6.31) over the other sources, which were on par. Soil exchangeable K, Ca, Mg, S, Zn and B were significantly influenced by different organic manures. Ash + FYM resulted in significantly higher K (193.7 kg ha^{-1}), Ca (1.018 meq 100g^{-1}) and Mg (0. 977 meq 100g^{-1}).

The soil bulk density ranged from 1.28 Mg m^{-3} in ash + FYM to 1.54 Mg m^{-3} in absolute control. The porosity varied from 41.80% in PoP to 53.60% in STBF application of NPK + crop residue as organic source, which also had high water holding capacity of 49.20%. The soil of absolute control had the lowest water holding capacity of 38.30%.

Among the NUE genotypes, Sree Pavithra with 25% NPK resulted in a tuber yield (32.50 t ha^{-1}) on par with H-1687 under PoP (35.05 t ha^{-1}). The other genotypes viz., CI-905 (21.75 t ha^{-1}), CI-906 (25.60 t ha^{-1}) and 7III E3-5 (25.35 t ha^{-1}) produced significantly low yield, which were on par. The tubers of H-1687 under PoP contained the lowest tuber cyanogen (34.10 µg g^{-1}) on par with CI-905 under 25% NPK (45.03 µg g^{-1}). Significant effect of NUE genotypes was seen in the soil available status of N, P, K, Ca, Mg, S, B and Zn, wherein H-1687 under PoP had significantly higher N (169.8 kg ha^{-1}), P (141.2 kg ha^{-1}), K (209.9 kg ha^{-1}) and Zn (3.73 ppm), whereas Ca (1.145 meq 100g^{-1}), Mg (0.894 meq 100g^{-1}), S (7.57 ppm) and B (0.897 ppm) were significantly higher under CI-906.

Soil and foliar application of nutrients viz., K (33.50 t ha^{-1}) and Ca (32.40 t ha^{-1}) resulted in significant difference in tuber yield over STBFR (NPK) (27.70 t ha^{-1}). Soil and foliar application of K caused significant reduction in tuber cyanogen (56.30 ppm) compared to the other nutrients viz., P, Ca, Zn and Si, which significantly increased the tuber cyanogen as 86.80, 88, 80 and 70.40 ppm respectively. The same trend was noted with K in tuber starch (22.54%) and over STBFR (NPK). Other nutrients did not produce any significant increase and were on par.

The CMD grading was done at three intervals viz., before treatments at 3, 6 and 8 MAP. Statistical analysis of the data indicated that there was no significant difference in disease grade among the plots before application of treatments and the mean disease index value was 70.82%. But there was significant difference in the symptom grade among the nutrients at 6 and 8 MAP with mean values of 58.32 and 49.15% respectively. At 6 MAP, among the nutrients, the per cent reduction in symptom expression was in the order K>Si >P>Zn>Ca with mean value 17.59%

over initial value. At 8 MAP, the reduction in symptom grade expression was in the order K>Ca>P>Zn>Si with mean value of 30.52% over initial value. The changes are depicted in Fig. 51.

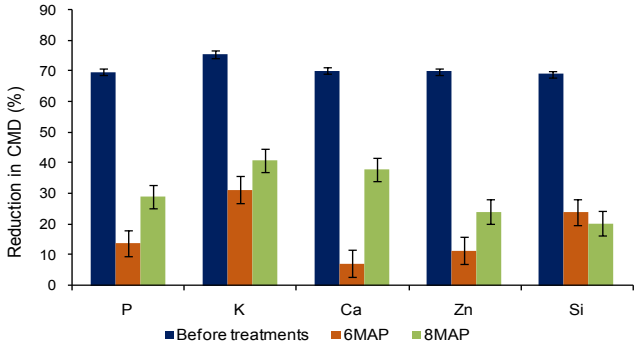


Fig. 51. Reduction in CMD expression due to nutrients at different growth stages

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

The main objective was to diagnose and correct the recently observed nutritional disorders in tropical tuber crops mainly, cassava, sweet potato and yams, especially tuber cracking due to B deficiency. In greater yam, to diagnose the suspected B deficiency manifested as blackening and hollowing of the tubers, the same set of treatments as in the first year was repeated for the second season experiment, which in turn comprised of nutrients viz., B and Ca through soil and foliar application along with PoP. Soil application of B was done as borax @ 25 kg ha^{-1}, half each as basal and at 3-4 MAP.

Foliar application of B was done as solubor @ 0.5%, thrice at maximum vegetative growth stage (3-4 MAP) and tuber bulking stages (5-6 MAP and 7-8 MAP). Calcium as soil application was done through lime @ 2 t ha^{-1} and foliar as calcium nitrate @ 1%. During this year also, there was no significant difference in yield due to treatments (Fig. 52) and there was no visual manifestation of symptoms in tubers irrespective of treatments.

Soil and plant samples were collected from this experiment at four intervals viz., 6, 7, 8 and 9 MAP and analysed for soil pH, organic carbon, available N, P, K, Ca and B and plant samples for P, K and Ca content. Though

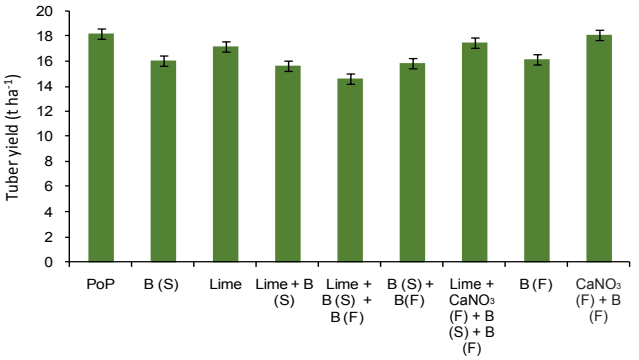


Fig. 52. Tuber yield as influenced by B and Ca in the management of the suspected B deficiency in greater yam

the treatments were mainly Ca and B to ameliorate the suspected problem due to these nutrients, the variation noticed in the content of soil available Ca and B and plant Ca was not significant. However, the mean soil available Ca during these intervals were 1.61, 0.686, 0.857 and 0.950 meq 100 g^{-1} soil and soil available B was 0.740, 0.378, 0.640 and 3.13 ppm respectively and the plant vine Ca was 0.577, 0.476, 0.445 and 0.499%, which in turn were sufficient as per their respective critical levels. Correlation among these parameters indicated significant negative correlation between soil and plant Ca at 7 (-0.902) and 8 MAP (-0.854). The same experiment conducted for sweet potato in lysimeter was repeated for the second season to confirm the soil and plant levels of Ca and B for B deficiency.

Analysis of soil and plant samples at fortnightly intervals since 45 DAP for soil chemical parameters viz., pH, organic carbon, available P, K, Ca and B and vine samples for P, K and Ca revealed no significant difference (liming was done uniformly in all tanks to

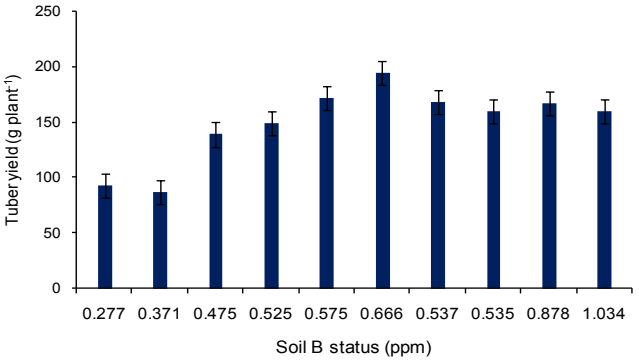


Fig. 53. Tuber yield of sweet potato under varying soil B status

raise soil pH for favouring tuberization) for these nutrients due to varying B status, except for soil B. Available soil B from 0.5 ppm was reflected in tuber yield and the mean value of soil B status at four intervals and the tuber yield corresponding to these B status is depicted in Fig. 53.

Soil carbon quality and conservation studies in tropical tuber crops

During the reporting period, 18 kg of near neutral zeolites 4A was prepared using acetic acid extraction method. The pH of the above zeolites was 7.7 with a CEC value of 220 cmol (p+) kg^{-1} and was used in the evaluation of carbon emission studies with different organic manures in laterite soil. The 90 days study was initiated during December 2022 with 18 treatments and three replications in CRD. Different sources of organic manures viz., FYM, vermicompost (VC) and leaf wastes (LW) (which are the most common organic sources used in farming) were taken up at 2 levels viz. 50% and 100% (12.5 t ha^{-1}) and zeolites were taken in 1 and 2% with and without addition of organic materials to understand the soil total C, different forms of labile C and the carbon dioxide emission efficiency. The soil was mixed with different treatments and maintained at a constant water holding capacity of 50% during the incubation period at 37°C. Results from the cumulative values of carbon evolved during the initial 25 days of study indicated that increasing levels of zeolites had a significant effect on carbon dioxide emission. Among the organic materials used (at 100% level), vermicompost released 332 mg CO_2 kg^{-1} soil, followed by leaf waste (265 mg CO_2 kg^{-1} soil) and FYM (251 mg CO_2 kg^{-1} soil), whereas in 50% level, the magnitude of the release was in the order of 310 (VC) >287 (FYM) >235 (LW) mg CO_2 kg^{-1} soil.

Climate change adaptation and mitigation in tropical tuber crops

On-station experiment on climate smart agriculture and climate modelling studies

Field experiment on climate smart agriculture (CSA) practices showed significantly higher tuber yield in CSA practice (29.50 t ha^{-1}) than conventional practice (25.40 t ha^{-1}). Greenhouse gas (GHG) emission estimates of the two production systems using the GHG accounting tool, CCAFS-MOT, have been worked out. Carbon footprint (CF) estimation of the two production systems was done.

Climate modelling studies were conducted to predict the climate and suitability changes of cassava for three times 2030, 2050 and 2070. Two models ECOCROP and MAXENT were calibrated and used for studies.

Studies on drought tolerance in tropical tuber crops through mineral nutrition

The second season field experiment to study the role of mineral nutrients in drought tolerance in cassava was undertaken during November 2021 to August 2022. The experiment was laid out in RBD with 11 treatments replicated thrice. This study evaluated the morpho-physiological response of cassava var. Sree Swarna across 10 mineral nutrition viz., 1% solubor, 1% calcium chloride, 1% potassium sulphate, 1% potassium nitrate, 1% potassium chloride, 1% magnesium sulphate, 1% ammonium molybdate, 1% calcium silicate, 1% selenium and 0.5% zinc sulphate against control (NPK @ 100:50:100 kg ha^{-1}). The crop was subjected to early season water deficit stress for 90 days during 3-5 MAP. The mineral nutrients were applied (foliar spray) twice at fortnightly intervals during 120-150 DAP. Mineral nutrition had significant, but varying effect on storage root yield. It was found that cassava drought tolerance could be enhanced with the proper application of fertilizer nutrients. The foliar application of 1% KNO_3 resulted in the highest storage root yield (3.22 kg $plant^{-1}$), followed by magnesium (3.05 kg $plant^{-1}$) and boron (2.80 kg $plant^{-1}$) in comparison to control (1.74 kg $plant^{-1}$).

Studies on heat stress management in cassava

The objective of the study is to develop simple and farmer friendly technologies to manage drought and heat stress in cassava. Two poly chambers each of 4 m x 4 m x12 m (H x W x L) size were constructed for this purpose with a white 200-micron multilayer poly-plastic sheet. The tuber bulking phase was synchronized with heat stress in the months of August-September, 2022 to assess the

effect on cassava growth and yield. Four chemical spray treatments viz., 0.2% salicylic acid (SA), 0.2% calcium chloride (CC), 1000 ppm benzyl adenine (BA), and a control (water spray) were employed in open condition (OPEN), humidifying (HUM+) and without humidifying chamber conditions (HUM-). The crop was sprayed at 15 days interval using the above treatments for two months (3-4 MAP). The treatments were replicated thrice in RBD. The variety Sree Vijaya was planted during June 2022 and harvested during December 2022. Tuber yield observations taken during 4 MAP revealed that the highest average tuber yield (454 g plant^{-1}) was obtained under open conditions as compared to chamber, 102.5 g plant^{-1} (Hum+) and 67.5 g plant^{-1} (Hum-) conditions. Among the chemical treatments, 1000 ppm benzyl adenine performed better under open conditions and 0.2% calcium chloride performed better in HUM+ chamber conditions (Fig. 54).

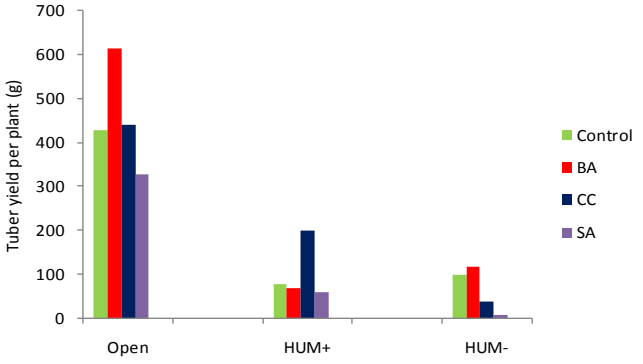


Fig. 54. Effect of different chemical treatments on cassava tuber yield

Physiological studies related to climate change in tropical tuber crops

A field experiment was undertaken to study the effect of drought stress on cassava genotypes, to identify the stress tolerant cassava and to identify the physiological basis of stress tolerance. The experimental design consisted of RBD with 24 cassava genotypes subjected to three treatments (control, mild stress and severe stress) and replicated four times. The plants were subjected to drought stress by withholding irrigation. Control plants were well watered once in every ten days. Observations on growth, canopy temperature, photosynthetic gas exchange, chlorophyll-a fluorescence kinetics and yield parameters were studied to investigate the effect of stress on cassava genotypes.

Significantly lower canopy temperature was observed in control plants (25.29°C) compared to mild and severe stress (Fig. 55). Mean net photosynthetic

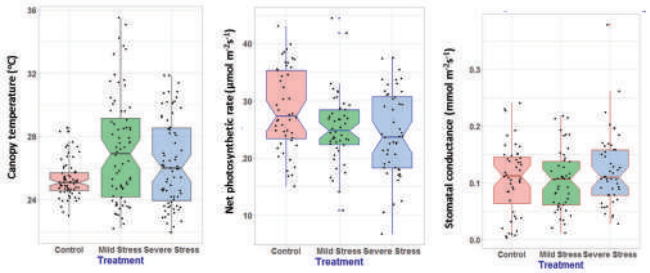


Fig. 55. Changes in the canopy temperature, net photosynthetic rate and stomatal conductance of cassava under control, mild and severe stress treatments

rate (P_n) was highest in the control (28.48 µmol m^{-2} s^{-1}) and varied significantly among the treated plants followed by mild (25.22) and severe (24.20) stressed cassava genotypes respectively. However, significant differences were not observed for leaf conductance and leaf transpiration rates among the treatments.

Plant height at 4 MAP (1 month after imposing the treatments) was not significant, whereas number of leaves per plant was highest in control (71.7), followed by mild stress (66.6) and severe stress (65.6). Chlorophyll-fluorescence kinetics parameter indicates the functioning of photosynthetic light reaction and efficiency of light energy capture and photosynthetic performance of plants. These parameters are influenced by the abiotic and biotic factors and hence provide opportunity to understand the stress response of plants. The Chl-a fluorescence parameters were studied using LI-6400XT portable photosynthetic meter and the data is presented in Fig. 56 for the control and stressed cassava plants. Significant differences were observed for base level fluorescence (Fo), Fv/Fm (maximum efficiency of photosystem) and PhiPS2 (Photosystem II efficiency) parameters in cassava under different stress level.

Photochemical and non-photochemical quenching parameters imply light energy utilization for photosynthetic assimilation and heat dissipation (non-productive). Significant differences were not observed for photochemical (qP) and non-photochemical quenching (qN), whereas

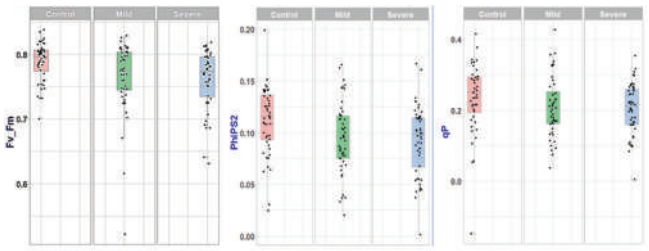


Fig. 56. Changes in selected chlorophyll fluorescence kinetics parameters of cassava under control and drought stress

T_{leaf} showed significant difference and stressed plants experienced higher leaf temperature compared to control plants.

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 minor tuber crops

Virus free planting materials were produced through indexing, micro propagation, hardening and minisett multiplication under protected environment. Further, seed village programme was expanded in selected areas of Kerala, Tamil Nadu, Andhra Pradesh, Odisha and North Eastern India in a farmer participatory mode. Seed producers were identified for production of quality planting materials, area expansion of tropical tuber crops in non-traditional areas was made and farmer's training programmes were conducted for mass multiplication and popularization of disease-free planting materials of improved varieties of tuber crops. The quality planting material production at ICAR-CTCRI, Thiruvananthapuram and Regional Station, Bhubaneswar, are given in Table 7.

Quality planting material production in cassava

Large scale multiplication of quality planting material production of cassava: Improved varieties of cassava viz., Sree Vijaya, Sree Jaya, Sree Pavithra, Sree Suvarna, Sree Sakthi and Sree Reksha were planted in an area of 8.50 acres in blocks II, III and V of ICAR-CTCRI farm during 2022-23 crop season.

Rapid multiplication through minisett technique in cassava: Minisett technique was followed in cassava varieties, Sree Vijaya, Sree Jaya, Sree Pavithra and Sree Reksha. The minisetts (3000 nos.) were planted inside the net house for one month and then transplanted to main field in an area of 30 cents.

Table 7. Quality planting material production of tuber crops during 2022

Sl. No.	Name of the crop	Unit	Varieties	Quantity of planting materials produced
1.	Cassava	Number of stems	Sree Vijaya	35000
			Sree Jaya	28000
			Sree Reksha	60000
			Sree Suvarna	5000
			Sree Sakthi	5000
			Total	**133000**
2.	Sweet potato	Number of vine cuttings	Bhu Sona	550000
			Bhu Krishna	504000
			Kishan	400000
			Sree Arun	2000
			Sree Kanaka	2000
			Gouri	2000
			Total	**1460000**

3.	Elephant foot yam	Ton	Gajendra	20.50
			Sree Padma	10.50
			Total	**31.00**
4.	Greater yam	Ton	Sree Shilpa	8.50
			Sree Roopa	6.50
			Sree Keerthi	5.50
			Sree Karthika	6.50
			Sree Nidhi	5.50
	White yam	Ton	Sree Priya	2.00
			Sree Dhanya	1.00
	Lesser yam	Ton	Sree Latha	3.50
			Total	**39.00**
5.	Taro	Ton	Muktakeshi	1.50
			Telia	1.00
			Total	**2.50**
6.	Chinese potato	Number of stem cuttings	Sree Dhara	50000
7.	Yam bean seeds	kg	RM-1	200

Effect of growth regulators on plant growth and yield parameters in cassava: A field experiment was conducted with nine treatments in randomized block design (RBD) with three varieties of cassava viz., Sree Reksha, Sree Pavithra and Sree Vijaya to study the effect of different growth regulators on growth and yield parameters in cassava. Cassava setts were soaked for 30 minutes before planting with different growth regulators viz., GA3 100 ppm (T_1), GA3 200 ppm (T_2), IAA 100 ppm (T_3), IAA 200 ppm (T_4), potassium nitrate 1% (T_5), potassium nitrate 2% (T_6), thiourea 0.5% (T_7), thiourea 1% (T_8), water (T_9) and control (T_{10}). Stems treated with GA3 200 ppm resulted in higher sprouting of 94.75% and 99.80% at 15 and 30 days DAP respectively, in Sree Reksha, followed by IAA 200 ppm treated stems. The plant height (91 cm), stem girth (12 cm) and canopy spread (47 cm) were higher in GA3 100 ppm treatment, followed by IAA 200 ppm treatment at 90 days after planting in Sree Reksha. Among the treatments, GA3 100 ppm produced significantly higher tuber yield (46.25 t ha^{-1}) in Sree Reksha (Fig. 57).

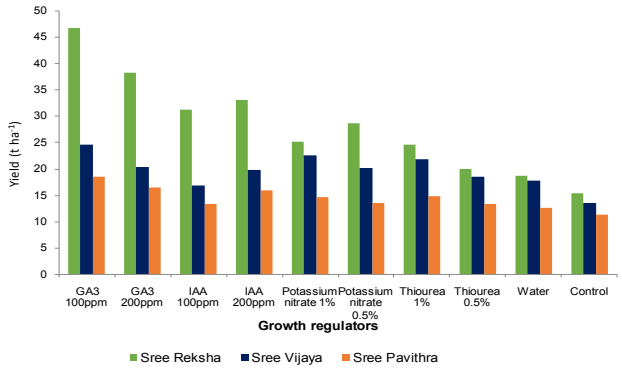


Fig. 57. Effect of growth regulators on tuber yield in cassava

Standardization of growth media and crop management in nursery: A field experiment was initiated during 2022 for standardization of growth media and crop management in minisett nursery in cassava variety Sree Reksha. Two methods of sett cutting viz., minisetts with single node and minisetts with two nodes and four nursery growth media comprising different potting mixture viz., 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) were evaluated in RBD with three replications. Two node minisetts resulted in greater plant establishment in nursery, with plant height

of 6 cm and 22 cm at 15 and 30 days respectively, under T_1. The performance of minisett nursery raised plants was evaluated in the field. Minisett seedling was uprooted after one month in the nursery and transplanted in the field. Among the 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 to determine the ideal stage of stem cutting for planting material production in cassava varieties, Sree Reksha and Sree Vijaya. The five treatments comprised of stem cutting at 4, 3, 2 and 1 month before harvesting and designated as T_1, T_2, T_3 and T_4 respectively in RBD with three replications. The stem was cut and immediately planted in the field. The results indicated that first sprouting took 8 and 9 days in T_1, 6 and 7 days in T_2, 5 and 6 days in T_3 in Sree Reksha and Sree Vijaya respectively. The experiment is in progress.

Seed village programme: A total of 25 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 80 acres (Table 8).

Decentralised Seed Multiplier (DSM): A total of 86 farmers from Kerala, Tamil Nadu, Andhra Pradesh and Odisha (covering 84.60 acres) have been registered as DSM for quality planting material production of tuber crops (Table 9).

Table 8. 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 Jaya Sree Reksha	Kanakapillaivalasai, Tenkasi	2
		Sree Jaya Sree Reksha	Mekkarai, Tenkasi	4
		Sree Athulya Sree Reksha	Gangavalli, Attur, Goodamalai, Sentharapatti, Salem	10
		Sree Athulya	Veeradipatti, Pudukottai	10
		Sree Athulya Sree Reksha	Mettupatti, Naraikinanu, Namakkal	10
		Sree Athulya	Pillikalmedu, Tiruchenkode, Namagiripettai, Namakkal	6
		Sree Reksha	Malayankeezh, Manapuram, Karipur Thiruvananthapuram	10
			Total	**52**
2.	Sweet potato	Sree Kanaka Sree Arun	Kilimanoor, Pothencode, Thiruvananthapuram	4
		Sree Kanaka Sree Arun	Eraniel and Thuckalay, Kanyakumari	2
			Total	**6**

3.	Elephant foot yam	Gajendra	Pallakal Pothukudi, Tirunelveli	**2**
4.	Chinese potato	Sree Dhara	Pallakal Pothukudi, Mannarkovil, Tirunelveli	10
			Kuthapanjan, Rajankhapuram Velayuthasamykudiyiruppu K.Alankulam, Tenkasi	10
			Total	**20**
			Grand Total	**80**

Table 9. Decentralised Seed Multipliers for production of quality planting materials of tuber crops

Sl.No.	State	Crop	Varieties	Number of farmers	Area (Acre)
1.	Kerala	Cassava	Sree Reksha Sree Pavithra	13	7.75
2.	Andhra Pradesh	Cassava	Sree Reksha	3	6.80
3.	Tamil Nadu	Cassava	Sree Reksha Sree Athulya	17	38.50
4.	Odisha	Cassava	Sree Athulya Sree Reksha	10	2.50
5.	Kerala	Sweet potato	Sree Arun Sree Kanaka Bhu Sona Bhu Krishna Kanjangad Gouri	5	2.75
6.	Odisha	Sweet potato	Sree Arun Sree Kanaka Bhu Sona Bhu Krishna Kanjangad Gouri	4	1.25
7.	Kerala	Elephant foot yam	Gajendra Sree Padma	11	6.25
8.	Kerala	Greater yam	Sree Keerthi Sree Neelima Sree Shilpa Sree Swathy Sree Nidhi Da 340	6	5.55

9.	Odisha	Greater yam	Orissa Elite Sree Keerthi	12	3.25
10.	Tamil Nadu	Chinese potato	Sree Dhara	4	9.00
11.	Odisha	Yam bean	RM1	1	1.00
			Total	**86**	**84.60**

Storage studies in Chinese potato: Storage studies were conducted with nine different treatments in Chinese potato after harvesting. The treatments included storage in pucca floor, wooden surface, gunny bags, plastic bags, paddy straw, sand, aerated net bags, paper cover and plastic tray. Minimum loss of dry weight of storage tuber of Chinese potato was observed with those stored in plastic basket (5.66%) and wooden surface (6.90%) after three months. Storage in paper cover was the best with greatest tuber weight (24.50 g tuber^{-1}) and number of sprouts (2.9 per tuber) after three months. Those stored in plastic basket and paddy straw were also good after three months with less than 22% loss in weight and 80 to 90% germination.

Promotion of tuber crops in non traditional areas: A total of 4000 stems of cassava variety Sree Reksha were distributed to KVK, Lakshadweep.

Investigations on rapid multiplication of yams and aroids

Refinement of micro/minisett method of multiplication in yams: An experiment was conducted in protray with four varieties of greater yam (Sree Nidhi, Sree Neelima, Sree Keerthi and Sree Swathy) and four sett sizes [(10 g (S_1), 20 g (S_2), 30 g (S_3) and 50 g (S_4)] replicated four times in a two factor CRD design (Fig. 58). Among the varieties, Sree Nidhi was the fastest in sprouting (32.43 days), whereas the variety Sree Keerthi was the slowest in sprouting (42.42 days). Comparison of sett size for days to complete germination showed significant variation. Sett size of 50 g (S_4) was the first to germinate, which took only 31.58 days, followed by S_3 (34.82 days) and S_2 (38.78 days). Maximum time for germination was observed with sett size of 10 g (43.77 days), which indicated an inverse association between sett size and days

Preparation of greater yam minisett | Different stages of development of greater yam nursery plant

Nursery plants of greater yam var. Sree Neelima ready for planting | Field view of established plants

Fig. 58. Stages in establishment of greater yam nursery plants raised from minisetts

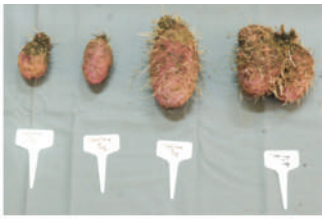
to germination. In general, the length of vine increased with sett size used in all varieties, where the minimum length was produced in 10 g sett and the maximum with 50 g sett. The number of leaves was the maximum with 50 g sett and decreased with decrease in size of sett. Thus, it could be concluded that initial vegetative growth was positively associated with sett size used.

Tuber bulking was more or less gradual in the case of Sree Keerthi and Sree Swathy, whereas in the case of Sree Neelima and Sree Nidhi, the dry matter accumulation was slow till 4 MAP and rapidly increased afterwards indicating late bulking character in these varieties. This could have implications at the time of interculture and fertilizer application. Effect of sett size on mean dry matter accumulation of tuber indicated that the mean

initial tuber dry matter accumulation at 2 MAP was 14.8, 15.33, 14.51 and 14.72% for S_1, S_2, S_3 and S_4 respectively. The mean dry matter was on par at 3 MAP and 4 MAP for various sett sizes. At harvest, the tuber dry matter accumulation was high in S_1 (35.89 %), S_2 (35.28%) and S_3 (34.12 %) compared to S_4 (29.53%). Thus, it could be inferred that per cent dry matter accumulation was not affected by the different sett sizes used.

The tuber length, girth and weight varied significantly among different sett sizes evaluated. Tuber length, girth and weight of tuber and tuber yield was the highest in S_4 (35.06 cm, 17.95 cm, 940.75 g plant^{-1} and 34.84 t ha^{-1} respectively), followed by S_3, indicating strong positive correlation between initial sett size used and final tuber yield obtained (Fig. 59).

Effect of sett size on tuber yield of Sree Nidhi at 4 MAP



Effect of sett size on tuber yield of Sree Neelima at 4 MAP

Effect of sett size on tuber yield of Sree Nidhi at harvest

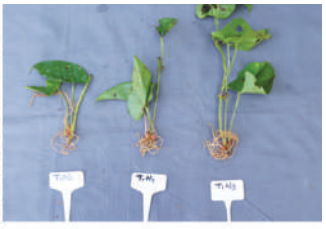
Effect of sett size on tuber yield of Sree Neelima at harvest

Fig. 59. Effect of sett size on tuber yield in different yam varieties

Investigations on rapid multiplication of greater yam through vine cuttings: An experiment was conducted with three different size of vine cuttings viz., single node, two node and three node cuttings and six pre-treatments in two factor CRD to understand the multiplication pattern. Vines were collected from 180 days old greater yam variety Sree Nidhi in field. The cuttings were planted in protray filled with potting mixture and maintained at mean RH of 95.60% and mean air temperature of 27.04°C in a mist chamber. Observations on sprouting and root characters were recorded at 20 days after planting in grow bag as well as field.

The two node cuttings exhibited the highest per cent sprouting after 15 days of planting (89.97%), which was significantly superior to single and three node cuttings with 74.46 and 74.04% respectively. Similarly, the highest mean sprouting was observed in IBA (87.59%), followed by *Trichoderma* (84.20%), whereas the lowest rooting per cent was in saaf treatment (70.30%). The interaction effects showed that two node cuttings with IBA treatment produced 100% rooting as against 57.70% rooting in saaf treated three node cuttings. There was no significant difference in the number of roots produced by various size of vine cuttings. Interaction effects showed that the highest number of roots was produced when single node cutting was treated with IBA (8.22), which was followed by three node cuttings treated with *Trichoderma* (7.99) and two nodes treated with PGPR Mix-1 (Fig. 60).

Establishment of greater yam vine cuttings in mist chamber



Effect of size of vine cutting on rooting of greater yam var. Sree Nidhi

Fig. 60. Effect of various pre-treatments on rooting of two node vine cuttings of greater yam var. Sree Nidhi

Refinement of minisett method of multiplication in elephant foot yam: An experiment was laid out with three elephant foot yam varieties (Sree Athira, Sree Padma and Gajendra) and three sett sizes (50 g, 100 g, 150 g) replicated five times in factorial CRD. The highest corm yield of 52.17 t ha^{-1} was obtained in Sree Padma,

which was on par with Gajendra (49.73 t ha^{-1}). The lowest corm yield was recorded in Sree Athira (32.96 t ha^{-1}). This showed that Sree Padma and Gajendra responded well to minisett propagation compared to Sree Athira. The highest corm yield of 68.47 t ha^{-1} was obtained in 150 g sett, which was significantly superior to 100 g sett (42.98 t ha^{-1}) and the lowest corm yield was in 50 g sett (23.35 t ha^{-1}). This indicated strong positive association between size of minisett used and corm yield at harvest. The highest corm yield of 77.71 t ha^{-1} was obtained from 150 g sett of Gajendra variety, followed by 150 g sett of Sree Padma (75.25 t ha^{-1}), which were on par. The lowest yield was obtained with 50 g sett of Sree Athira (20.12 t ha^{-1}).

On-station large scale multiplication of released varieties (Farmer demanded/preferred) of greater yam, white yam and lesser yam by following BAP: Quality seed material of released and popular varieties of all the three species of yams, greater yam, white yam and lesser yam were planted in 1 acre in block I. The best agronomic practices and timely crop management practices were followed. A total of 2805 kg of yams (Greater yam (var. Sree Keerthi and Sree Nidhi): 1026 kg; White yam (var. Sree Priya): 165 kg; Dwarf white yam (var. Sree Dhanya): 142 kg; Lesser yam (var. Sree Latha): 1472 kg) was produced during 2022.

Storage studies in lesser yam: Storage studies in lesser yam (var. Sree Latha) was conducted with eight treatments viz., spreading on dried leaves, wooden surface, plastic sheet, saw dust, sand, rice straw, storage racks and control, replicated thrice in CRD. The physiological weight loss did not significantly differ among the storage treatments up to 45 days after storage (DAS). At 60 days, rice straw resulted in the lowest physiological weight loss (16.27%) on par with all treatments, except control and dried leaves. Significantly highest weight loss was observed in dried leaves (34.13%) and control (26.90%). The same trend was noticed until 90 days of storage. Thereafter, the lesser yam tubers stored in the different treatments were planted in field with the same eight treatments replicated thrice in RBD. Sprouting, establishment and yield are being monitored.

Storage studies in taro: Storage studies were conducted with 15 different treatments to store taro cormels after harvesting. The treatments included storage in pucca floor, coir pith, wooden surface, gunny bags, plastic sheets, saw dust, rice husk, paddy straw, banana leaves, sand, earthern pot, aerated plastic bags, paper cover, cloth bags and mixture of ash and sand. Among the methods tried for storage of taro cormels for two cycles, minimum physiological loss of weight of cormels after two months was recorded with those stored in paper covers (13.80%) and gunny bags (15.60%). The third cycle of storage studies were conducted with selected ten methods, treated and untreated with fungicide saaf. Storage in cloth bags was the best with minimum physiological loss in weight (12.90%) after two months. Those stored in sand, paper cover and gunny bags were also good after two months with less than 20% loss in weight and 68 to 80% viability, irrespective of the fungicide treatment.

Crop Protection

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

Development of biorational control measures for the management of insect pests of tuber crops

Foliar and systemic application of synthetic insecticides and their impact on sweet potato weevil, *Cylas formicarius*

Efficacy of six insecticides, namely imidacloprid, chlorpyrifos, malathion, dimethoate, dichlorvos and quinalphos at three concentrations (0.001, 0.01 and 0.05%) were evaluated against sweet potato weevil (SPW) by two bioassay methods, foliar application and vine dipping and their toxicity was compared with absolute control (water). In the case of foliar application, the mortality of SPW at 1, 3, 5, 7 and 9 days after treatment (DAT) was highest in the treatments with imidacloprid and chlorpyrifos, whereas it was least in malathion and dimethoate. Similarly, imidacloprid was found most effective for vine dipping, and its effect lasted up to 9 DAT. The present study revealed that foliar application of imidacloprid even at concentration of 0.01% was effective against SPW. In the foliar bioassay, there was a positive correlation between the mortality and concentration of imidacloprid (r= 0.8). In vine dipping bioassay, there was a positive correlation between mortality of weevil and DAT of imidacloprid (r= 0.9).

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

In the field experiment to know the effectiveness of various promising insecticides and their combinations against cassava mealybug, *Shreya* at 0.8% followed by *Nanma* at 1% after 5 days was the best treatment, followed by imidacloprid 17.8 SL at 0.01% with mortality of 85.30% and 80.80% respectively, over control. The other effective treatments were *Nanma* with imidacloprid at 1:1, *Nanma* with imidacloprid at 3:1 (each at 0.8% and 0.01% respectively) and *Shreya* with imidacloprid at 1:1 and 3:1 respectively. The mortality of these treatments ranged from 55.40 to 74% over control. It was also observed that fortnightly insecticidal application was mandatory to check the infestation in endemic areas.

Among the various organic practices for cassava mealybug management, entomopathogenic fungi (EPF), *Purpureocillium lilacinum* @ 20 g l^{-1} (1 x 10^8 CFU) was very effective in the management with 70% more mortality over control (Fig. 61).

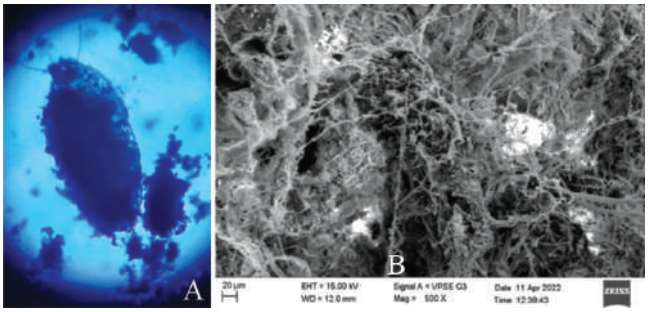


Fig. 61. A: *P. lilacinum* growth on treated mealybug; B: SEM image of fungal growth on mealybug

In taro cormels kept under storage, severe attack of coffee bean weevil (*Araecerus fasciculatus*) was observed during the season (Fig. 62). The following package is recommended:

Fig. 62. Coffee bean weevil (*Araecerus fasciculatus*) infestation in taro under storage

i. spray storage sheds with 2% formalin solution and allow to dry; ii. after harvest, soak the cormels in 1% solution of neem oil + soap (7:3) for 5 to 10 minutes and shade dry and iii. ensure proper aeration and shade dry the cormels once in two weeks to avoid moisture buildup. Observe regularly and if found infested, cormels need to be destroyed immediately to avoid population build up in others under storage.

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

Screening of wild *Ipomoea* sp. and identification of new sources of host resistance are one of the alternate ways for developing resistant cultivars for the management of sweet potato weevil. By screening the different wild *Ipomoea* sp. by multiple choice assay, it was found that the leaf feeding of weevils on *I. mauritiana* was significantly less compared to *I. batatas*, *I. triloba. I. palmata* and *I. obscura* (Fig. 63). The feeding by weevil was significantly less due to the presence of proteins which inhibits leaf feeding. Similarly, the weevil infestation on *I. mauritiana* leaves, vines and tubers was significantly less compared to *I. batatas* (Fig. 64). Based on the morphological screening data, the different phytochemical constituents were identified

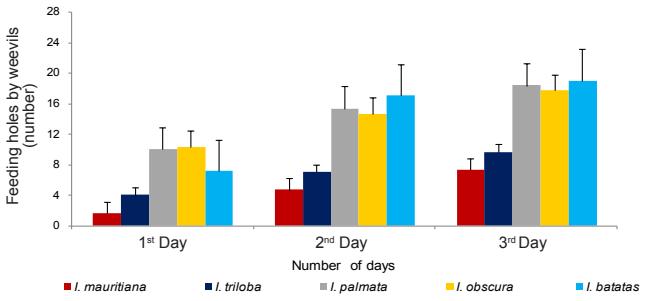


Fig. 63. Leaf feeding by sweet potato weevils on five *Ipomoea* species by multiple choice assay

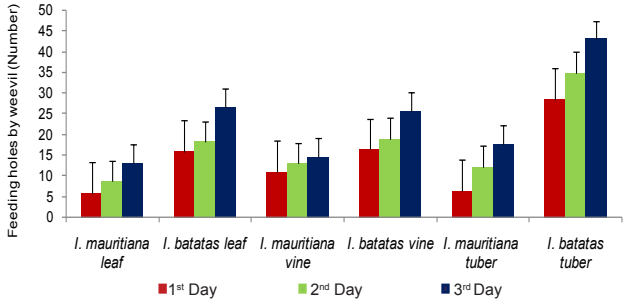


Fig. 64. Feeding by sweet potato weevil on *I. batatas* and *I. mauritiana* by two choice assay

using GC-MS analysis from the methanolic root extract of *I. mauritiana, I. batatas* and *I. palmata.* The phytochemical constituents of *I. mauritiana* comprise sucrose (77.01), quinic acid (20.93) and undecane (2.06). The quinic acid is a secondary plant metabolite reported to have insecticidal activity. The major constituents of *I. batatas* comprise melezitose (38.53%), alpha-I-rhamnopyranose (21.26%), 5-O- methyl-d-gluconic acid dimethylamide (7.03% and desulphosinigrin (4.04%). The phytochemical constituents of *I. palmata* comprise dihydrofuran-2-one, 4-(3,4-dimethoxybenzyl)-3-(4-hydroxy)(45.48%), 1-cyclohexanone, 2-methyl-2-3-(3-methyl-2-oxobutyl) (17.22%), quinic acid (7.65%), scopoletin (5.22%), 3-cyclopentylpropionic acid, 4-pentadecyl ester (3.32%) and panaxydol (3.29%). The phytochemical constituents of methanolic extract also revealed the presence of various compounds which are reported to have insecticidal activity. Thus, these components are responsible for less weevil infestation in *I. mauritiana.*

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

A new isolate of an entomopathogenic nematode, *Heterorhabditis* sp. has been identified from a soil sample collected from Thiruvananthapuram, Kerala. The nematode was isolated by soil baiting technique using *Galleria mellonella*. The nematode-infected cadavers were red in colour and all stages of the nematode had excretory pore posterior to the nerve ring (Fig. 65). Both

Fig. 65. *Galleria mellonella* cadavers infected with *Heterorhabditis* sp.

characteristics confirm the generic identity but the specific identity is yet to be ascertained through molecular characterization.

Efficacy of the newer nematicides

The efficacy of the newer nematicides, fluensulfone 2% GR (1 and 2 g) and fluopyram 34.48% SC (0.5 and 0.7 ml) were tested against second-stage infective juveniles of root-knot nematode, *Meloidogyne incognita* in elephant foot yam under pot conditions. The corms treated with fluopyram showed lesser damage (25 and 35% respectively at 0.7 and 0.5 ml concentrations), respectively while those treated with fluensulfone had 30 and 40% infestation with 2 and 1 g doses respectively (Fig. 66). Fluopyram resulted in higher yield (2.68 kg plant^{-1}) over that of fluensulfone (2.35 kg) and control (1.05 kg) (Fig. 67).

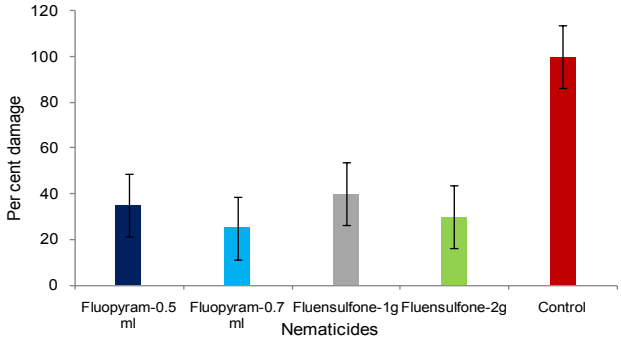


Fig. 66. Effect of nematicides on infestation caused by *Meloidogyne incognita* in elephant foot yam

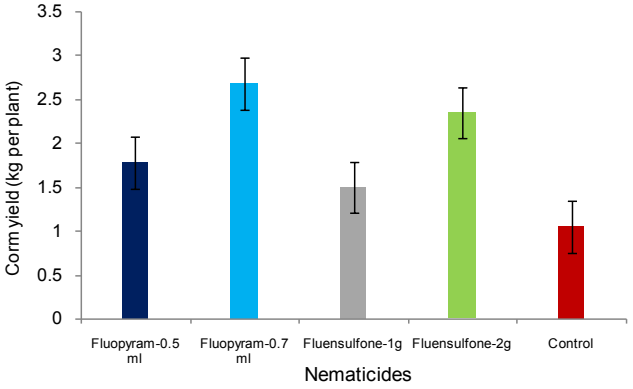


Fig. 67. Corm yield of elephant foot yam as affected by nematicides

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

Thirty one 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, Kollam and Pathanamthitta districts in Kerala (Fig. 68). Seventy nine isolates obtained were grouped into 20 based on the morphology. Maximum number of organisms (8) was isolated from the samples collected from Adoor, Pathanamthitta district, Kerala. However, Koch's postulates were successfully proved only with

Fig. 68. Symptoms of leaf and pseudostem rot of elephant foot yam

the isolates of *Phytophthora* sp., *Colletotrichum* sp. and *Fusarium* sp. (Fig. 69).

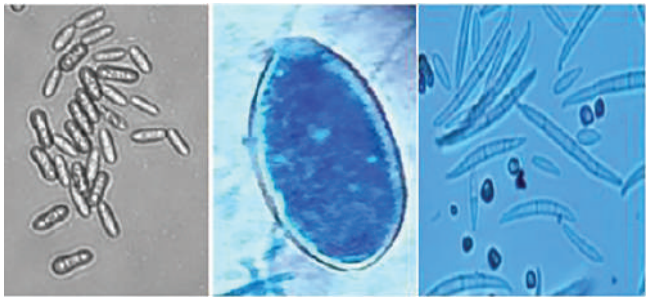


Fig. 69. Microscopic view of the organisms causing leaf rot

Field evaluation to manage collar rot in elephant foot yam

The experiment was laid out in RBD with eight treatments viz., hexaconazole 0.1% (T_1), propineb 0.1% (T_2), difenoconazole 0.1% (T_3), combination fungicide, mancozeb + carbendazim 0.2% (T_4), *Trichoderma* enriched vermicompost (T_5) and untreated control (T_6) in the variety Gajendra, untreated control in Sree Padma (T_7) and untreated control in Sree Athira (T_8) replicated thrice. There was no disease incidence in the variety, Sree Athira. Among the fungicides and bioagents evaluated, the lowest disease incidence with 75% disease reduction was observed with difenoconazole 0.1% (T_3) over control. This was followed by hexaconazole 0.1% (T_1) and *Trichoderma* enriched vermicompost (T_5) with 62.50% disease reduction over control (Fig. 70). Yield

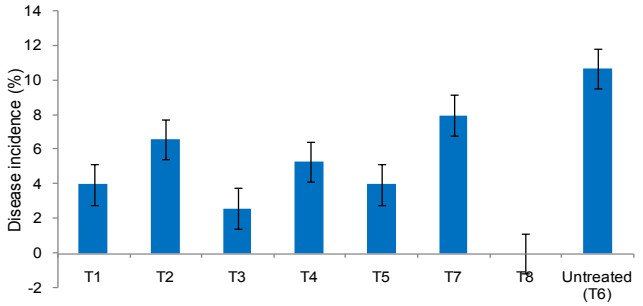


Fig. 70. Collar rot incidence in elephant foot yam under various treatments

was also highest with difenoconazole 0.1% (T_3), with 60.30% yield increase over untreated plants, followed by hexaconazole 0.1% (T_1) with 41% yield increase over untreated plants (Fig. 71).

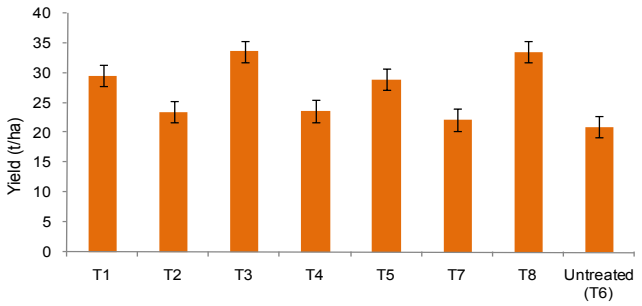


Fig. 71. Yield of elephant foot yam as affected by different treatments

Management of postharvest rot in elephant foot yam

Six treatments were evaluated for their efficacy in managing postharvest rot in elephant foot yam (Fig. 72). The treatments were 0.1% turmeric powder (T_1), 0.1% crushed garlic (T_2), *Trichoderma* in cow dung slurry (T_3), mancozeb + carbendazim 0.2% (T_4), 0.1% propineb (T_5) and control (T_6). The varieties tested were Gajendra, Sree Padma and Sree Athira. Among the varieties, highest postharvest rot was observed in the variety, Sree Athira (87.50%) and least incidence was in Gajendra (46.10%). All the treatments could effectively check the postharvest rot pathogens (>70% over control). Highest inhibition was shown by the fungicide, carbendazim + mancozeb (0.2%) with <8% infection in all the varieties. The treatments 0.1% turmeric powder (T_1) and 0.1% crushed garlic (T_2) could restrict the rot to the extent of 20% incidence.

Fig. 72. Assessment of postharvest rot in elephant foot yam after imposing various treatments

Field evaluation of various fungicides to manage taro leaf blight

The experiment was laid out in RBD, with nine treatments viz., spraying 0.1% of mancozeb 64% + cymoxanil 8% WP (T_1), metalaxyl 4% + mancozeb 64% (T_2), famoxadone 16.60% + cymoxanil 22.10% (T_3), propineb 70% WP (T_4), metalaxyl 3.30% + chlorothalonil 33.10% (T_5), 0.2% of mancozeb (T_6) and copper oxychloride (T_7), 0.3% potassium phosphonate (T_8) and untreated control (T_9) replicated thrice. All the other treatments, except propineb 70% WP (T_4), showed >70% PDI (percent disease incidence) reduction over control (Fig. 73). The least PDI was noticed with famoxadone 16.60% + cymoxanil 22.10% (T_3) with 78.40% PDI reduction over control, followed by metalaxyl 3.30% + chlorothalonil 33.10% (T_5) with 77.80% PDI reduction over control. Even though most of the treatments reduced PDI considerably, only three treatments viz., famoxadone + cymoxanil (T_3), metalaxyl + mancozeb (T_2) and potassium phosphonate (T_8) showed >20% yield increase over untreated plants. The highest yield was also produced in the treatment, famoxadone + cymoxanil (T_3) with 60% yield increase over control (Fig. 74).

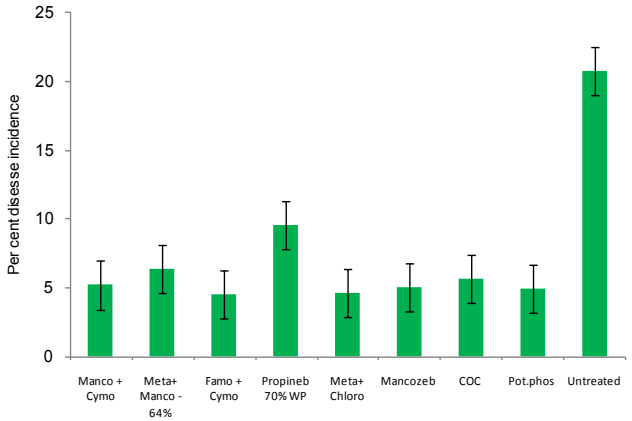


Fig. 73. Taro leaf blight incidence as affected by various treatments

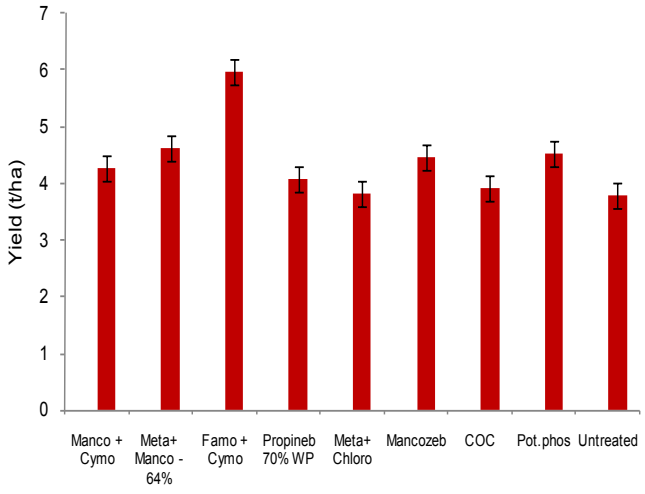


Fig. 74. Yield of taro under different treatments

Isolation, identification and screening of endophytes from taro plants against *Phytophthora colocasiae*

A total of 97 endophytic bacteria were isolated from root, corm, petiole and leaves of taro plants. Seventy three endophytic bacteria and eight endophytic fungi exhibited antagonistic activities against *P. colocasiae* in varying degrees. The most efficient bacterial isolates which showed maximum inhibitory effect were selected for further studies. The bacterial isolate S1P4a showed the highest inhibition of 84.44%, followed by S5R4 (82.22%) and S6L3a (81.66%) (Fig. 75). The inhibition of *P. colocasiae* growth by bacterial volatiles was not very remarkable. In the case of inhibition by diffusible metabolites from bacterial endophytes, S1P4a showed the highest inhibition potential of 76%, followed by S5R4, S5C14, S1P3 and S6L3. These potent bacterial

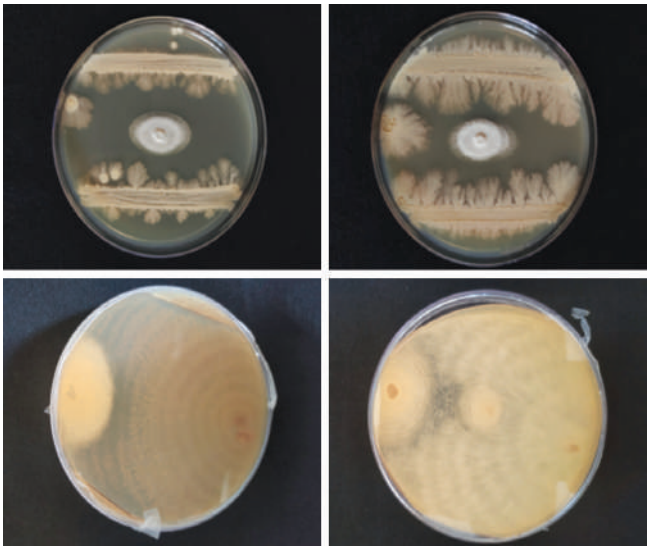


Fig. 75. Antagonistic effect of the endophytic bacterial isolates on *P. colocasiae* in dual culture method

isolates were identified as *Bacillus subtilis*, *B. cereus*, *B. safensis*, *B. tequilensis* and *Bacillus* sp. respectively by 16SrRNA gene sequencing followed by Gen Bank analysis. Multiple plant growth promoting traits of the potent endophytes such as phosphate solubilization, IAA production, siderophore production and potassium solubilization were studied *in vitro*. All the five isolates were able to solubilize phosphate and produce IAA. The isolates S6L3 and S5C14 were able to produce siderophore. The isolates S1P4a, S1P3 and S5R4 were able to solubilize potassium in the medium.

Fungal pathogens and disease management in cassava and yams

Isolation and identification of pathogens associated with cassava stem and root rot

More isolates of pathogens were obtained from cassava stem and root from different farmers' fields which showed wilting symptoms. Rotting of stem, root and tuber, as well as presence of pustules, which were either white or dark in colour in stems, were the general symptoms (Fig. 76). Presence of *Fusarium* spp. and *Colletotrichum* sp. were observed in field samples. Irrespective of the location of the samples collected, 100% of the samples showed presence of *Fusarium* spp. with chlamydospores, macro conidia, and micro conidia. Whereas, 10-30% samples from various locations tested positive for *Colletotrichum* sp. DNA sequences of the second largest subunit of RNA polymerase (RPB2) and the translation elongation factor (TEF-1α) gene were generated for five isolates. The results of Mycobank analysis (https://www.mycobank.org/page/pairwise_alignment) of the edited sequence (Bio edit) depicted the association of *Fusarium falciforme* with the samples.

Screening of different varieties of cassava against *Fusarium falciforme*

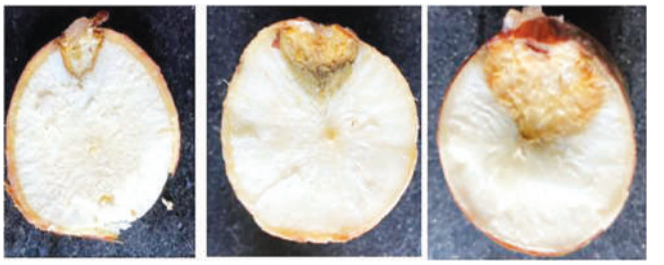
Standardization of inoculation method: Soil, stem, root and tuber inoculation of the pathogen were tried for symptom development *in vitro*. The cassava setts took only slight infection, which was not spread further. Cut roots dipped in spore suspension and whole tuber took

A: Infected tuber (Outer view); B: Infected tuber (Inner view); C: Infection in tuber slices; D: Microscopic view of chlamydospores inside inoculated roots

Fig. 76. Artificial inoculation of *Fusarium falciforme in vitro*

infection within five days after inoculation (Fig. 76). Due to physiological damage, the tuber slices were spoiled and could not be rated. The development of disease was only 10% in glass house when tried in whole plant through different inoculation methods, which will be attempted further.

Screening of different cassava accessions using tubers for root rot resistance: Ten lines of cassava from germplasm collections maintained at ICAR-CTCRI were inoculated with the pathogen in whole tuber. Among them CE-510 showed least infection compared to the other accessions (Fig. 77).



CE 510 CE 546 CE 558

Fig. 77. Reaction of different cassava accessions to *Fusarium falciforme*

Field management of cassava stem and root rot

Thirteen cassava accessions from the germplasm repository maintained at ICAR-CTCRI were tested for their field reaction to stem and root rot in Kollam (Sadanandapuram), Pathanamthitta (Adoor), Kottayam (Marangattupilly) and Thiruvananthapuram (Pallichal and Koliyoor) districts of Kerala. All those areas were heavily infected by root rot in the previous season. None of the varieties showed infection, except Sree Suvarna, in one field (25%) and local varieties (10 to 20%). Sree Reksha was 100% free with good stand for two seasons (2021-2022).

In general, the cassava root rot incidence was less during 2022. However, on-farm management of cassava root rot with the ad-hoc recommendations by ICAR-CTCRI (Removal and burning of highly infected plants, ensuring good drainage in the plot, application of lime @ 150 to 250 g per plant at 10-15 days before planting, use of healthy setts and avoiding setts from infected fields, application of neem cake @ 20 g per plant, application of *Trichoderma asperellum* enriched FYM @ one kg per plant, sett treatment with carbendazim (0.1%) (or) combination of carbendazim and mancozeb (0.2%) for 10 minutes, drenching with the same fungicides starting from planting three times at 15 days interval) could manage the disease effectively without any incidence compared to control, which showed 10 and 15% incidence in Sadanandapuram, Kollam and Pallichal, Thiruvananthapuram.

Screening of fungicides against *Fusarium falciforme:* A few fungicides, viz., carbendazim, chlorothalonil, hexaconazole, tebuconazole + trifloxystrobin, thiophanate methyl and propineb were screened at 2.5, 5, 7.5 and 10 ppm concentration against *F. falciforme in vitro*. Carbendazim and tebuconazole + trifloxystrobin showed 100 and 50% inhibition at 5 ppm, which could be utilized further for management of these diseases.

Management of greater yam anthracnose

In a field trial on the management of anthracnose in greater yam (var. Orissa Elite) using endophytic isolate *Bacillus licheniformis* at ICAR-CTCRI for three consecutive years (2020-2021, 2021-2022 and 2022-2023), soil treatment with *B. licheniformis* resulted in highest reduction of anthracnose intensity (49.09%) compared to absolute control, which was on par with fungicide control of spraying of carbendazim seven times. This was followed by soil treatment with spraying combination (40.29%).

In another trial to manage yam anthracnose, different treatments of bioformulations (*Nanma*, *Trichoderma asperellum*) and fungicides (carbendazim, propiconazole, difenoconazole and tebuconazole + trifloxystrobin) were tried in Orissa Elite. Spraying carbendazim (0.05%) and the combination of carbendazim (0.025%) and *Nanma* (0.7%) resulted in highest disease reduction of 68 and 65% respectively, followed by 0.1% difenoconazole (52%).

Media formulation: Different types of natural media, viz., fresh vegetable broth, dried vegetable broth, mixed weeds, biopesticide waste (from cassava), cassava fresh leaves, dry leaves, greater yam peel (dried), greater yam tuber flesh (dried), tender coconut water and sterile tap water were utilized for growing the endophyte, *Bacillus licheniformis*. Out of the ten media tested, fresh vegetable waste broth was effective in maintaining the endophytic population ($5x10^8$ cfu ml^{-1}) and viability. Vegetable wastes collected from different sources were tested. Results showed that a smaller number of ingredients accounted for slow growth of endophytic biomass as well as required more than six hours for minimal multiplication compared to nutrient agar. Overall, fresh vegetable broth was a better alternative to nutrient agar, a synthetic media.

Expression of pathogenicity gene

The amplification of pathogenicity genes of *Colletotrichum gloeosporioides* standardized during 2021 was utilized for the study. The expression of pathogenicity genes in *Colletotrichum gloeosporioides* was studied by using tissue culture raised greater yam plants (var. Orissa Elite). Kinetics of selected gene expression in the assessed time intervals were studied. In general, all the chosen genes were up-regulated during the infection, especially from the 4^{th} to 24^{th} hour, and then dropped gradually. The qRT PCR of a major pathogenicity gene,

PacC (master transcription factor for colonization in host) of *C. gloeosporioides* was conducted. Significant difference in the amplification profile was observed both in test and control samples. The PacC gene expression was upregulated in infected leaf sample, in the 4th hour, when compared to endophyte co-inoculated *C. gloeosporioides*.

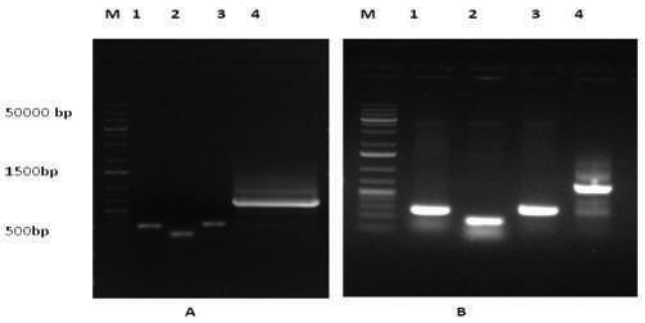
Virus and phytoplasma diseases of tropical tuber crops and their management

Cassava mosaic disease (CMD)

Micro RNA detection using specific primers: MicroRNAs are small molecules containing only 17-24 nucleotides. Apart from small size, they lack common features like a poly (A) tail, 3′ end-modifications, and presence of a precursor. These factors affect the detection and the quantification of miRNAs. Therefore, a miRNA-specific stem-loop RT primer is hybridized to miRNA and then reverse transcribed using specific stem-loop RT primers. The RT product is amplified using miRNA specific forward primer and an universal reverse primer. Another method is poly A tailing of RNAs followed by reverse transcription using an adapter probe. In this work, only two microRNAs were detected using specific stem loop primers by end point PCR.

Management of cassava virus infection through microbial treatment: Stem cuttings of cassava var. H-226 were treated with ten isolates of *Trichoderma* cultures namely, T-G, T-Y, T-IISR, T2, T11, T14, T15, T16, T18 and T28 along with untreated control. Cassava mosaic virus infection in source plants and treatments were confirmed by PCR. After 45 days of treatment, qPCR was performed to analyze viral load in each treatment and the results revealed that the isolates T15, T16 and T11 showed drastic reduction in virus load, which was evident from their Cq values as compared to control (T15-34.35 and 34.38; T16-34.26 and 34.24; T11-34.41, 34.12 and 33.66; Control-12.70 and 12.66).

Development of artificial microRNA gene constructs for developing resistance against cassava mosaic virus: Artificial micro RNAs were designed using sequences of viral genes, derived from predominant strains such as *Sri Lankan cassava mosaic virus* (SLCMV) and *Indian cassava mosaic virus* (ICMV), in such a way that they target the RNAs of invading viruses by mRNA degradation. The multiple alignment showed very less conserved domains between viruses, with respect to AC4 gene, hence two small stretches of viral genes were selected as follows: (i) ICMV-SLCMV-1 TCCTTGTCGATGTAGGA CTTGACGTCGGAGCT GGA and (ii) ICMV-SLCMV-2 CCCCCTCTGGCCGATCGTCCATCGA TCTGAAA. These regions were used and primers were designed using Webmicro RNA designer and the oligos were synthesized. Using these oligos and pRS 300 vector, artificial microRNAs were produced through PCR, which yielded a larger fragment of approximately 600bp (Fig. 78) and the products were cloned in pJET1.2/Blunt



A: SLCMV-ICMV combination Lanes M: 1Kb ladder, 1. PCR-a, 2. PCR-b, 3. PCR-c, 4. PCR-d; B: SLCMV alone. Lanes M: 1Kb ladder, 1. PCR-a, 2. PCR-b, 3. PCR-c, 4. PCR-d

Fig. 78. PCR amplicons generated using oligos on pRS300 template

Vector. The resulted clones were confirmed through restriction analysis and sequencing. Sequencing of the SLCMV amiR clones had sequence of chromosome 4 of *Arabidopsis thaliana* on which miR 319 gene is located and it suggests the incorporation of selected viral sequence to miR319 backbone.

Editing of Geminiviral genome for developing resistance to cassava mosaic disease: Cloning of four single guide RNA transcription units to binary vector was done and confirmed by sequencing. Three of them are SLCMV Rep gene specific and one is BV1 specific. Cloning of one multiple guide RNA transcription unit comprising four sgRNAs was also done, which comprises three gRNAs targeting Rep and another one targeting BV1 region of

SLCMV. Confirmed sgRNA clones were mobilized to EHA105 (*Agrobacterium tumefaciens)* through triparental mating. *Nicotiana benthamiana* leaf discs were infected with these transformed EHA105. Successful regeneration of transformed *Nicotiana* plantlets on Kanamycin selection media was obtained only from leaf discs infected with two transformed EHA105 clone, of which one is harbouring multiplex editing vector and another one with single gRNA vector. Plantlets are now growing on rooting media.

Dasheen mosaic disease in elephant foot yam

Molecular variability analysis of DsMV in plant samples collected from different geographical locations: The whole genome sequences of *Dasheen mosaic virus* (DsMV) available in the NCBI database were aligned using ClustalW and found that there was genome wide variation in the sequences, which included P1, P3, CI, NIa, NIb, CP region. Primers were designed to sequence the region of NIb-CP junction, P1 protein (the most hypervariable regions) and NIa region. The amplification of gene spanning NIb-CP junction was performed using cDNA template and DMV 9 primer, which was further cloned into pTZ57R/T cloning vector.

The most variable regions of DsMV genome (NIb-CP, NIa, P1 regions) were cloned into pTZ57r/t vector and confirmed through restriction analysis and sequencing. Multiple sequence alignment (MSA) of NIb-CP gene of different isolates from Kerala viz., Wayanad (WYND), Malappuram (MLP) and Thiruvananthapuram (TVM) along with other reference sequences revealed that these isolates showed high variability in these regions. Similarly, 5'UTR and P1 regions comparison of Wayanad and Malappuram isolates with other sequences also revealed high variability.

Sweet potato leaf curl disease

Cloning and characterization of *Sweet potato leaf curl virus* (SPLCV): Field-infected sweet potato cultivars were collected from different parts of Kerala. The vine cuttings were propagated in the greenhouse of ICAR-CTCRI. PCR analysis was performed to check the presence of S*weet potato leaf curl virus* (SPLCV) in these plants by using SPLCV coat protein (CP) primers (Fig. 79). Through rolling circle amplification method (RCA), full genome of

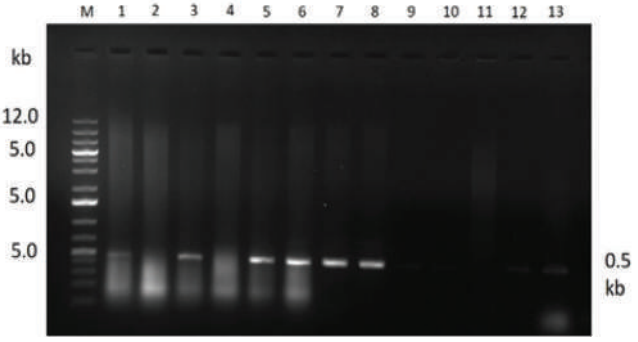


Fig. 79. PCR analysis of field-infected sweet potato samples with CP primers

SPLCV were obtained and confirmed through restriction digestion of the high molecular weight amplification product with *Bam*HI, which gave the expected 2.8 kb full-length viral genome (Fig. 80). The amplification products from different field infected samples were cloned in the *Bam*HI site of pUC18 or pBSIIKS$^+$ and the clones were subjected to PCR analysis with M13 forward and reverse primers, which amplified a 2.8 kb fragment in

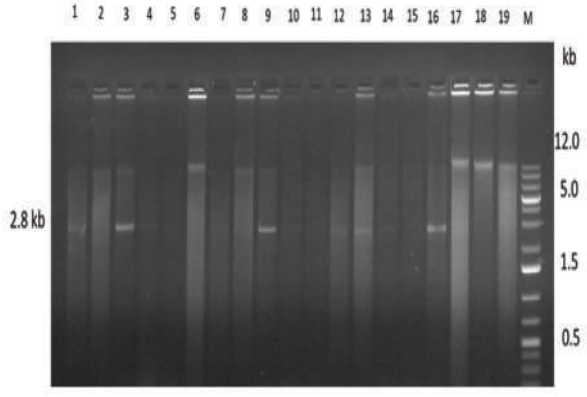


Fig. 80. RCA of field-infected sweet potato samples

most of the clones. A few clones gave shorter fragments of sizes 1.5 kb, 0.7 kb and 0.4 kb also. Selected clones were digested with multiple restriction enzymes and compared with available sequence information from NCBI database (Fig. 81) and sequenced with M13F and M13R primers. Upon BLAST analysis, the sequences showed 91 to 98 percentage nucleotide sequence similarity with other published SPLCV sequences.

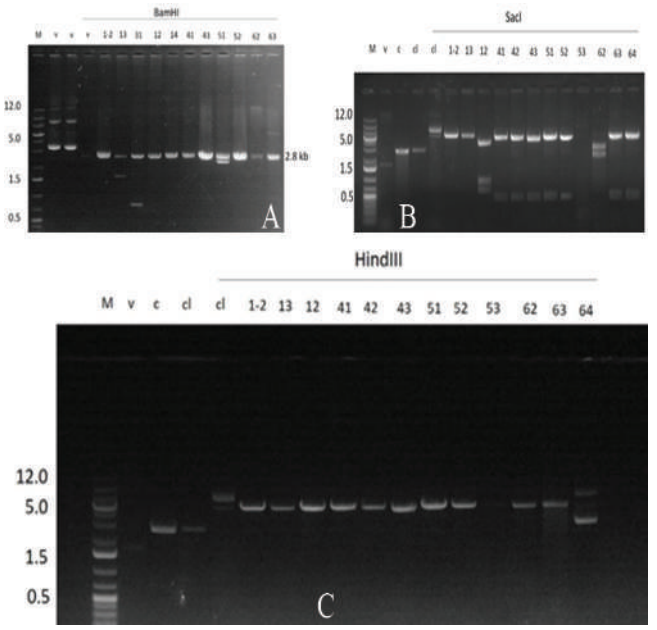


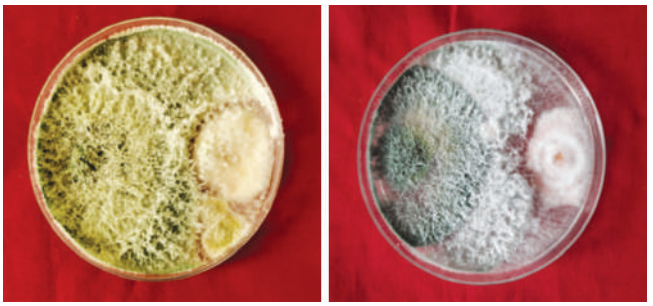
Fig. 81. Restriction enzyme digestion of SPLCV clones with A: Bam HI; B: Sac I; C: Hind III

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

Isolation of efficient bioagents from tropical tuber crops growing eastern regions of India

Forty *Trichoderma* isolates were obtained from rhizosphere soils of Tripura and Odisha states. Cultural characteristics of these isolates were studied in detail and the best performing isolate was used for mass multiplication in organic substrate and bioformulation development.

***In vitro* screening of *Trichoderma* isolates against fungal pathogens (dual culture assay):** Forty *Trichoderma* isolates were tested against *Sclerotium rolfsii* and *Colletotrichum gloeosporioides,* the causal agents of collar rot of elephant foot yam and anthracnose of yam respectively. The isolate, T29 showed the highest inhibition against *S. rolfsii* and the isolates T9 and T11 showed the least inhibition. Isolates, T4 and T29 showed highest inhibition against *C. gloeosporioides* and the least by T15 isolate (Fig. 82). Based on the results, isolates were selected for formulation development and mass multiplication in organic substrates.



Isolate T29 against *S. rolfsii* | Isolate T4 against *C. gloeosporioides*

Fig. 82. Testing dual culture assay of *Trichoderma* isolates against fungal pathogens on PDA agar medium

Development of cost-effective protocols for mass production of *Trichoderma* using low-cost carrier material from tuber substrate: Ten tuber crops were evaluated for the shelf life and its suitability for the mass multiplication of *Trichoderma* under *in vitro* conditions. Results revealed that at 28 days after inoculation (DAI), sweet potato (orange and purple flesh) was the best substrate for mass multiplication of *Trichoderma,* while greater yam was the least suitable. The shelf life was calculated by conidial count using haemocytometer and CFU/gram on a weekly basis. After 28 days, sweet potato (purple flesh) exhibited highest spore count, whereas count was the least in greater yam (Fig. 83).

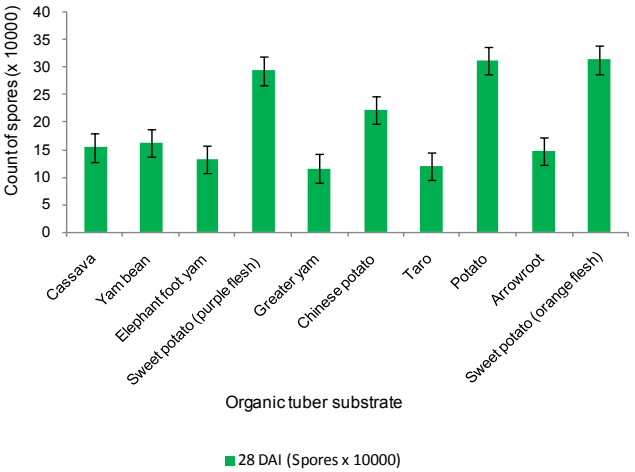


Fig. 83. Sporulation of *Trichoderma* on various tuber substrates

Development of cost-effective protocols for mass production of *Trichoderma* using low-cost carrier material from agro-substrate: Seven different solid

agro-substrates viz., rice, pigeon pea, wheat, corn, compost, oats and sugarcane were evaluated for the shelf life and its suitability for the mass multiplication of *Trichoderma*. After 28 days of inoculation, corn was the best substrate for mass multiplication of *Trichoderma,* while compost was the least suitable. The viability of formulation was recorded and corn had highest spore count and the count was the least in compost (Fig. 84).

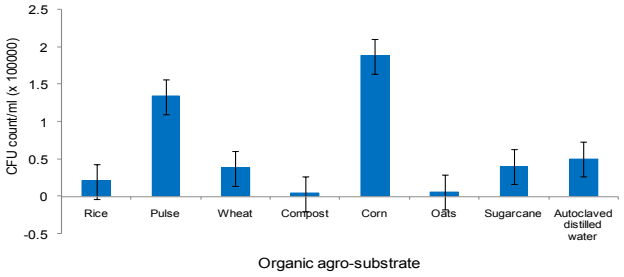


Fig. 84. Sporulation of *Trichoderma* on various agro-substrates

Development of new oil-based bioformulations with *Trichoderma*: Thirteen different oils used in bioformulations were evaluated for examining the shelf life and its suitability for the mass multiplication of *Trichoderma*. These oils were mixed with emulsifying-dispersing agent, shelf-life increasing agents, carbon source, osmoticant and the structural agent. These oil substrates were then inoculated with *Trichoderma* isolate. The shelf life was calculated by conidial count using haemocytometer and CFU/gram on weekly basis. The sunflower oil was the best substrate for mass multiplication of *Trichoderma*, while groundnut oil and autoclaved water were least suitable. The viability of formulations after 28 days revealed that sunflower oil maintained highest spore count, whereas spore count was least in autoclaved water (Fig. 85).

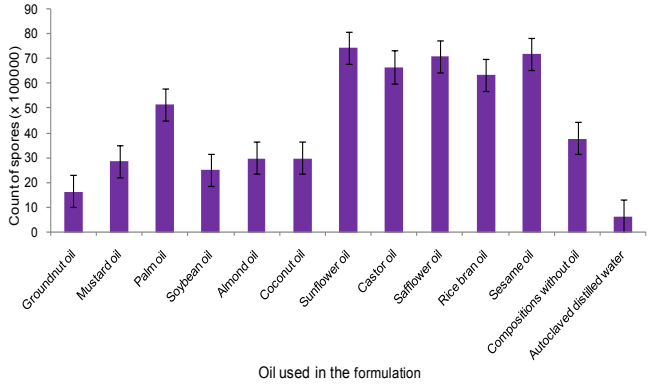


Fig. 85. Sporulation of *Trichoderma* on various oil-based bioformulations

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

Thermoplastic sheets from cassava starch and fibre

Thermoplastic starch sheets were prepared from cassava starch added with sugarcane bagasse and banana fibre at different process conditions and the conditions were optimized using Box Behnken design. The variables and their levels used were: concentration of glycerol: 20, 30 and 40% based on the weight of the starch; temperature of the die plate: 120, 130 and 140°C; pressure of the die plate: 130, 140 and 150 bar, and concentration of sugarcane bagasse/banana fibre: 10, 20 and 30%. The time of pressing was fixed at 5 min. The moisture content, density and total colour difference of the banana fibre based thermoplastic sheets were in the range of 9.14-23.40%, 670-694 kgm^{-3} and 22.52 - 43.56, respectively (Fig. 86). The yellowness index ranged from 16.56 to 58.56. The lowest water activity of 0.588 was observed for the sheet made at 130°C and 130 bar with 30% glycerol and 30% banana fibre. At 75% relative humidity, the lowest moisture absorption (3.85%) was for the sheet made at 130°C and 130 bar pressure with 30% glycerol and 20% banana fibre.

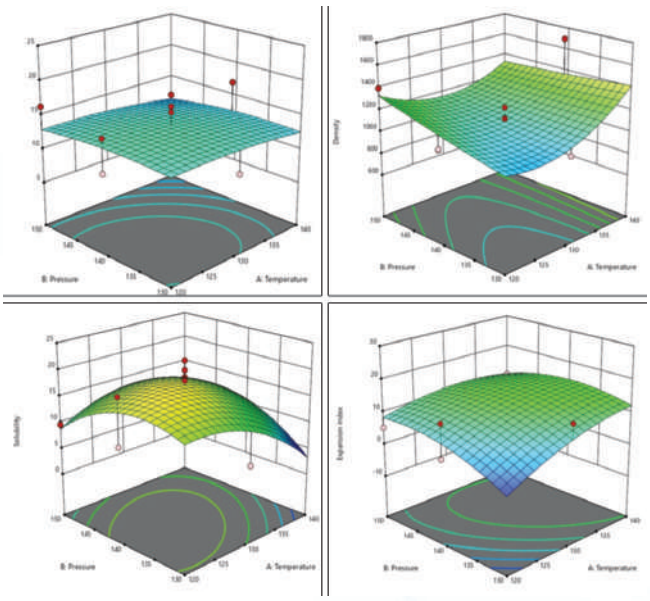


Fig. 86. Properties of cassava starch-banana fibre thermoplastic sheets

For the bagasse based thermoplastic sheets, the moisture content range was 5.30-10.94% and the density range was 670 -1483 kgm^{-3}. The total colour difference was highest (53.44) for the sheet made at 130°C and 130 bar with 30% glycerol and 10% bagasse, while the lowest (31.51) was for the sheet made at 120°C and 140 bar with 20% glycerol and 20% bagasse. The yellowness index ranged from 25.56 to 48.94 (Fig. 87). The variations in water activity of the thermoplastic sheet from cassava starch with respect to different combinations of glycerol, bagasse, temperature and pressure were not significant. The highest water activity in the thermoplastic sheet made from cassava starch was 0.732 at 140°C and 140 bar with 20% glycerol and 20% bagasse, while the lowest was 0.549 at 130°C and 140 bar with 30% glycerol and 20% bagasse (Fig. 87). The hygroscopicity of the sheets were analyzed by observing the variations in absorption of moisture by the sheet exposed to 75, 85 and 95% relative humidity. The lowest moisture absorption of 4.94% was observed for

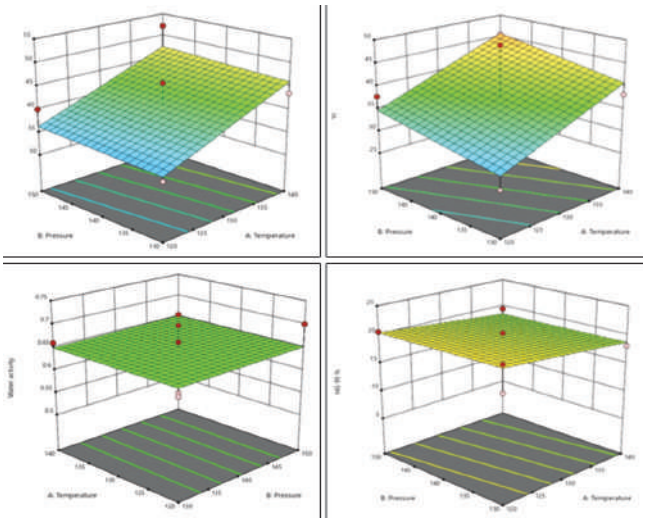


Fig. 87. Properties of cassava starch-sugarcane bagasse fibre thermoplastic sheet

the sheet made at 130°C and 140 bar with 30% glycerol and 20% bagasse at 75% relative humidity.

The optimized process parameters and the corresponding physico-functional and hygroscopic properties of cassava starch, bagasse/banana fibre composites are given in Table 10.

Table 10. Optimized process parameters and the properties of cassava starch, bagasse/banana fibre composites

Parameter	Unit	Bagasse	Banana fibre
Temperature	°C	124.10	120.00
Pressure	bar	132.90	140.00
Glycerol	%	23.03	25.82
Fibre	%	27.19	24.26
Moisture content	%	6.01	15.79
Water activity	-	0.637	0.640
Density	kg m^{-3}	1457	1290
Solubility	%	30.06	15.36
Expansion index	%	12.75	3.37
Total colour difference	-	31.50	29.50
Yellowness index	-	30.60	45.60
Hygroscopicity at 75% RH	%	8.74	8.97
Hygroscopicity at 85% RH	%	14.37	12.12
Hygroscopicity at 95% RH	%	18.71	17.18

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

Evaluation of high viscosity crosslinked cassava starch phosphate as thickener/viscosity enhancer in model food system

Two samples of food grade high viscosity cassava starch phosphates prepared by the crosslinking reaction of cassava starch with sodium tripolyphosphate/sodium trimetaphosphate were evaluated for their potential as a thickener in dehydrated vegetable soup mix formulation. The moisture content, rehydration ratio and swelling index of the soup mix were 9.60%, 9.26 and 0.9 respectively and were on par with those of the commercial sample (10.70%, 9.40 and 0.9 respectively). The soup mix made from cassava starch phosphate had significantly higher viscosity (1517. cP) and bulk density (1.86) than those of commercially available soup mixes (253. cP and 1.45 respectively). The cooking temperature of the modified starch-based soup mix was also lower.

Isolation of starch from the tubers of different varieties of *D. esculenta* with suitable pretreatments and characterization

Starch was isolated from the tubers of three varieties/ accessions of lesser yam viz., Sree Kala (*Nanakizhangu*, *D. esculenta* var. *Fasciculata*), Sree Latha (*Cherukizhangu, D. esculenta* var. *Fasciculata*) and *Mukkizhangu* (*D. esculenta* var. *Spinosa*) and their physicochemical and functional properties were determined. The process was standardized for the pretreatment of tubers for maximum starch extraction without the interference of mucilage and other extraneous compounds. The starch yield was 18.50±1.58%, 19.80±2.11% and 13.60±1.23% based on tuber fresh weight respectively for *Nanakizhangu, Cherukizhangu* and *Mukkizhangu.* The amylose content varied from 22.30 to 24.20% for different starch samples, which was higher than that of cassava starch. The starch pastes were highly opaque. The aqueous solubility (27.30-

33.70%) and water binding capacity (163-215%) were significantly higher than that of cassava starch (17-22% and 68-75% respectively). These properties of lesser yam starches can be exploited in food applications.The *in vitro* starch digestibility of *Cherukizhangu* starch (31.10±1.70%) was significantly lower than the other two i.e., 53.60±3.20% and 59.30±4.40%, respectively for *Nanakizhangu* and *Mukkizhangu* starches. The paste viscosity of these starches ranged from 1792 cP to 2361cP, which was more or less similar to that of cassava starch. However, the viscosity breakdown and setback were significantly lower for the lesser yam starches when compared to cassava starch indicating the high paste stability of the former, which is a highly desirable property in food applications.

Synthesis and characterization of cassava starch phosphate carbamate with high water absorption capacity

Cassava starch phosphate carbamates with high water absorption capacity have been synthesized by the reaction of starch with urea-phosphoric acid (Fig. 88) and the reaction conditions were optimized for highest water absorption capacity. The samples were characterized by determination of N and P contents and degree of substitution (DS). The granule morphology and crystalline properties were determined by SEM and powder XRD analyses, respectively. Among the 16 samples synthesized, the highest water absorbency of 91.67±0.212 g g^{-1} was obtained for the sample made using 6% of urea and 4% orthophosphoric acid. The water sorption kinetics of the samples and the deswelling pattern of the microgels have been studied. The effect of different parameters such as pH, temperature and presence of salts in the absorption medium on the absorption capacity was also studied. The maximum absorbency was noticed at pH 7.0 after swelling for about 90 min. There was a decrease in absorbency with increase in temperature as well as with the presence of cations such as Na^{+}, Ca^{2+} and Mg^{2+}. Being completely biodegradable, these microgels can be potentially utilized in the place of synthetic hydrogels in different applications.

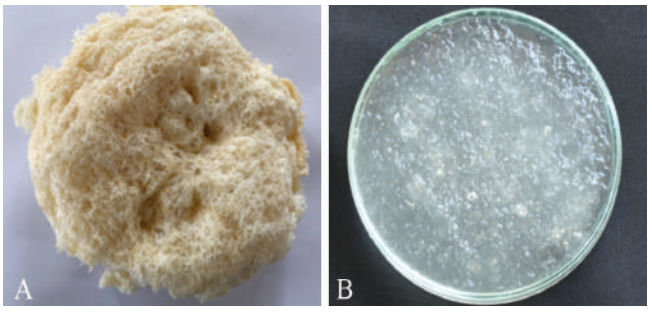


Fig. 88. A: High water absorbing cassava starch phosphate carbamate; B: Microgel after water absorption

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

Probiotic and bioactive compounds (anthocyanin and β-carotene) rich frozen yogurt from sweet potatoes

Twenty five combinations of purple-fleshed sweet potato (var. Bhu Krishna) puree (PFSPP) based frozen yogurt were prepared. Among these, the combination containing higher amount of PFSPP (70%) showed higher contents of anthocyanins, i.e., 55.24 and 51.14 mg100g^{-1} in the initial sample and after tenth day of storage at -4°C, respectively. The protein (4.68 and 4.10%), and fibre (0.69 and 0.31%) contents also were higher in these samples. In addition to the nutritional and functional properties, beneficial *Lactobacillus* microbial count of all the 25 samples was studied and it was found steady even on tenth day of storage at -4°C. A full factorial experimental design with two factors resulting in 10 different combinations were studied for the development of probiotic and β-carotene rich orange-fleshed sweet potato based frozen yogurt. Here also, the sample containing higher amounts of sweet potato showed higher nutritional and functional properties. Higher amounts of β-carotene content, i.e., 6.97 and 6.66 mg 100 g^{-1}, respectively on 1st day and 10th day of storage at -4°C was observed. Furthermore, protein content and beneficial microbial count were also higher (6.57 and 6.21%) in the initial and stored samples. This study showed that frozen yogurt with probiotic as well as prebiotic potential can be integrated into health-focused

dietary solution strategies, especially to improve human gut health and to mitigate chronic oxidative stress-linked non-communicable disease challenges.

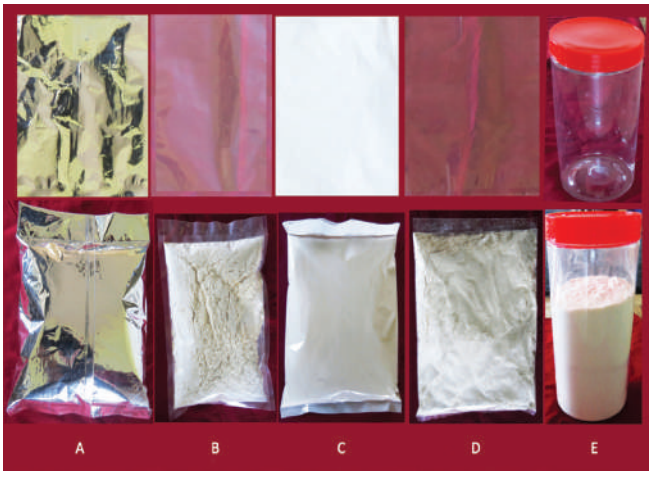
Design and development of pre- and post-harvest machineries/storage systems in tuber crops

Design and development of a tractor operated Chinese potato harvester

Chinese potato (*Plectranthus rotundifolius* Poir.) is an important minor tuber crop grown mostly in India. It is widely cultivated in Tenkasi and Tirunelveli districts of Tamil Nadu and Palakkad, Thrissur and Malappuram districts of Kerala. The Chinese potato is mostly planted in ridge and furrow method using stem cuttings after the onset of south west monsoon. Cultivation and harvesting are labour intensive operations in Chinese potato production, which need about 33% and 50% of total man-power requirement, respectively. Manual harvesting involves digging out the tubers using spades, which is expensive, time consuming and tedious. To design and develop the Chinese potato harvester, baseline information about physical properties of Chinese potato tubers (size, sphericity, angle of repose), soil properties (moisture, bulk density) and maximum depth of tubers in the soil were estimated. The measured physical properties of the tubers are important to determine the load bearing capacity of the harvester during operation. The measured soil properties also influence the performance of the harvester. It was found that more than 99% of Chinese potato tubers lie up to the depth of 15 cm, and more than 94% of tubers have size >20 mm, with the angle of rolling friction (angle of repose) lying above 15°. Thus, a prototype tractor operated Chinese potato harvester was designed and developed for harvesting of the tubers cultivated in ridge and furrow system.The prototype harvester functions to dig out and separate the tubers from soil mass. The machine was designed to cover three ridges having spacing of 30 cm and 15 cm depth of operation. It consists of seven major units viz., main frame, digging system, elevator conveyor, soil sieving system, discharge system, power transmission system and transport system. The fabrication of the harvester was completed and the performance evaluation is in progress.

Effect of different packaging materials on long term storage of cassava flour

The effect of various packaging materials on the shelf life and quality of cassava flour were studied. The selected packaging materials for the study were: aluminium foil, ethylene vinyl alcohol (EVOH), low density polyethylene (LDPE) and polypropylene (PP) bags of 40 µm thickness. The prepared 500 g samples of cassava flour with a particle size of 75 µm were packed in the selected materials and stored at room temperature (28±4°C) for 12 months, with a PET jar serving as the control (Fig. 89). The physicochemical properties of the flour studied were moisture content, crude fibre, crude fat, crude protein, total sugars, total ash, colour value, water activity and functional properties such as swelling power, solubility and viscosity at one-month intervals. The physicochemical and functional properties of cassava flour samples were significantly (p<0.05) affected by the type of packaging material along with the storage period. The moisture content was significantly influenced by the packaging material, whereby it increased over the storage period. The highest moisture content (6.5 g 100 g^{-1}) and water activity (0.60) were recorded in the cassava flour stored



A: Aluminium foil bag B: EVOH bag C: LDPE bag D: PP bag E: PET jar

Fig. 89. Fresh cassava flour stored in different packaging materials

in EVOH bag, followed by PET, LDPE and PP bags. The lowest moisture content (5.52 $g100g^{-1}$) and water activity (0.52) was recorded in cassava flour stored in aluminium foil bag during the storage period. The colour of the cassava flour stored in aluminium foil bag was clear with highest whiteness index (87.08) than the flour stored in PP, LDPE bags and the control. Overall, the quality of cassava flour stored in aluminium foil bag was best for 12 months, followed by PP, LDPE, and control. Thus, cassava flour may be stored in aluminium foil bag or aluminium foil lined PP laminated bags to prevent moisture absorption, which would ultimately result in shelf stability of the flour and aid in its effective marketing and distribution.

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 Chinese potato and OFTs on site specific nutrient management (SSNM) in Chinese potato were established in Tamil Nadu and Andhra Pradesh with 53 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 and sucking pests and nematode in Chinese potato were managed with integrated pest, disease and nematode management practices.

Improved varieties of cassava

Data from seven FLDs conducted during April 2021-January 2022 at Goodamalai in Salem district revealed that yield of Sree Athulya (42.73 t ha^{-1}) was higher (14.19 %) than that of local varieties (37.42 t ha^{-1}). The net income realized from Sree Athulya was ₹ 1,37,000 ha^{-1} (B:C ratio: 2.23) when compared to local varieties, which was ₹ 1,05,000 ha^{-1} (B:C ratio:1.95) (Fig. 90). Technology gap, extension gap and technology index of Sree Athulya was estimated as 27.27, 5.31 and 38.96 respectively. Similarly, data from ten FLDs conducted during April 2021-January 2022 at Kandarvakottai in Pudukottai district showed that yield of Sree Athulya (44.06 t ha^{-1}) was higher (9.65%) than the yield of local varieties (40.19 t ha^{-1}). The net income realized from Sree Athulya was ₹ 1,07,000 ha^{-1} (B:C ratio:1.94) when compared to local varieties, which was ₹ 86,000 ha^{-1} (B:C ratio: 1.75) (Fig. 91). Technology gap, extension gap and technology index of Sree Athulya was estimated as 25.94, 3.87 and 37.06 respectively.

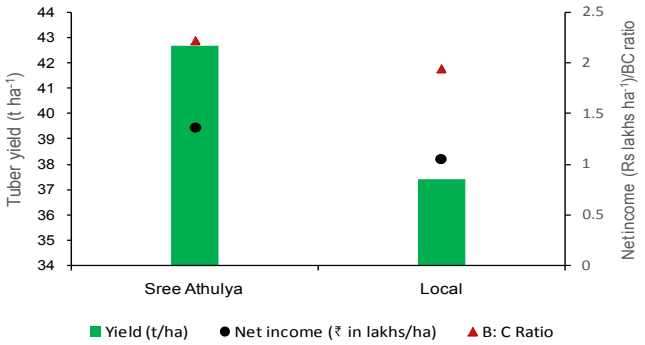


Fig. 90. Performance of Sree Athulya in Salem district

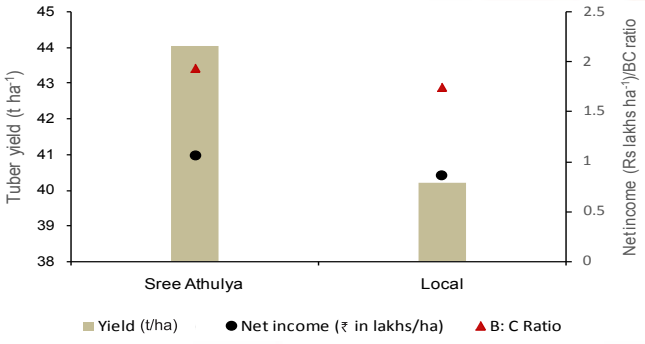


Fig. 91. Performance of Sree Athulya in Pudukottai district

Ten FLDs on improved variety of cassava, Sree Reksha conducted during June 2021 to February 2022 in East Godavari district of Andhra Pradesh revealed that the average yield of Sree Reksha was 36.96 t ha^{-1}, which was (12.50%) higher than the yield of local varieties (32.85 t ha^{-1}) under irrigated conditions. The net income realized from Sree Reksha under irrigated conditions was ₹ 1,17,000 ha^{-1} (B:C ratio: 2.71), when compared to local

varieties, which was ₹ 1,00,000 ha^{-1} (B:C ratio: 2.53) (Fig. 92). Technology gap, extension gap and technology index of Sree Reksha was estimated as 43.64, 4.11 and 53.80 respectively. Whereas, under rainfed conditions the yield of Sree Reksha was 23.68 t ha^{-1}, which was higher (14.81%) than the yield of local varieties (20.62 t ha^{-1}). The net income from Sree Reksha was ₹ 65,000 ha^{-1} (B:C ratio: 2.20) and ₹ 48,000 ha^{-1} (B:C ratio: 1.87) from local varieties (Fig. 93). Technology gap, extension gap and technology index of Sree Reksha was estimated as 26.32, 3.06 and 52.64 respectively.

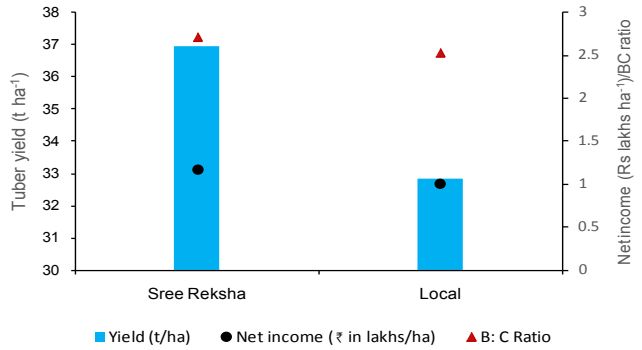


Fig. 92. Performance of Sree Reksha in East Godavari district under irrigated conditions

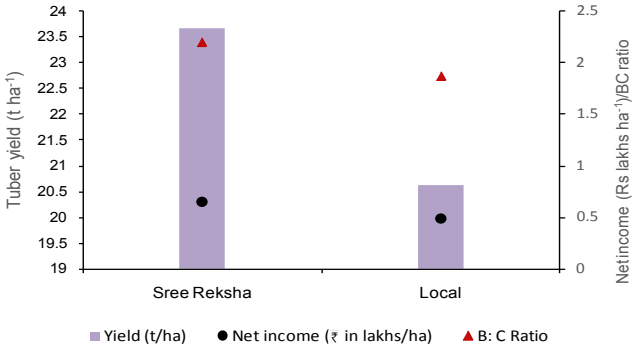


Fig. 93. Performance of Sree Reksha in East Godavari district under rainfed conditions

Improved variety of Chinese potato

Data from ten FLDs conducted during August 2021-January 2022 in Tirunelveli district of Tamil Nadu revealed that the yield of Sree Dhara (16.44 t ha^{-1}) was higher (21.24 %) than the yield of local varieties (13.56 t ha^{-1}). The net income realized from Sree Dhara was ₹ 1,94,000 ha^{-1} (B:C ratio: 2.65), when compared to local varieties, which was ₹ 1,33,000 ha^{-1} (B:C ratio: 2.21) (Fig. 94).Technology gap, extension gap and technology index of Sree Dhara was estimated as 11.56, 2.88 and 41.29 respectively. Similarly, results from six FLDs conducted during August 2021-January 2022 in Tenkasi district of Tamil Nadu showed that yield of Sree Dhara (15.25 t ha^{-1}) was higher (17.67 %) than the yield of local varieties (12.96 t ha^{-1}). The net income realized from Sree Dhara was ₹ 1,74,000 ha^{-1}(B:C ratio: 2.50) when compared to local varieties, which was ₹ 1,24,000 ha^{-1}(B:C ratio: 2.13) (Fig. 95). Technology gap, extension gap and technology index of Sree Dhara was estimated as 12.75, 2.29 and 45.54 respectively.

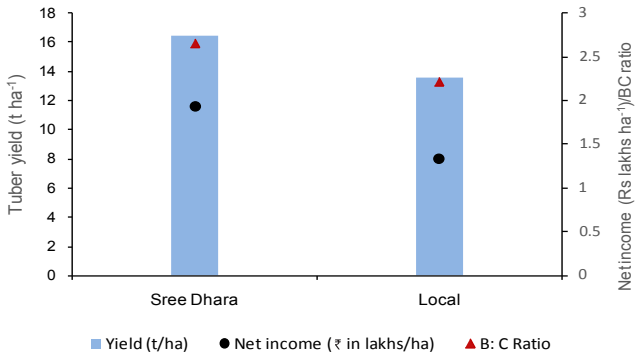


Fig. 94. Performance of Sree Dhara in Tirunelveli district of Tamil Nadu

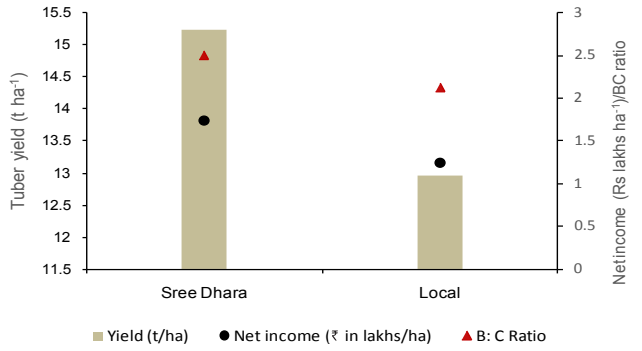


Fig. 95. Performance of Sree Dhara in Tenkasi district of Tamil Nadu

Site specific nutrient management (SSNM) in Chinese potato

A total of 10 farmers (with 50 cents plot each) from Kuthapanjan and K. Alangulam villages in Tenkasi district of Tamil Nadu were selected for the OFTs on SSNM in

Chinese potato during October 2021 to February 2022. 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. Results on site specific nutrient management in Chinese potato in Tenkasi district revealed that the yield of SSNM treated plot of Sree Dhara (17.73 t ha^{-1}) was 14.61% higher than the yield obtained from farmer's practice (15.47 t ha^{-1}). The net income realized from SSNM treated plot of Sree Dhara was ₹ 2,32,000 ha^{-1}(B:C ratio: 2.96), when compared to farmer's practice, which was ₹ 1,92,000 ha^{-1} (B:C ratio: 2.68) (Fig. 96).

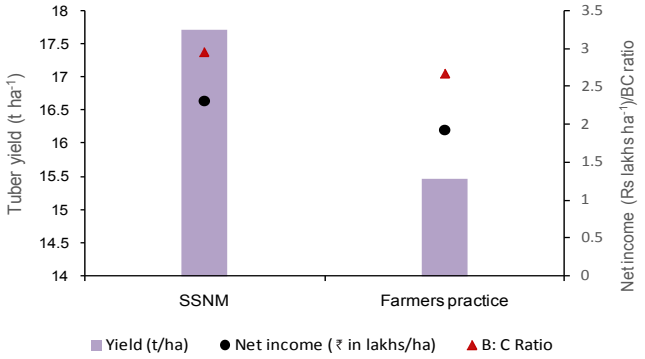


Fig. 96. Performance of SSNM in Chinese potato in Tenkasi district of Tamil Nadu

Technological interventions through farm machinery

Use of farm machinery viz., cassava chipping machines and cassava slicers were demonstrated and distributed to farmers in Salem district of Tamil Nadu for post-harvest processing and value addition in cassava.

Five Farmer Producer Groups (FPGs) on Chinese potato were mobilised in Tirunelveli and Tenkasi districts of Tamil Nadu for enhancing the farmers' income by adoption of improved varieties and technologies of Chinese potato under the technical guidance of the scientists of ICAR-CTCRI. The Chinese potato grader developed by ICAR-CTCRI was handed over to two FPGs in Tirunelveli and Tenkasi districts of Tamil Nadu.

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 tuber crops growers of Kolli hills in Namakkal, Pachamalai hills in Salem and Trichy districts, Tenkasi and Tirunelveli districts of Tamil Nadu and Ganjam district of Odisha.

Upscaling tuber crops technologies for promoting food and nutritional security

Promotion of biofortified sweet potato in non-traditional areas

For assessing the performance of biofortified sweet potato varieties compared to local check in the production systems of Tamil Nadu and Kerala, 13 on-farm trials (Attapadi-8; Kallakurichi-5) involving five varieties (Bhu Sona, Kamalasundari, Sree Kanaka, Sree Bhadra and Kalinga) were conducted.

Nutriseed village model: Targeted nutritional interventions

For assessing the effectiveness of the nutriseed village scheme implemented through ICAR-CTCRI Agri-Business Incubator, an evaluation framework was developed. In the first phase, performance of various biofortified sweet potato varieties under OFTs are being tested. Forty farmers in Kallakurichi district of Tamil Nadu with an area of 1.5 acres and 24 farmers at Attapadi, Palakkad with an area of 0.65 acres were covered under nutriseed village model.

Identifying strategies for scaling up of biofortified sweet potato

The strategies for scaling up of biofortified sweet potato were identified through stakeholder Focus Group Discussion. Two Focus Group Discussions were conducted with 32 participants from different line departments of Tripura and responses were analyzed through thematic analysis. Two raters coded the responses and an inter-rater reliability of 76.60% was achieved. The summary of various intervention strategies identified are given in Table 11.

Sensory acceptability of cassava pasta by students

The sensory acceptability of cassava pasta was evaluated against commercial wheat pasta among 80 students of Kerala and Telangana. The independent sample t test results of the sensory acceptability are displayed in Table 12.

Results indicated that wheat pasta scored significantly higher for general appearance (M=7.04), colour (M=6.89) and texture (M=6.73), while cassava pasta for its aroma (M=6.06). Both pasta products had similar taste scores.

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

A study was conducted to find out the empowerment index of women involved in sweet potato cultivation. Using simple random sampling, 60 men and 60 women farmers from Ganjam district of Odisha, involved in sweet potato cultivation, were selected as respondents. The identified respondents were interviewed using a well developed interview schedule and the data collected were tabulated and analysed.

Table 11. Themes and strategies identified to scale-up biofortified varieties

Sl.No.	Themes	Strategies
1.	Targeted nutritional interventions	▪ Household nutritional security – Availability and accessibility ▪ Introducing biofortified tuber crops in kitchen gardens ▪ Growing of biofortified crops in anganwadis
2.	Healthy eating campaign	▪ Creating awareness among people about healthy eating
3.	Promoting integrated farming systems	▪ Designing farming systems by integrating the indigenous fruits and vegetables, livestock, poultry and ducks ▪ Promoting the integrated farming systems through frontline demonstrations
4.	Replacing local landraces of tuber crops with biofortified sweet potato and yam varieties	▪ Production and supply of quality planting materials of biofortified sweet potato and yam varieties to the farmers ▪ Development of grassroot level seed production centres
5.	Development of entrepreneurship for value-added products from tuber crops of biofortified varieties	▪ Promotion of value-added food products developed from biofortified tuber crops ▪ Capacity building of women on preparation and use of nutritious food products developed from biofortified tuber crops varieties

Table 12. Mean differences in the sensory attributes of cassava and wheat pasta

Sl. No.	Sensory attributes	Mean acceptability scores		Mean difference	t
		Cassava pasta	Wheat pasta		
1.	General appearance	5.09	7.04	-1.95	-8.179**
2.	Colour	5.61	6.89	-1.95	-5.804**
3.	Texture	5.35	6.73	-1.28	-5.858**
4.	Aroma	6.06	5.31	-1.28	2.856**
5.	Taste	6.10	5.61	-1.38	1.937^{NS}

**p<0.01; NS-Not significant

Socio-economic profile of the respondents

An analysis of the age of the respondents revealed that the mean age of men was 53.48 years and women were 45.65 years. Majority of the women (58.33%) and 41.67% of men were literates. Only 1.67% of both men and women had under graduate education. All the women had agriculture as their main occupation and only 3.33% had allied activities along with agriculture. Fifty one percent had nuclear family and this clearly indicates that joint family system is declining even in rural areas. Majority (65%) had 4-6 members in their family. The mean farm experience of men was 34.41 years and women was 26.98 years. The mean farm size of the respondents was 2.56 acres and only 3.33% had large farms (5 to 10 acres). The mean area in which sweet potato was cultivated by women was 0.90 acres, but it supported their economic standing. Only 33.33% of women possessed livestock. Majority of the women had limited access to credit facilities as they were living in remote villages. The aspirations of women were medium (63.33%) and women with high aspiration were very less (20%) (Fig. 97). Majority of

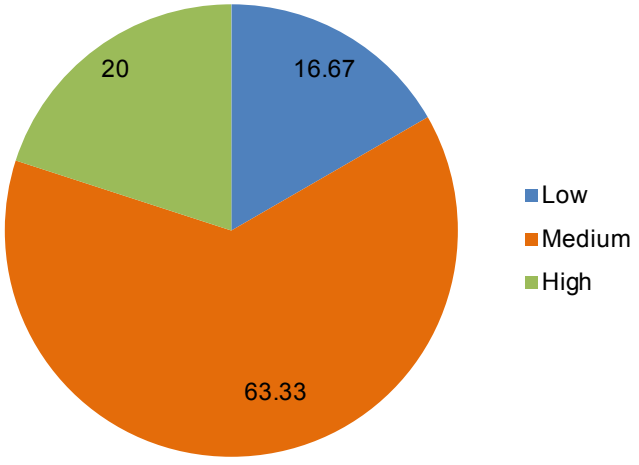


Fig. 97. Aspiration of women respondents in sweet potato cultivation

women (75%) had medium level of innovativeness and only 15% had high innovativeness. It was interesting to note that the mean innovativeness of women was higher (2.03) than men (1.87) (Fig. 98).

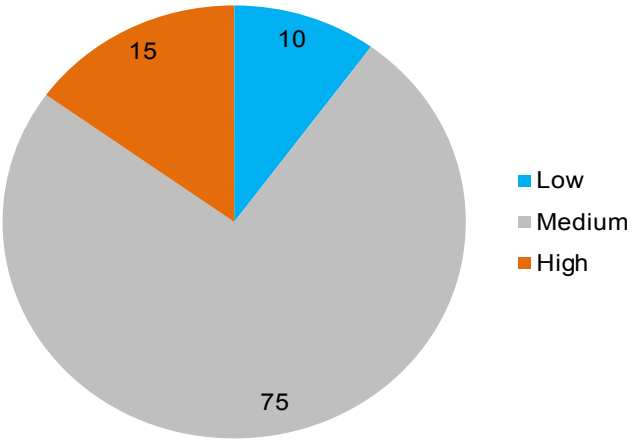


Fig. 98. Innovativeness of women respondents in sweet potato cultivation

Participation of men and women in sweet potato cultivation

The extent of participation of men and women was worked out using mean and standard deviation and they were categorised into low, medium and high level of participation. The participation level of women in sweet potato cultivation was medium for 71.67% and it was high only for 15% of women (Fig. 99).

In the selection and planting of vine cuttings, the participation of women was more (2.25 mean score), whereas the participation by men was 1.82%. The participation of men and women were similar in storage of planting materials, harvesting and value addition. The chi square test revealed that significant difference was observed in land preparation (51.15), selection of variety (18.54), application of inputs (14.75) and identification of pests (13.59) and diseases (13.34).

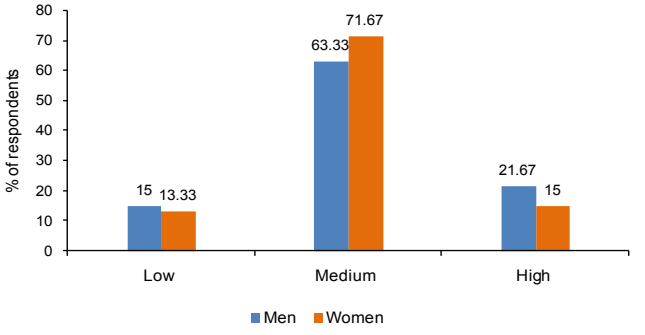


Fig. 99. Level of participation of respondents in sweet potato cultivation

Empowerment index

The women empowerment index in sweet potato (WEISP) includes five domains viz., 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.

Regarding women empowerment indicators, significant difference was observed in areas of input in productive decisions (mean score of 2.78 for men and 2.05 for women), autonomy in production (men 2.60; women 1.78), ownership of assets (men 2.78; women 1.32), access to and decisions on credit (men 2.18; women 1.68), control over use of income (men 2.33; women 1.88) and group membership (men 1.70; women 1.55) (Fig. 100). The overall empowerment index was 0.76 for men and 0.57 for women. Women empowerment was low when compared to men.

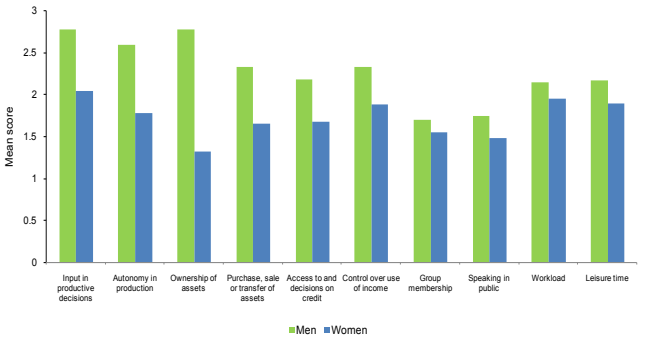


Fig. 100. Empowerment indicators of respondents in sweet potato cultivation

Needs and preferences of farm women in sweet potato cultivation

The analysis on needs of women revealed that the first rank was given to more demonstrations on improved varieties/technologies (2.67), followed by trainings (2.52) and availability of quality planting materials (2.46) (Fig. 101). They preferred high yielding varieties (mean score 2.90), followed by good keeping quality (2.60), good size and shape (2.52) and pest and disease resistant varieties (1.95) (Fig. 102).

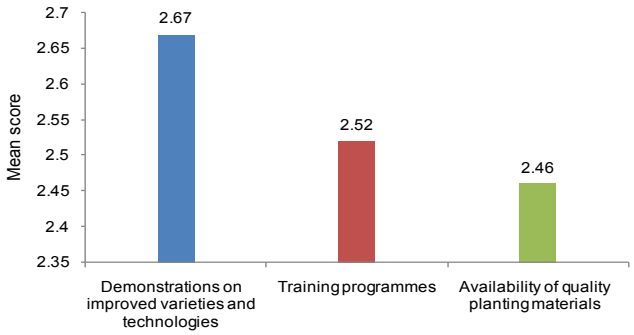


Fig. 101. Needs of farm women in sweet potato cultivation

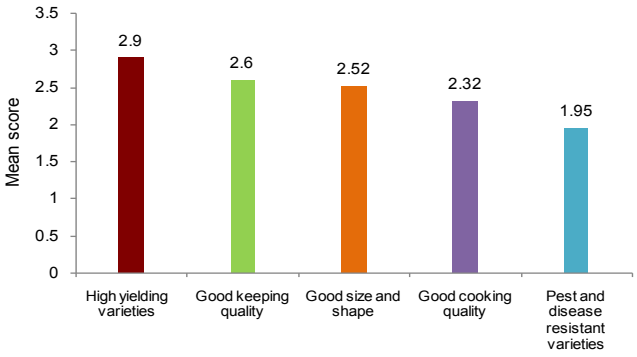


Fig. 102. Preferences of farm women in sweet potato cultivation

Opportunities in sweet potato cultivation

The opportunities in sweet potato cultivation perceived by the women respondents were yield enhancement by adoption of improved varieties (2.68), suitability for including in cropping systems (2.38) and short-duration and women-friendly crop (2.30) (Fig. 103).

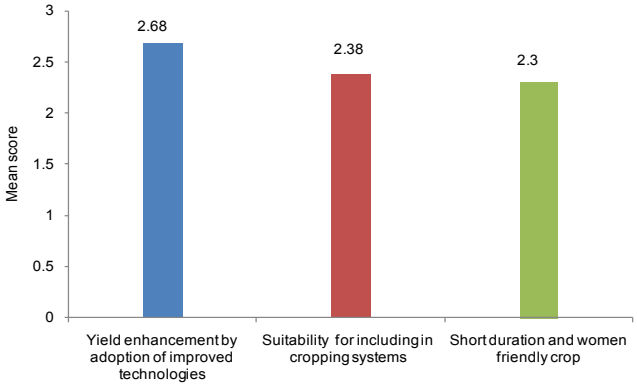


Fig. 103. Opportunities in sweet potato cultivation as perceived by farm women

Constraints in sweet potato cultivation

Major constraints as reported by women were price fluctuation (2.75), less access to training (2.45), non

availability of quality planting materials (2.40), lack of marketing facilities (2.38), attack by wild animals (2.33) and lack of knowledge and access to crop loans and subsidies (2.32) (Fig. 104).

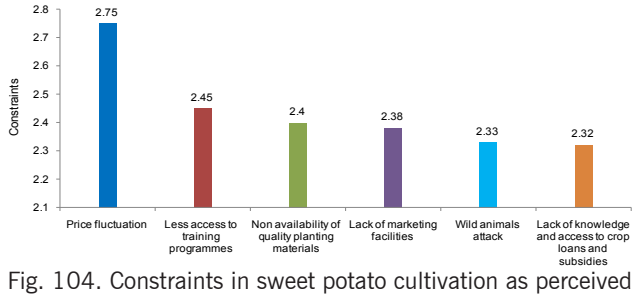


Fig. 104. Constraints in sweet potato cultivation as perceived by farm women

Impact assessment of technologies of tropical tuber crops

Impact assessment on improved variety and technologies of Chinese potato was conducted among 200 farmers in Tenkasi and Tirunelveli districts of Tamil Nadu. These districts were purposefully selected for field interventions involving improved variety and technologies as these districts have over 50% of the area under Chinese potato cultivation. Multistage random sampling method was used for selecting the blocks, villages, and farmers. In each district, two blocks were selected. From each block, two clusters comprising 2 to 3 villages were selected based on the area of Chinese potato cultivation. From each selected cluster of villages, 25 households were randomly selected for the survey. Thus, the survey included 200 households consisting of 124 farmers, who adopted local varieties and 76 farmers, who adopted improved variety from eight clusters of villages (~20 villages) in two districts of Tamil Nadu. A logistic regression model was used to identify factors determining adoption of Sree Dhara and the Inverse Probability Weighted Regression Adjustment (IPWRA) method was used to estimate the impact of adoption of Sree Dhara on yield and income and these were estimated using STATA Software V. 15.1.

Chinese potato cultivation

Chinese potato is cultivated in Tenkasi and Tirunelveli districts of Tamil Nadu as an irrigated and also rainfed crop. About 38% of the area in these districts are under Sree Dhara and 62% under local varieties. Chinese potato is a commercial crop in Tamil Nadu. Generally farmers kept minimum quantity of tubers for consumption and seed purposes, and the rest was marketed.

Economic benefits of Chinese potato

The total cost for cultivating Chinese potato between adopters and non-adopters varied and Sree Dhara variety incurred ₹ 1,89,000 ha^{-1}, whereas it was ₹ 1,77,000 ha^{-1} for local varieties. Sree Dhara variety yielded 25% more than the local varieties. The net return from Sree Dhara was 87% higher than the local varieties and the unit cost of production declined by 15% (Fig. 105). Tubers of Sree Dhara fetched 10% higher price than local varieties. Adoption of Sree Dhara variety generated 11.28% more employment due to increased yield, which needs more labour for harvesting, grading and packaging.

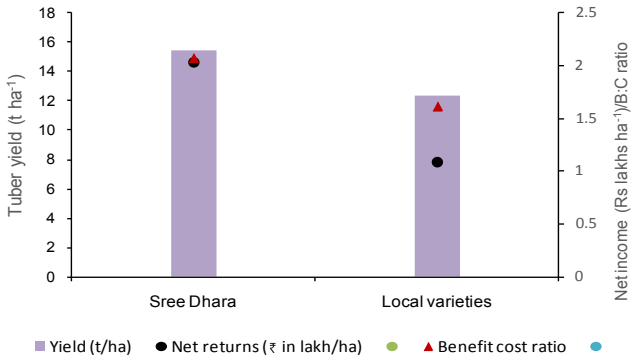


Fig. 105. Economic benefits of adoption of Sree Dhara over local varieties

Social impact of Chinese potato variety

Social impact of Chinese potato cultivation revealed that higher income had enabled Chinese potato producers not only to spend more on agriculture (55%), but also spending for basic necessities like education (12%) and health (10%).

Impact of adoption of Sree Dhara on yield and income

The IPWRA results (Table 13) showed that both Chinese potato yield and income were significantly higher for adopters than the non-adopters. Chinese potato yield

was higher by 2.97 t ha^{-1} and income by ₹ 78,600 ha^{-1} for adopters as compared to non-adopters, indicating that adoption of Sree Dhara increased yield by 23.65% and income by 24.69%.

Table 13. IPWRA estimates on the impact of the adoption of Sree Dhara on yield and income

Outcome variable	Mean value of outcome variables		ATET
	Adopters	Non-adopters	
Yield (t ha^{-1})	15.53	12.56	2.975*** (1.187)
Income (₹ lakh ha^{-1})	3.99	3.20	0.786*** (0.342)

ATET = Average treatment effect of the treated; Figures in parentheses are standard error; *** denote significance at 1% level

Determinants for the adoption of improved variety

Adoption of improved variety was affected by several factors, which were identified through binary logit regression (Table 14).

Factors such as years of education, farm income, access to extension services, and block dummies were significant factors for the adoption of improved variety. All other variables included in the model were non-significant. The analysis of marginal effects showed that the probability of adopting Sree Dhara increases by 2.5% for each year of increase in formal schooling. The estimated marginal effects of farm income suggests that a one percent increase in farm income will increase the likelihood of adopting Sree Dhara by 42.50%. The estimated marginal effects of the dummy variable showed that the accessibility to extension services increases the probability of adoption by 11.80%. Block dummies were significant, which suggested that the adoption decision was influenced by soil types, rainfall and cropping pattern.

Farmer's perception on improved variety of Chinese potato

All sampled farmers (100%) indicated that the Chinese potato var. Sree Dhara offer many advantages over local

Table 14. Logit model explaining factors affecting adoption of Chinese potato var. Sree Dhara

Variables	Estimates of the binary logit model		Marginal effects	
	Coefficients	Z	(dy/dx)	Z
Dependent variable: (1: if farmer adopted the improved variety, 0: otherwise)				
Age (year)	0.001	0.07	0.000	0.07
Education (year)	0.142***	2.68	0.025***	2.85
Family size (number of people)	0.012	0.12	0.002	0.12
Farm size (ha)	-0.076	-0.55	-0.013	-0.55
Access to extension service (1/0)	0.675*	1.84	0.118*	1.90
Ln_farm income (₹ lakh ha^{-1})	2.432***	4.69	0.425***	5.94
Block dummies				
Block 2 (1=Pappakudi, 0=otherwise)	1.533***	2.12	0.270***	2.19
Block 3 (1=Ambasamudram, 0=otherwise)	0.962*	1.68	0.164*	1.79
Block 4 (1=Kadayam, 0=otherwise)	0.570	1.04	0.094	1.09
Constant	-33.399	-4.95		
LR chi^2(11)	56.970			
Pseudo R^2	0.215			
Prob> chi^2	0.000			
Observations (n)	200			

***and * denote significance at 1% and 10% respectively

varieties viz., higher tuber yield (69%), less incidence of nematode (58%), generates employment (53%), good shape and size (42%), early maturing (36%), fetches remunerative price (28%) and less tuber rotting during water stagnation (21%) (Fig. 106). About 26% of farmers

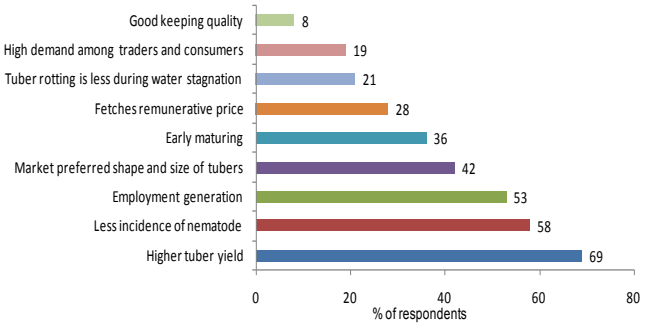


Fig. 106. Farmer's perception of improved variety of Chinese potato

reported that Sree Dhara variety had disadvantages when compared to local varieties because it was difficult to get seed tubers (23%). When non-adopters were asked, the reasons given were that they had never heard about the variety (55%), local varieties met their needs (31%) and there was no access to seeds/planting materials (14%).

Development of intelligent smart technologies for tropical tuber crops

Validation trial on smart farming using e-Crop was carried out for the second season with sweet potato. Field trial to validate the efficacy of e-Crop based smart fertigation device in sweet potato was carried out. Sweet potato var. Sree Bhadra was planted in the trial, in five replications with the three treatments comprising irrigation and fertilizer application viz., e-Crop based smart farming recommendation through drip fertigation (T_1), PoP recommendation of ICAR-CTCRI through drip fertigation (T_2) and PoP recommendation of ICAR-CTCRI by manual application (T_3). The results showed that T_1 was comparatively better than T_2 and T_3 because the yield was high with very low water consumption. Though the yield of T_2 and T_1 were on par, water productivity was very high with T_1, which was almost thrice that of T_2 (Fig. 107).

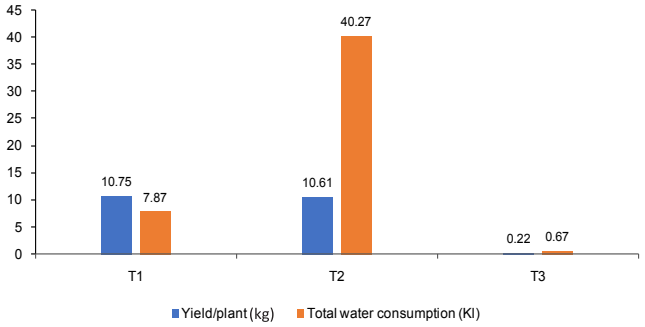


Fig. 107. Comparison of e-Crop based smart fertigation and normal fertigation in sweet potato

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

Bioinformatics analysis of whole genome data of cassava

A workflow for the analysis of whole genome sequence data of cassava was developed (Fig. 108). The main steps involved were quality control to assess the quality of the raw sequencing data of cassava samples, and filter out low-quality reads using FastQC, read pre-processing to perform read trimming, adapter removal, and read filtering using fastp or trimmomatic, alignment of the pre-processed reads to a reference genome from phytozome using BWA-MEM, sorting of bam files based on coordinates

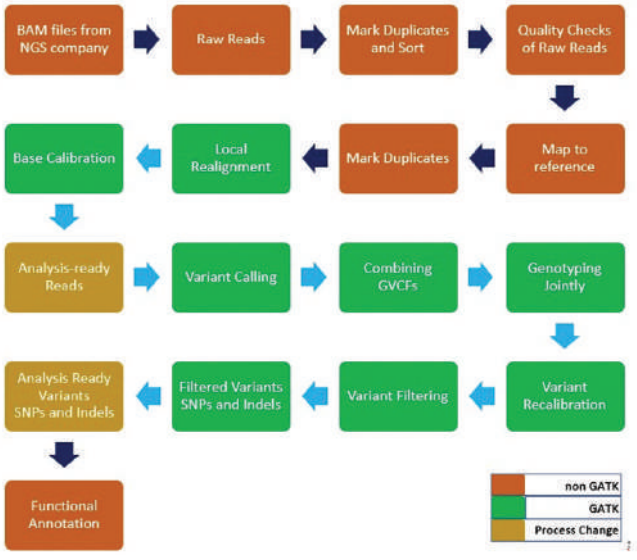


Fig. 108. Flow chart of the pipeline developed for the bioinformatics analysis of whole genome data of cassava

using Picard, removing PCR duplicates from the aligned reads using GATK4, recalibration of the base quality scores to improve the accuracy of variant calling using GATK4, variant calling (HaplotypeCaller) using the GATK HaplotypeCaller tool, recalibrate the variant quality scores to improve the accuracy of downstream analysis using GATK4 and filter out low-quality variants based on various criteria such as variant quality, depth of coverage, and allele frequency using GATK4. The final output of the pipeline is a VCF file containing the high-quality SNPs and INDELs identified from the input data. The workflow of the pipeline developed is shown in Fig. 108. This pipeline developed will enable researchers to accurately and rapidly identify, and annotate, sequence variants. Database generation and data integration with genomic and QTL information is in progress.

The type of variants predicted from the two samples 8S-501 and 9S-127 are shown in Fig. 109.

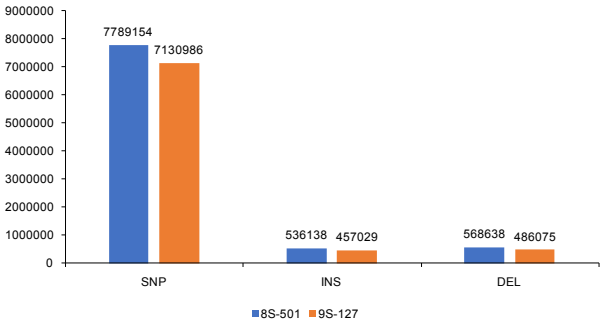


Fig. 109. Type of variants predicted

Developmental Projects

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

During the year 2022, 450 tribal farmers were adopted from Semiliguda, Koraput, Lamtaput blocks in Koraput district, G. Udayagiri block in Kandhamal district, Mohana block in Gajapati district, Sukinda block in Jajpur district and Kuliana block in Mayurbhanj district of Odisha. Planting material of 8000 kg of greater yam, 8500 kg of elephant foot yam, 7000 kg of taro, 150 kg of yam bean, 9,00,000 vine cuttings of sweet potato and 5000 stems of cassava were distributed to the tribal farmers. Vegetable kits (450 numbers) containing *Amaranthus*, okra, chilli, cowpea, French bean, tomato, palak and *Dolichos* seeds were distributed. Besides, four types of small tools (each 267 nos.) and chicks (3420 numbers) were distributed to the tribal farmers. For capacity building of the tribal farmers on tuber crops cultivation and value addition, eight on-farm trainings were organized. In tribal farmers field, sweet potato, yam bean, taro and elephant foot yam were harvested and the yield obtained was 13.60, 21.30, 12.80 and 23.50 t ha^{-1} respectively. Tuber day was celebrated on 22 March 2022 and Tuber crops harvest day was celebrated on 22 December 2022.

2. **ICAR-CTCRI-SCSP: Empowerment of tuber crops farmers through sustainable use of resources and tuber crops technologies** (ICAR, SCSP; Nodal Officer: G. Byju; 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 were selected from seven village/ panchayats of Parakode block of Pathanamthitta district of Kerala and Mangalur block of Cuddalore district of Tamil Nadu. A total of 124 farmers were identified to improve their livelihood through judicious use of resources and latest tuber crops technologies, including varieties.

A total of 140 field demonstrations were established to showcase the ICAR-CTCRI technologies, including latest varieties of tuber crops. A total of 11,000 cassava stems of Sree Reksha and Sree Pavithra and 25 tons

of elephant foot yam variety Gajendra were distributed to farmers. Customised fertilizers and micronutrient inputs like micronol were given to 70 farmers from Erath, Kodumon and Ezhamkulam panchayat during August-September 2022. In addition, inputs like neem cake, straight and water soluble fertilizers, gypsum, micronutrients, effective microorganisms solution, pusagel were purchased for distribution other than PP chemicals, farm tools like spade, pickaxe, battery type sprayer (15 litres) to 124 farmer beneficiaries and cassava slicer to the farmer groups representing the beneficiary villages. A total of 21 farmer stakeholders training program/farmer's interface cum meetings was conducted benefitting 1246 farmers. In addition, planting materials of greater yam (var. Sree Roopa), farm inputs, implements, sprayers etc. were distributed to the beneficiary SC farmers from villages at Mezhuveli, Pallichal, Kizhuvilam, Kilimanoor and Puliyoor panchayats in Kerala during March-October 2022 and at Pudukottai, Karur and Salem districts of Tamil Nadu during August 2022. A cassava harvest fest cum field day was organised at Munaiyanur, Karur district on 29 December 2022, highlighting the success story of SCSP programme and provided awareness to other farmers for adoption of cassava farming in these least explored areas through the use of latest varieties and other crop production technologies available at ICAR-CTCRI.

3. **ICAR-CTCRI NEH Programme: Scaling up of biofortified tuber crops through 'Rainbow diet approach' in the north eastern hill region** (Nodal Officer: Sheela Immanuel; PI: P. Sethuraman Sivakumar; Co-PIs: M. Nedunchezhiyan, K. Laxminarayana, V.B.S. Chauhan, R. Arutselvan, M.S. Sajeev, H. Kesava Kumar, T. Krishnakumar and P. Prakash)

Creation of new facility-Tuber crops information and agri-entrepreneurship facilitation centre, Tripura: A new collaborative facility 'Tuber crops information and agri-entrepreneurship facilitation centre' (TCIAEFC) was established in the Multi Technology Testing Centre (MTTC) and Vocational Training Centre (VTC), College of Fisheries, Central Agricultural University (CAU-Imphal), Lembucherra, Tripura, to facilitate entrepreneurship development in Tripura. This is serving as a Satellite Incubation Centre under the technical guidance of ICAR-CTCRI Agri-Business Incubator.

Technological intervention for maximizing yield of yams and elephant foot yam: Twenty homestead based FLDs (Yam var. Orissa Elite:10 nos. and Elephant foot yam var. Gajendra: 10 nos.) were conducted in Sepahijala district of Tripura to maximize farm income. Results revealed that yield of yam variety Orissa Elite (3.30 tha^{-1}) was higher than that of local variety (2.20 t ha^{-1}) and net income from Orissa Elite was ₹ 1,34,569 ha^{-1}, which was 72% higher than that of the local variety. The elephant foot yam var. Gajendra yielded 1.05 t ha^{-1}, which was higher than local check (0.72 t ha^{-1}) and provided a net income of ₹ 29,636 ha^{-1}, which was 37.21% higher than local check.

Scaling up of biofortified varieties: Under the biofortified sweet potato varieties scaling up programme, 17 seed entrepreneurs were created, 10 nutriseed gardens established and 655 farmers trained in production and processing technologies.

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)

Twenty one taro and 18 elephant foot yam lines were maintained in the field gene bank at Regional Station, Bhubaneswar, Odisha, as reference collection. Two lines were received for testing during 2022. The morphological characterization of all the reference varieties has been done based on pre-harvest characteristics viz., leaf shape, leaf colour, margin pattern, petiole colour and structure. Maintenance breeding was done to maintain the reference varieties.

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. Three 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)

DUS testing guidelines for both yam bean and greater yam have been notified in the Gazette of India and it is open for registration under all categories during 2022. Seven reference varieties of greater yam and 10 reference varieties of yam bean lines were maintained in the field gene bank at ICAR-CTCRI, Regional Station, Bhubaneswar. Seven greater yam lines were received from Andaman and Nicobar islands and morphological characterization has been done based on pre-harvest characteristics (leaf shape, leaf colour, margin pattern, petiole colour and structure). Maintenance breeding was done to maintain the reference varieties.

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 application for registration of two cassava varieties viz., *Pachikizhangu*

and *Manna* were prepared. The database of the reference/ released varieties of sweet potato was prepared based on DUS test guidelines. Farmers were sensitized to start registration of cassava and sweet potato varieties.

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)

In the field gene bank, 43 sweet potato and 17 cassava reference varieties were maintained at ICAR-CTCRI, Regional Station, Bhubaneswar. Pre-harvest morphological characterization of both cassava and sweet potato reference lines have been identified and documented based on DUS guidelines. Maintenance breeding was done to maintain the reference varieties.

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)

Twenty thousand hybrid seeds of controlled crosses from CIP, Peru,were received through NBPGR in 2018. Germination was carried out in a phased manner of about 4000 seeds each. Two hundred and fourteen hybrids were selected during 2022 for preliminary yield trial in augmented design along with Sree Kanaka and Bhu Sona as controls during rabi season. The storage root yield ranged from 14 g to 898 g plant^{-1}in the progeny. The highest starch content was recorded in 656/45 (20%). A total of 30 promising hybrids were selected from this batch. Of the last set of 4090 seeds germinated and planted, 119 hybrids were selected based on flesh colour and dry matter.

7. ICAR-Bioversity International & CIAT Alliance collaborative workplan 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, R. Muthuraj)

Five elite cassava varieties viz., Sree Reksha, Sree Sakthi, Sree Suvarna, PDP-CMR-1 and 85-501 with resistance to cassava mosaic disease caused by ICMV and SLCMV were established *in vitro* and multiplied through micro propagation. The *in vitro* plants were established for germplasm transfer. DNA isolation and multiplex PCR was done using SLCMV and ICMV specific primers and virus free cultures were established. DNA profile of 15 released varieties/popular landraces of cassava was completed using SSR markers. A field experiment was laid out at ICAR-CTCRI, Thiruvananthapuram during August 2022 to evaluate the drought tolerance and to work out the water footprint in cassava. Eight CMD resistant genotypes of cassava viz., Sree Reksha, Sree Sakthi, PDP-CMR-1, CTS-247, KBH-18, CTS-17(19S-6-4), 8S-501-2, and CTS-48 were included as main plot treatments in split plot design and two production systems viz., irrigated and rainfed systems as sub plots. Supplemental irrigation was provided by drip system @ 100% cumulative pan evaporation. Periodical growth observations and biomass partitioning are being recorded at bimonthly intervals. The leaf retention percentage was more or less similar in all the cassava genotypes under irrigated and rainfed conditions, except CTS-17(19S-6-4), which showed 27.50% more leaf retention under irrigated than rainfed condition.

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)

With the aim of facilitating exchange of germplasm, for initiating *in vitro* tuberization studies in sweet potato, explants were taken from both field and tuber sprouts. For the establishment of cultures, basal MS media with charcoal was used in full strength and half strength conditions along with different surface sterilizing agents, such as mercuric chloride, sodium hypochlorite and sodium

dichloroisocyanurate. For callus initiation, MS media with varying concentrations of NAA (0.01-0.5 mg l^{-1}) and BAP (0.5-5 mg l^{-1}) were used and nodes, petiole and leaves were used as explants. Different concentrations of sucrose (3, 6, 9, and 12%) in combination with NAA (0.01mg l^{-1}) were also tried with nodes as explants for inducing tuberization. Contamination rate was low when tuber sprout was used as explant source with a survival of 95.83% when compared to field explants. Fungal contamination was higher compared to bacterial. In callus initiation experiments, the callus initiated was non-embryogenic. With regard to tuberization initiation experiments, 3 and 6% sucrose concentration showed normal growth, while 9 and 12% showed drying due to high osmotic pressure. The sequence information of five genes related to photoperiodic tuberization in potato were downloaded and used as a query for the similarity search against sweet potato database. Similarity search revealed five genes coding for *cyclic dof factor 3-like* and *latex serine proteinase inhibitor*-like family genes. In order to screen for photosensitive tuberization, selected accessions of germplasms viz., Bhu Sona, H-526/7, Kanjangad local, Sree Kanaka and SD-11 were planted in polybags. Observations on vegetative characters and tuber characters were taken at 10 days interval. RNA was isolated at every 10 days interval and cDNA amplification along with PCR amplification for validation of designed primers is in process.

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: Kalidas Pati, K. Hanume Gowda and M. Nedunchezhiyan)

Development of *in vitro* plant regeneration protocol for elephant foot yam var. Gajendra: Surface sterilized buds of elephant foot yam were inoculated on Murashige and Skoog's (MS) (1962) basal medium supplemented with 8.0 mg l^{-1} 2,4-D and shoot buds were initiated after two months (Fig. 110). The initiated shoots were harvested and sub-cultured on MS medium supplemented with different concentrations of different growth regulators. Maximum numbers of shoots were proliferated on MS basal medium supplemented with mT 4.0 mg l^{-1} and GA3 2.0 mg l^{-1} after 2.5 months of culture. *In vitro* regenerated shoots were rooted on MS medium.

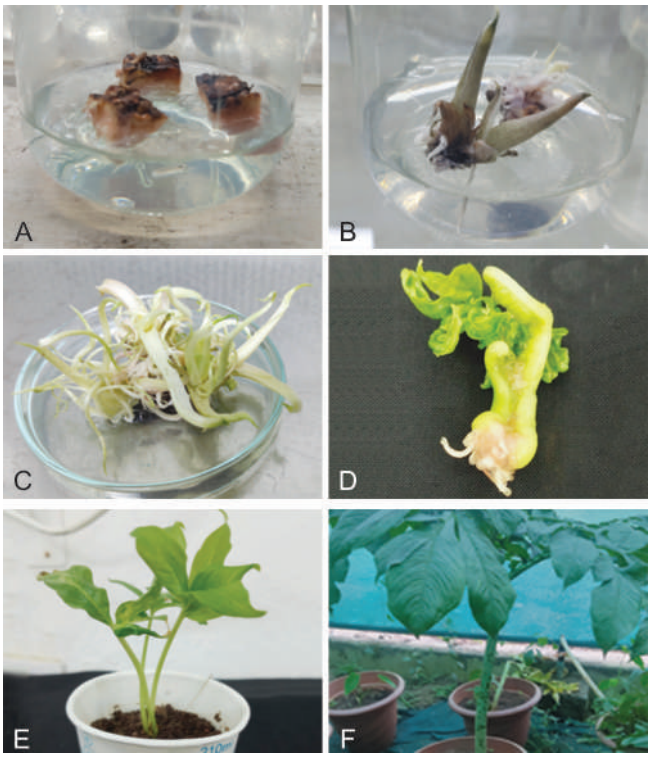


Fig. 110. A & B: Inoculation of elephant foot yam corm and shoot bud initiation after two months in MS medium supplemented with 8.0 mg l^{-1} 2,4-D; C: Multiple shoot proliferation and elongation on MS medium augmented with MS + 4.0 mg l^{-1}mT and 2.0 mg l^{-1} GA3; D: Rooting of regenerated plants on MS medium; E: Hardening in paper glass containing soil:sand:vermicompost (1:1:1); F: Established *in vitro* plants in green house

Quality planting material production: Tissue cultured disease free plants of sweet potato varieties, Bhu Krishna, Bhu Sona, Kishan, Gouri; taro variety, Muktakeshi; yam variety, Orissa elite; cassava variety, Sree Jaya and Chinese potato variety, Sree Dhara were maintained in net house and further planted in field for multiplication. Sweet potato *in vitro* produced plantlets, after hardening were planted in field for multiplication. Disease free planting material of sweet potato (5,00,000 vine cuttings), cassava (10,000 stem cuttings), yam (200 kg) and taro (200 kg) were produced in field nursery for distribution to the

farmers for cultivation. The first generation (G_1) tubers of sweet potato, yam, taro and Chinese potato were further multiplied for production of quality planting materials. The same time tissue culture plants of these crops were maintained in net house for multiplication in field for further distribution to the farmers.

Crop Production

10. 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 cassava varieties to organic production system, to develop integrated organic farming system involving tuber crops and to conduct geo-referenced on-farm characterization of organic growers. 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: Economic analysis of the system indicated that of the four systems evaluated, cassava-groundnut was the most remunerative in the sixth consecutive year. In cassava-groundnut, 25% organic + 25% inorganic + innovative practice and in cassava-vegetable cowpea system, 50% organic + innovative practice was profitable. On comparison, taro-based cropping systems were less remunerative than the cassava-based systems. In taro-green gram system, without premium price, 100% inorganic and with premium price, 100% organic was profitable. In taro-black gram system, state package of practices recommendation was profitable. In cassava-vegetable cowpea, 50% organic + innovative practice resulted in the highest tuber equivalent yield, equivalent energy and production efficiency. In cassava-groundnut, 25% organic + 25% inorganic + innovative practice and taro-green gram and taro-black gram systems, 100% organic resulted in the highest tuber equivalent yield, equivalent energy and production efficiency (Fig. 111).

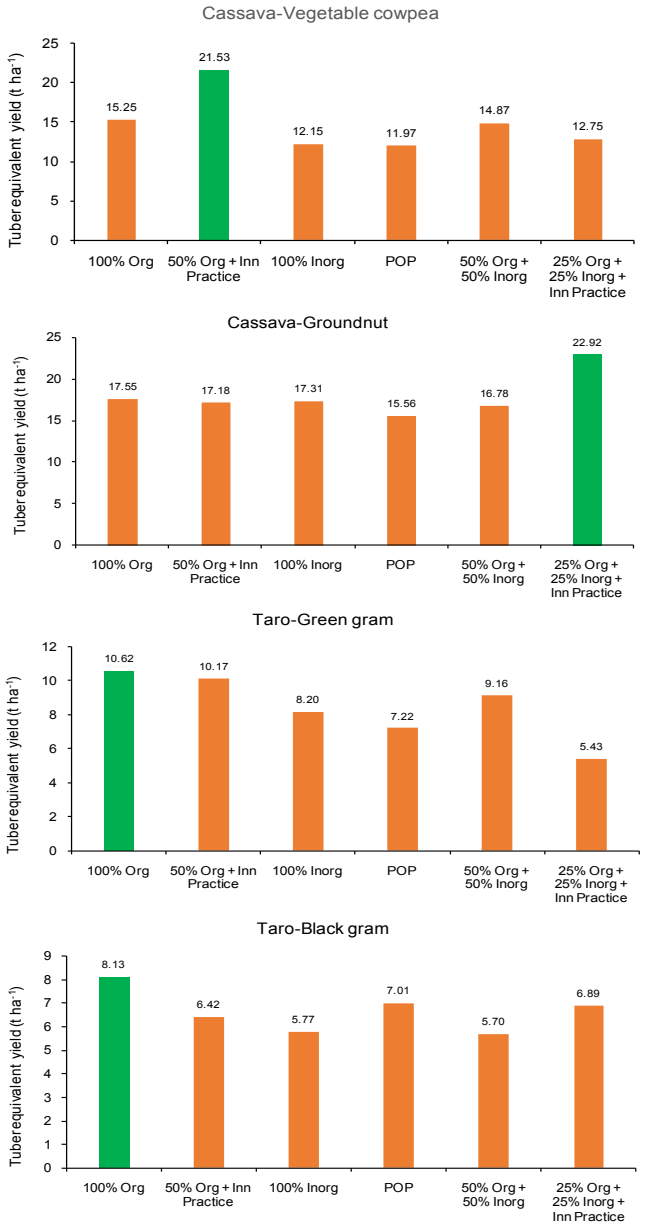


Fig. 111. Tuber equivalent yield obtained in different cropping systems under various management practices

Evaluation of response of different varieties of cassava to organic farming: In the sixth consecutive year, cassava variety Sree Reksha continued to produce significantly higher yield (20.51 t ha^{-1}). Sree Pavithra was the next best

performer (18.31 t ha^{-1}). Sree Reksha generated higher profit (₹ 583,305 ha^{-1}) and B:C ratio (3.46), followed by Sree Pavithra (₹ 4,95,215 ha^{-1} profit and 3.09 B:C ratio) under organic mode. Combined analysis over six years indicated that the varieties varied significantly under organic management. Sree Reksha yielded the highest (33.97 t ha^{-1}), followed by Sree Pavithra (24.32 t ha^{-1}) (Fig. 112).

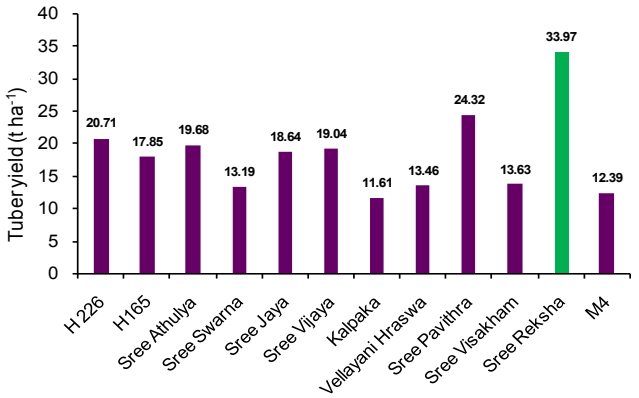


Fig. 112. Combined analysis of tuber yield of cassava varieties under organic management over six years; CD (0.05): 3.427

Geo-referenced on-farm characterization of organic growers: Geo-referenced survey of 30 farmers practising organic farming in Adoor block of Pathanamthitta district of Kerala was conducted.

Development of integrated organic farming system (IOFS) model: Net returns of ₹ 1,71,277 could be obtained from tuber crop-based farming system from an area of 75 cents. The marketable equivalent yield (MEY) from the system was 20.14 tons.

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 initiated as per the approved technical programme with nine treatments replicated thrice in RBD. The treatments were control (T_1), complete NF (application of *Bheejamrit*, *Ghanajeevamrit* and *Jeevamrit* (BGJ) + crop residue mulching (CR) + intercropping (IC) + whapasa) (T_2), NF-1 (without BGJ) (T_3), NF-2 (without CR) (T_4), NF-3 (without IC) (T_5), NF-4 (without whapasa) (T_6), AINPOF Package (T_7), Integrated crop management (ICM-1) (T_8) and ICM-2 (T_9). First season results indicated that the highest tuber yield of cassava was obtained under AINPOF package on par with ICM practices and NF-3 without intercropping and NF-4 without whapasa. The yield of the intercrop vegetable cowpea (bushy type) and green gram was the highest in complete NF. The highest tuber equivalent yield, production efficiency, lowest cost of cultivation and hence highest income was obtained in NF-4 without whapasa (Table 15). The experiment is

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

NF treatments		Yield (kg ha^{-1})				Production efficiency (kg ha^{-1} day^{-1})
		Cassava	Cowpea	Green gram	Tuber equivalent yield	
T_1	Control	29563	-	204.05	30787	85.52
T_2	Complete NF	32906	3036.14	328.07	47019	130.61
T_3	NF-1 (Without BGJ)	34442	2275.44	255.66	45077	125.21
T_4	NF-2 (Without CR)	34173	3019.30	311.27	48118	133.66
T_5	NF-3 (Without IC)	37459	-	324.07	39403	109.45
T_6	NF-4 (Without whapasa)	41405	2369.30	300.47	52685	146.35
T_7	AINPOF Package	46455	-	270.86	48081	133.56
T_8	Integrated-1	43666	-	288.87	45399	126.11
T_9	Integrated-2	45491	-	286.47	47210	131.14
	CD (0.05)	10231	-	NS	11478	31.882

BGJ: *Beejamrit, Ghanajeevamrit and Jeevamrit*; CR: Crop residue; IC: Intercropping

ongoing for the second season for conclusive results and confirmation.

11. 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 being implemented in Rayagada district (Rayagada, Muniguda and Bissamcuttack blocks) in collaboration with the Department of Horticulture and the NGOs, Centre for World Solidarity and Balasore Social Service Society. A total of 100 beneficiary farmers representing nine Gram Panchayats (GPs) of Rayagada, Muniguda and Bissamcuttack blocks of Rayagada district and 100 farmers from five GPs of Bangriposi and Kuliana blocks of Mayurbhanj district of Odisha have laid out demonstrations on cassava, sweet potato, yam bean, yam and elephant foot yam during 2022. Under the project, maize seeds, micronutrient fertilizers ($ZnSO_4$ and Borax) and pesticides (chlorpyriphos, imidacloprid and bavistin) were provided. This new initiative of tuber crops cultivation, especially biofortified sweet potato by the poor tribal farmers in non-traditional areas resulted in a realization of ₹ 2,000-30,000 on an average, per family. Infrastructure facilities comprising basic soil analytical instruments, laptop, digital camera, furniture have been created. Eight capacity building programmes were organized in different villages of both the districts during 2022.

Crop Protection

12. Radiation technology for quality improvement of tuber crops and management of its byproducts (Department of Atomic Energy, BARC; PI: C.A. Jayaprakas; Co-PIs: E.R. Harish, R. Saravanan, H. Kesava Kumar and B.G. Sangeetha)

Irradiation of planting materials of cassava and sweet potato against major pests: The planting materials of cassava (var. Sree Pavithra) and sweet potato (var. Sree Arun) were irradiated with gamma rays at the doses 10, 20, 30 and 50 Gy and were planted to study the sprouting inhibition and impact on pest population of cassava mealybug and sweet potato weevil. Sprouting was observed in cassava at 10 and 20 Gy, whereas 30 and 50 Gy were found to be lethal. But no sprout inhibition was observed in sweet potato in all the given doses; nevertheless, general vigour of the plants was affected when the cuttings were exposed to 50 Gy. In the case of sweet potato, the feeding mark of the plants due to the infestation by sweet potato weevil was comparatively less in 30 and 40 Gy than the control batch.

The effect of irradiation on nematodes was studied in elephant foot yam corms. Root-knot nematode, *Meloidogyne incognita* infected elephant foot yam corms were irradiated at five different doses viz., 500, 1000, 1500, 2000, and 2500 Gy at an irradiation centre at BARC, Trombay. Uninfected elephant foot yam corms were also irradiated as a control. But nematode mortality was not observed in any of the gamma-irradiated tubers including the highest radiation dose of 2500 Gy.

13. 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)

Sensitivity analysis of Recombinase Polymerase Amplification (RPA) for different concentrations of cDNA from elephant foot yam and sweet potato leaf samples having virus infection: A RPA analysis was performed for checking the sensitivity of the reaction for different concentrations of cDNA from elephant foot yam and sweet potato leaf samples. The cDNA concentrations ranging from 5 ng to 1 µg were used. Even though amplification was observed in all the cDNA concentrations, 50 ng and 100 ng were ideal for performing RPA for RNA viruses (DsMV& SPFMV) (Fig. 113).

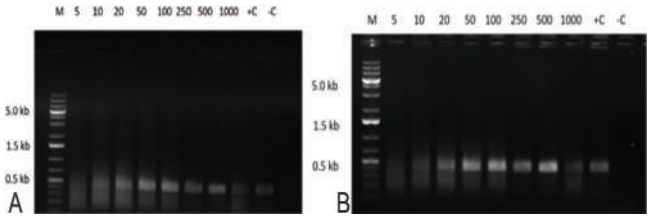


Fig. 113. Sensitivity analysis of RPA for A: Elephant foot yam sample infected with DsMV; B: Sweet potato sample infected with SPFMV

Validation of dipstick for detecting *Sweet potato feathery mottle virus* (SPFMV) infections in field infected samples: Sweet potato samples showing SPFMV symptoms were collected from different fields. The presence of SPFMV in these samples was tested by using dipsticks coated with SPFMV-IgG. Test line and control lines were lighted up in all samples infected with SPFMV and the negative control showed only the control line, and thus proved its efficacy in detecting SPFMV infection. The test was done for different dilutions of sap extracted from sweet potato plants infected with SPFMV. Dilutions ranging from 50 to 200% were used and it was found that the dipstick can detect the presence of virus even in the sap dilution of 200% (Fig. 114).

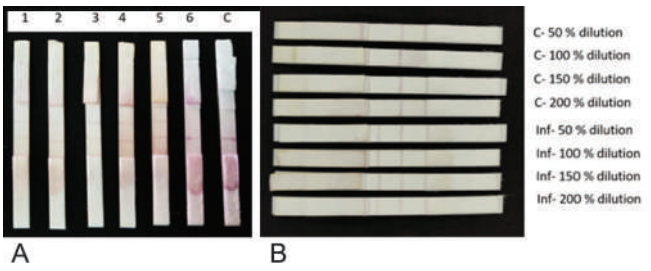


Fig. 114. Validation and sensitivity analysis of SPFMV dipstick for detection of SPMV infection in sweet potato; A: Dipsticks prepared using SPFMV-IgG has detected SPFMV infection in field samples; B: Sensitivity analysis of dipsticks for detecting SPFMV in infected sweet potato leaf samples using different sap concentrations ranging from 50 -200%

Standardisation of ELISA to detect *Sri Lankan cassava mosaic virus* with CTCRI-raised SLCMV-IgG: Cassava leaf samples exhibiting typical cassava mosaic virus symptoms were collected from fields around CTCRI. The ELISA with antibody raised against coat protein of SLCMV was performed. Leaf samples were ground in extraction buffer and a direct antigen coating ELISA (DAC ELISA) with antibody concentration of 1:5000, 1:7000 and 1:10000 were performed. Different extraction buffers were also used. Antibody concentration of 1:5000 was ideal for the ELISA. The experiment was repeated four times and it gave consistent results.

14. 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)

The PHC was established at Regional Station, Bhubaneswar in 2022, to provide quick and reliable diagnostic (serological and molecular) facilities for plant diseases in tropical tuber crops and identification of resistant sources against major fungal, bacterial and viral diseases. The main objective is to utilize the application of diagnostics for production of disease free quality planting materials, exploitation of natural products in plant health management and to develop high quality manpower at post-graduate level. Different types of pathological equipments are available at the clinic for quick and reliable detection/identification as a pre-requisite for appropriate control measure. Moreover, four M.Sc. (Applied Microbiology) students from Utkal University, Bhubaneswar, were trained and their research dissertation were completed in PHC, Regional Station, Odisha.

Crop Utilization

15. 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)

Sweet potato cultivars with different flesh colours (white-yellow, cream, light orange, deep orange, and purple) were screened for total soluble phenolic (TSP) content, total antioxidant activity, anti-hyperglycemic function relevant α-amylase inhibitory activities using rapid *in vitro* assay models. Among the different cultivars, the purple-fleshed cultivar, Bhu Krishna had significantly

higher phenolic-linked antioxidant activity (phenolic content of 1.18 mg g^{-1} FW and 65 and 95% DPPH and ABTS based antioxidant activity respectively), followed by Bhu Sona, CO 3-4, Kishan, Sankar, Sree Arun and Kanjangad. In addition, high to moderate α-amylase enzyme inhibitory activities (54.42 to 24.84%) were observed among different sweet potato cultivars in the study. The results of this initial *in vitro* screening study suggest that selection of sweet potato cultivars such as Bhu Krishna, Bhu Sona, CO 3-4, Kishan, Sankar, and Sree Arun are ideal for further heat stress and wound stress experiments to enhance the phenolic-linked antioxidant protective system in biofortified sweet potatoes.

16. 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 objective of the study is to prepare the standard operating procedure (SOP) and hazard analysis and critical control points (HACCP) for good manufacturing practices for producing tapioca starch and sago free from harmful chemicals. A survey has been taken up in six starch factories in Salem and Namakkal districts of Tamil Nadu to review the currently existing starch and sago manufacturing processes and to collect relevant data based on a questionnaire prepared. Experimental trials have been initiated as per the approved technical programme.

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

A prototype of continuous type cassava peeler developed for small scale processing has been modified by changing the feeding and peeling mechanisms. The peeling and flesh loss efficiency of the modified prototype were 96 and 2.54%, respectively, compared to the peeling and flesh loss efficiency of 68.68 and 24.21% to the earlier prototype developed. The modified continuous type cassava peeler can peel the cassava tubers of diameter ranging from 35 mm to 110 mm. The capacity of the modified continuous type cassava peeler ranged from 200 to 250 kg h^{-1}.

Extension and Social Sciences

18. 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)

Technology commercialization

Two technologies were licensed to three agencies viz., Govt cooperative federation, Cooperative society and a startup. A total of ₹ 60,000 was generated through technology licensing, with ₹ 50,000 from cassava fried snack foods and ₹ 10,000 for contract manufacturing of Chinese potato grader.

IP Portfolio management

Two technology disclosure meetings were organized and a new patent application for power operated size based Chinese potato grader (Patent Application No: 202241043900) was filed.

Technology exposure for startups

Three technology exposure trainings were organized for startups and NABARD officials. A total of 92 startups and 25 NABARD officials were benefitted from these programmes. As a follow up of these events, two business linkages were facilitated for startups for export of cassava tubers (wax coated and frozen) and six technology related queries were addressed by ITMU.

19. 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, R. Saravanan, R. Muthuraj, A.V.V. Koundinya, P. Prakash and T. Krishnakumar)

Incubatee enrolment

The ICAR-CTCRI Agri-Business Incubator has established a TANUVAS-ICAR-CTCRI ABI Satellite Incubation

Centre at KVK, TANUVAS, Kallakurichi and identified a cooperating centre RARS, KAU, Pattambi, Palakkad and launched four new programmes for scaling up ICAR-CTCRI varieties for entrepreneurship development. They include (i) Nutriseed villages for producing quality seeds/ planting materials of biofortified varieties (ii) School connect programme for creating student entrepreneurs (iii) Industry connect programme for scaling up industry-focused cassava varieties and (iv) Farmer innovator scheme for validating and commercializing local innovations. The enrolment status of incubatees in these schemes is given in Table 16.

Table 16. Enrolment of incubatees under different schemes of ICAR-CTCRI ABI

Sl. No.	Schemes	No. of incubatees enrolled
1.	Nutriseed village scheme for farmers	37
2.	School connect programme for students	05
3.	Industry connect programme for farmers	27
4.	Farmer innovator scheme	05
5.	Incubation programme for startups	02
	Total	**76**

Incubation services provided

The ICAR-CTCRI ABI has provided need-based mentoring services to incubatees as well as startups who got license for ICAR-CTCRI technologies. A total of 23 requests for new tuber crops technology and incubation services were received from entrepreneurs and the topic-wise details are displayed in Fig. 115.

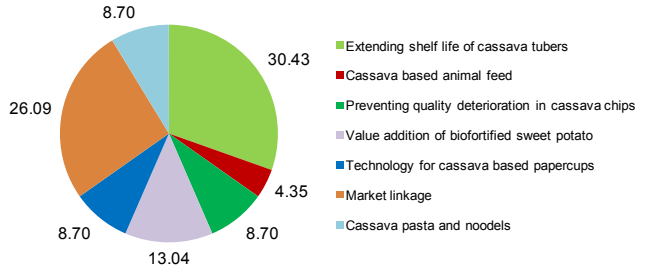


Fig. 115. Topic wise new technology and incubation service requests received from entrepreneurs

Based on requests received, the mentoring services like information provision, market linkage and technology support were provided to 89 entrepreneurs during 2022 (Fig. 116).

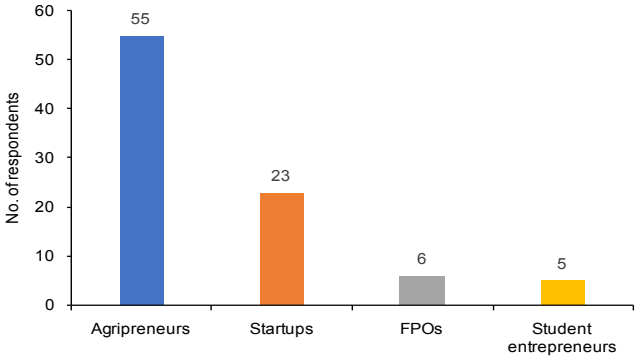


Fig. 116. Mentoring services offered to entrepreneurs

Seven training programmes were organised to build capacities of the agripreneurs, MSME and startups on improved tuber crops technologies. A total of 539 entrepreneurs (Startups-92; Agripreneurs-272; FPO-10 and students-165) participated in these programmes.

Performance of incubated entrepreneurs

During 2022, a new product-arrowroot ladoo was developed through the incubation programme. The incubated agripreneurs created three new jobs by using ICAR-CTCRI technologies and also generated revenue of ₹ 70,000 through sale of these products. Two startups created eight jobs and earned a revenue of ₹ 3,50,000 by selling tuber crops based products (Fig. 117).

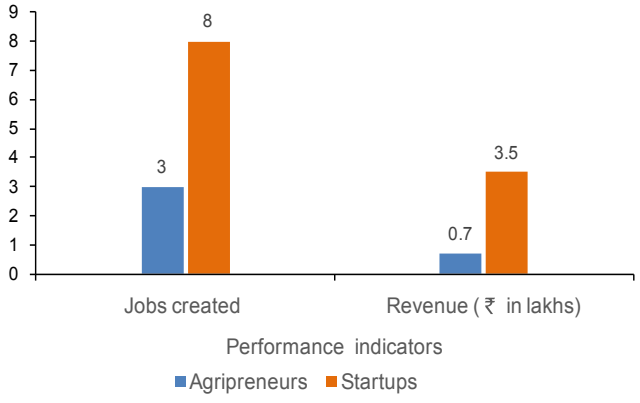


Fig. 117. Performance indicators of incubated entrepreneurs

20. Development of smart solutions for managing biotic and abiotic stresses in important tropical tuber crops through artificial intelligence

(DST-agrotech; PI: V.S. Santhosh Mithra; Co-PIs: G. Byju, T. Makeshkumar, M.S. Sajeev and E.R. Harish)

Images of leaves were collected at different time intervals from cassava, sweet potato and taro fields of Kerala and Odisha (Table 17). These images were grouped separately based on soil nutrient factors, soil moisture, soil types and pest and disease occurrence. Convolution neural network (CNN) model, which is a deep learning technology, is being developed to classify these images as per the required features. Soils collected from these fields were analyzed to identify the features for classifying these images (Table 18).

Table 17. Data on leaf images collected from fields for developing AI solutions

Sl. No.	Crop	Number of fields visited	No. of images collected
1.	Cassava	29	17202
2.	Sweet potato	20	47018
3.	Taro	36	52185

Table 18. Results of analysis of soils from fields for developing AI solutions

Particulars	Kerala	Odisha
No. of samples	49.00	98.00
Soil pH	4.59	5.06
Organic carbon (%)	1.27	0.64
Electrical conductivity (dS m^{-1})	0.26	0.69
Avail. N (kg ha^{-1})	220.80	277.23
Avail. P (kg ha^{-1})	136.50	43.45
Avail. K (kg ha^{-1})	278.44	312.50
Exch. Ca (cmol kg^{-1})	11.09	9.09
Avail. S (ppm)	23.90	0.00
Exch. Mg (cmol kg^{-1})	2.70	4.10
Avail. Fe (ppm)	38.78	67.62
Avail. Zn (ppm)	7.04	3.72
Avail. Cu (ppm)	4.01	66.51
Avail. B (ppm)	1.83	1.45

21. Improving rural agrosystem through horticultural crops based smart-farming technologies

(State Horticulture Mission, Govt. of Kerala; PI: V.S. Santhosh Mithra; Co-PIs: G. Byju, J. Sreekumar and D. Jaganathan)

Electronic crop (e-Crop), the IoT device developed by ICAR-CTCRI was installed at Krishi Bhavans of the selected panchayats. The soil samples were collected from selected farmers' fields of panchayats and analyzed for macro and micronutrients. These data were uploaded to the e-Crop Based Smart Farming (EBSF) system and the system generated the advisories accordingly. The project team ensured that the farmers regularly follow the advisories from the device at 10 days interval. The harvest of the crop was done during October 2022. The tuber yield obtained under sweet potato was 218% higher than traditional farming (TF) practices. This increase in yield was obtained at a reduced input application. Nitrogen, phosphorus and potassium fertilizers were applied at 49, 73 and 57% of the dosages in TF respectively (Fig. 118). Similarly for cassava, elephant foot yam and banana smart farming (SF) yields were 187, 218 and 152 percent over the corresponding TF yields respectively (Fig. 119). Implementation of EBSF system in the fields are expected to benefit the farmers by more automation as well as increased yield at reduced input application. The results of the analysis of soils from farmers' fields of Nedumangad block is given in Table 19.

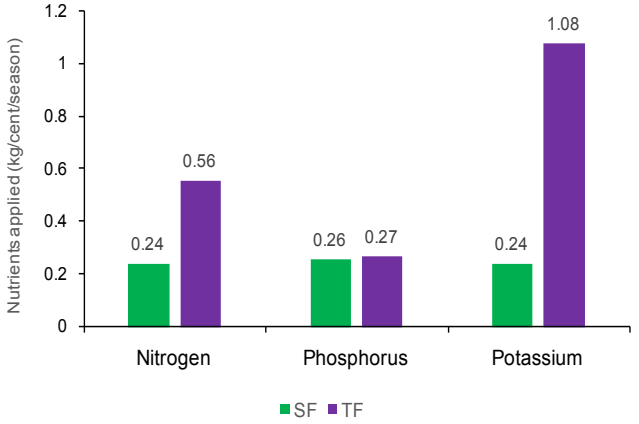


Fig. 118. Comparison of nutrients applied for smart farming (SF) and traditional farming (TF) of sweet potato

Table 19. Results of the analysis of soils from farmers' fields of Nedumangad block (n=29)

Soil pH	Organic C (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Exch. Ca (cmol kg^{-1})	Avail. Fe (ppm)	Avail. Mn (ppm)	Avail. Cu (ppm)
4.94	1.74	275.72	132.89	222.58	2.58	17.33	8.44	2.86

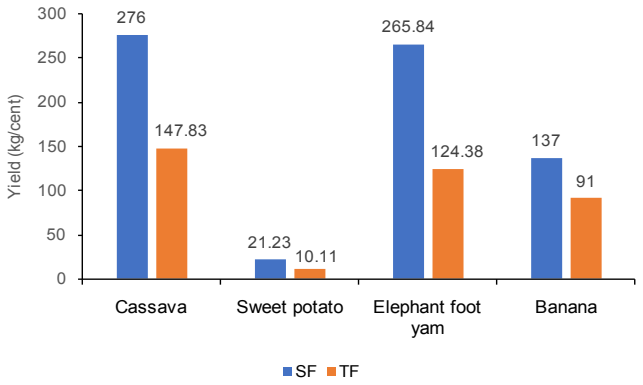


Fig. 119. Comparison of yield under smart farming (SF) and traditional farming (TF)

22. Smart cassava farms: Validation and upscaling of AI and an IOT device (Kerala State Planning Board, Govt. of Kerala; PI: V.S. Santhosh Mithra; Co-PIs: G. Byju, J. Sreekumar and D. Jaganathan)

Cassava and intercrops were planted in farmers' fields at Koottilangadi and Wandoor in Malappuram district. Planting was done at 15 days interval. Recommendations on nutrient and water management were given at 10 days intervals by the e-Crop installed in these panchayats. Images of fields were collected daily by CCTV. Data on soil nutrients and moisture were collected at regular intervals, whenever leaf images were taken using drones and crop canopy images were collected using drone at regular intervals. Soil samples from experimental fields were analysed before the experiment (Table 20). Daily weather data were collected by e-Crop.

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

On-farm validation of Site-Specific Nutrient Management (SSNM) involving customized fertilizers and micronol and organic farming technologies were initiated in 10 coconut gardens of 50 cents each in cassava and elephant foot yam in Pollachi taluk, Coimbatore, Tamil Nadu. Data on socio-economic background, available resources, farming details, farming practices, knowledge on coconut and tuber crops farming, constraints in farming etc. were collected in detail with the active participation of the farmers. Soil samples were collected from all the selected coconut gardens and the chemical properties were analysed for SSNM and organic farming demonstrations (Table 21 & 22).

Demonstrations on SSNM and organic farming are being carried out as per the soil test-based recommendations. Farmers were supplied with elite and quality planting materials of improved varieties of tuber crops, cassava var. Sree Pavithra and elephant foot yam var. Gajendra for planting in coconut gardens as per the recommendations. Ten on-farm demonstrations (3 SSNM in cassava, 3 organic farming in cassava, 2 SSNM in elephant foot yam and 2 organic farming in elephant foot yam) were established.

Table 20. Soil nutrient status of farmers' fields at Kootilangadi and Wandoor before planting

Panchayat	Moisture (%)	Soil pH	Organic C (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Avail. S (ppm)	Avail. B (ppm)
Kootilangadi	38.50	5.69	0.74	192.86	40.51	480.03	24.49	1.48
Wandoor	23.22	4.43	0.45	123.87	16.18	222.88	24.03	0.84

Table 21. Soil nutrient status of coconut farmers' fields for SSNM demonstrations (n=5)

Soil pH	Organic C (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Ex. Ca (c mol kg^{-1})	Ex. Mg (c mol kg^{-1})	Avail. S (ppm)	Avail. Fe (ppm)	Avail. Zn (ppm)	Avail. Cu (ppm)	Avail. B (ppm)
7.06	0.55	111.96	54.05	304.73	8.64	1.45	3.88	37.71	7.40	2.30	3.11

Table 22. Soil nutrient status of coconut farmers' fields for organic farming demonstrations (n=5)

Soil pH	Organic C (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})	Ex. Ca (c mol kg^{-1})	Ex. Mg (c mol kg^{-1})	Avail. S (ppm)	Avail. Fe (ppm)	Avail. Zn (ppm)	Avail. Cu (ppm)	Avail. B (ppm)
7.19	0.67	123.72	69.89	315.57	9.71	1.62	5.35	37.02	16.05	3.06	2.42

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

The AICRP on Tuber Crops, is the national network of tropical root and tuber crops covering 18 states and one union territory with 21 centres, affiliated to 12 State Agricultural Universities, three ICAR Institutes and two Central Agricultural Universities. The details are given in Fig. 120.

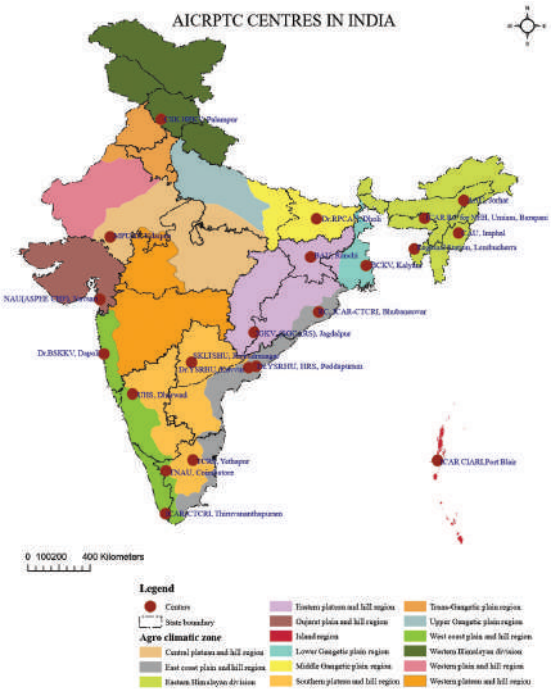


Fig. 120. Map of AICRP TC

Varieties recommended for release

Two varieties of Tannia (*Xanthosoma sagittifolium* (L.) Schott.) and three varieties of stolon taro (*Colocasia esculenta* var. *stoloniferum* (L.) Schott.) were recommended for release in different states due to higher economic yield.

Tannia

IGSGTN-1 (TTn14-1): Tannia from IGKV, Jagdalpur centre, with more than 30% tuber yield compared to check variety was recommended for central release, for the states of Chhattisgarh, Manipur and Kerala (Fig. 121)

Fig. 121. IGSGTN-1 (TTn14-1)

XaMTS Local (TTn14-5): Tannia from ICAR-CTCRI, Thiruvananthapuram, which performed second at the national level and highest in Kerala was recommended for state release in Kerala (Fig. 122).

Fig. 122. XaMTS Local (TTn14-5)

Taro

CAUST-2: A stolon taro, which produced the maximum caudex yield in Manipur was recommended for state release in Manipur (Fig. 123).

BCST 14: A stolon taro, which was found to produce the maximum stolon yield and caudex yield was recommended for central release for the states of West Bengal, Assam and Manipur (Fig. 124).

AAUST-2: Stolon taro, which produced the maximum caudex yield in Assam was recommended for state release in Assam (Fig. 125).

Fig. 123. CAUST-2


Fig. 124. BCST 14


Fig. 125. AAUST-2

Salient achievements and technologies recommended

- Mulching with porous ground cover weed mat was best for weed management in taro in agro-climatic zones of West coast plains and hills, southern plateau and hills, eastern plateau hills and in west Himalayan zones. However, hand weeding thrice-30, 60 and 90 DAP was more economical in central plateau and hills and middle gangetic plains.
- In a trial on fertilizer best management practices in sweet potato, application of customized fertilizers developed by ICAR-CTCRI @ 300 kg ha^{-1}as basal dose and one month after planting, followed by foliar application of micronol @ 5 ml l^{-1} thrice on 15, 30 and 45 days after planting was the best for higher tuber yield compared to the present PoP and was recommended for eastern plateau and hills, lower Gangetic plains, middle Gangetic plains, southern plateau and hills, and Gujarat plains and hills.
- Standardized the nutrient requirement of swamp taro for eastern Himalayan, and western Himalayan zones as application of FYM @ 15 t ha^{-1}+ N:P_2O_5:K_2O @120:60:90 kg ha^{-1} to produce good growth, stolons and caudex yield.
- For the management of taro leaf blight disease, spraying with mancozeb + metalaxyl M @ 0.1% was the best to reduce the disease incidence and enhance cormel yield, which is recommended for the zones of eastern Himalayan, western Himalayan, middle Gangetic plains, eastern plateau and hills, lower Gangetic plains, southern plateau and hills, and in Islands.
- Dipping of cormels in *Trichoderma* amended (@ 5 g kg^{-1}) cow dung slurry + soil application of *Trichoderma* amended vermicompost @100 g $plant^{-1}$ at the time of planting and later at the time of intercultural operations is recommended as technology for bio-intensive management of taro leaf blight in states declared as organic.

22nd Annual Group Meeting

Annual Group Meeting of the All India Coordinated Research Project on Tuber Crops was held at ICAR-RC for NEH region, Barapani during 11-13 May 2022. The meeting was inaugurated by Dr. M.N. Sheela, Director (A), ICAR-CTCRI and Project Coordinator, AICRP TC. Dr. Arnab Sen, Principal Scientist and Director i/c, ICAR-RC for NEH presided over the inaugural function. Fifty scientists from 21 AICRP TC centres across the country attended the meeting (Fig. 126). The three days' programme reviewed and discussed the different research programmes of the project for evaluation of new accessions and location specific technologies for the development of tropical tuber crops under different agro-climatic zones of the country. Two varieties of tannia, one at national level and one for the state of Kerala, and three varieties of stolon taro one at national level, one each for the states of Assam and Manipur were recommended for release. Also four improved technologies viz., weed management practices in taro, fertilizer best management practices in sweet potato, fertilizer recommendation for swamp taro and management strategy for taro leaf blight disease were recommended for adoption by farmers in various agro-

Fig. 126. Glimpse of 22nd AGM of AICRP TC

ecological regions of the country, which can improve the tuber crops productivity by 20-30% and reduce the input cost and increase farmers income.

In the plenary session held in the forenoon of 13 May 2022, Dr. A.K. Singh, DDG (Hort. Sci.) and Dr. Vikramaditya Pandey, ADG, ICAR, New Delhi joined the meeting online and interacted with the scientists. The deliberations emphasized the need for quality planting material production, value addition, women empowerment in tuber crops by the formation of farmer producer organizations. Among the 21 centres of AICRP on Tuber Crops, the centre at Indira Gandhi Krishi Viswavidhyala, Jagdalpur, Chhattisgarh state, bagged the best centre award for 2021 for their outstanding performance (Fig. 127). Thirty two publications in different vernacular languages prepared by different centres were also released during the occasion. In the afternoon session, farmers and scientists interface was held, in which 25 farmers from different villages of Meghalaya attended and shared their experiences and clarified some of their field problems, requested for hands-on training on value addition and financial assistance for creating the facilities either through NABARD or through National Horticulture Board. It was suggested to take women self-help groups either at ICAR-CTCRI, Thiruvananthapuram or its Regional

Fig. 127. Best centre award to IGKV Jagdalpur centre

Station, Bhubaneswar for imparting proper training by utilizing the funds available under NEH programme.

Training

A hands-on training for value addition of tuber crops was held at ICAR-CTCRI during 11-17 October 2022 for the farmers of Manipur state (Fig. 128).

Fig. 128. Hands-on training to Manipur farmers at ICAR-CTCRI

Technologies Assessed, Transferred, Consultancy and Patent Services

Technologies transferred

The Institute Technology Management Unit & Professional Services Cell (ITMU & PSC) under the guidance of the Institute Technology Management Committee (ITMC) has carried out the following technology transfer and contract activities during 2022.

Technology commercialization

- Fried snack foods and fried chips from tapioca were commercialized through licensing to two firms in Kerala (Kerala State Co-operative Federation for Fisheries Development Ltd, Matsyafed, Kamaleswaram, Manacaud P.O., Thiruvananthapuram 695009, Kerala on 14 January 2022 for an amount of ₹ 25000 and Chipro Karshaka Swayam Sahaya Sangham, Ponkunnam P.O., Kottayam 686506, Kerala on 02 March 2022 for an amount of ₹ 25000).
- Power operated size based Chinese potato grader was commercialized through licensing to M/s Stonehat Technologies, 26/262, Madasamy Kovil Street, Rajapalayam, Coimbatore, Tamil Nadu on 10 October 2022 for an amount of ₹ 10000.

Patent obtained/filed

- Filed patent application for power operated size based Chinese potato grader and methods of grading (Inventors: Krishnakumar, T., Sajeev, M.S., Pradeepika, C., Muthuraj, R. and Jaganathan, D.; Patent Application No: 202241043900) on 01 August 2022 and the response to the First Examination Report was submitted on 12 November 2022.

The revenue generated through various activities at the Institutional level is indicated in Table 23.

Table 23. Revenue generated through technology commercialization and other professional service functions

Sl. No.	Activity	Revenue generated (₹)
1.	Technology licensing	65000
2.	Sale of technological products, machineries and value-added products	25000
3.	Professional training (ABI and TIC)	146000
4.	Students' fees	621860
5.	ICAR-CTCRI Incubatee enrolment fee	10000
	Total	**867860**

Technologies developed

Varieties/Technologies for crop improvement

- Two varieties of tannia i. IGSGTN-1 (TTn14-1); ii. XaMTS Local (TTn14-5) and three varieties of stolon taro (*Colocasia esculenta* var. *stoloniferum* (L.) Schott.) i. CAUST-2; ii. BCST 14; iii. AAUST-2 having high yield were recommended by AICRP TC for release in different states.
- Identified two early bulking cassava varieties, D-48 and 15S-409 that yielded significantly higher than the control variety, Vellayani Hraswa.
- Identified white yam variety, SD-15 with high yield (44.72 t ha^{-1}) and good culinary quality for release in Kerala.
- Identified two cassava clones, 8S-501 and CR43-7 as highly drought tolerant based on their mean performance and stability. Developed 618 cassava hybrids by crossing between drought tolerant and

susceptible genotypes. Generated the information regarding the changes in leaf morphology and leaf biochemical traits under drought stress conditions.

- Developed 620 F_1 hybrid progenies in two different mapping populations. From this population, CMD resistant, high starch lines will be identified based on phenotypic screening and molecular marker work.
- Developed 867 cassava F_1 hybrids, segregating for PPD tolerance and other traits.
- Standardized Trizol-based RNA isolation protocol for isolation of the high-quality RNA from the tuberous tissues of sweet potato.
- Three high yielding orange-fleshed sweet potato hybrids, H-473/8, H-562/32 and H-43/83 are submitted for AICRP TC trials.
- Identified six sweet potato genotypes suitable for processing based on evaluation for important traits.
- Identified sweet potato genotypes, DB/21/57 (17.00 t ha^{-1}), RS-III-3 (16.60 t ha^{-1}), B × 7 (15.44 t ha^{-1}), SP-123 (13.37 t ha^{-1}) and S-162 (12.88 t ha^{-1}) as drought tolerant lines on the basis of field and *in vitro* screening in terms of yield.
- Developed *in vitro* plant regeneration protocol of elephant foot yam var. Gajendra.
- Standardized breeder seed standards for RM1 variety of yam bean including breeder seed health test methodologies.
- Elucidated *gbss* gene sequence from the whole genome sequence data of cassava 9S-127 and cassava 8S-501.
- Identified *Curcuma angustifolia* accession IC number 641835, on par with Tikhur 1 variety in antimicrobial effects. The methanolic extract of this accession showed antibacterial effects towards *Staphylococcus aureus, Klebsiella pneumoniae, Mycobacterium smegmatis, Vibro cholerae, Salmonella typhi* and also antifungal effects towards *Candida albicans.*

Technologies for higher yield and sustainability

- Productive, profitable and energy efficient cropping system model, rice-short duration cassava-cluster bean.
- Organic package for cassava-groundnut cropping system.
- Organic package for cassava submitted to KAU for inclusion in PoP of KAU.
- Soil and foliar nutrition of cassava with essential nutrients for cassava mosaic disease (CMD) management under continuous cultivation.
- Polyhalites/polysulphates containing K_2O, CaO, MgO and S @13.5, 16.6, 5.5 and 18.5% as best soil amendment for cassava in the acid laterite (Ultisols) of Kerala.
- Water saving technique in taro.
- Irrigation schedule in sweet potato.
- Fertigation schedule in taro.
- Seed villages for quality planting material production of cassava and Chinese potato.
- Perforated weed control ground cover mat @120 gsm for high yield and less weed incidence in taro.

Technologies for plant health management

- Standardized the combination dose of bio-pesticide and chemical insecticide against sweet potato weevil.
- Diagnostic PCR technique for the presence of bacterial endosymbionts in whiteflies using specific bacterial primers.
- *Bacillus licheniformis*, an endophyte from the leaf of Aloe vera against *Colletotrichum gloeosporioides* causing anthracnose in greater yam.
- Organic management of collar rot and corm rot in elephant foot yam.
- Organic management of taro leaf blight.

Mechanization

- Power operated size based Chinese potato grader.
- Wet processing for extracting starch from cassava stem of different varieties.

Value addition

- Standardized a laboratory scale process to synthesize high viscosity cross-linked cassava starch phosphates with high water absorption capacity for possible application as thickener in convenient foods.
- Optimized the process parameters for making thermoplastic starch sheets of cassava starch, bagasse/banana fibre composites.
- A bench scale process to produce a highly water absorbing cassava starch phosphate carbamate.
- Cassava and wheat composite flour based rusk.

Methodologies/ICT tools/Statistical tools/Models

- Seasonal ARIMA and Time delay Neural Network model for forecasting of price in sweet potato.
- Women empowerment index in Chinese potato.
- Methodology for assessing the impact of adoption of improved variety 'Sree Dhara' on yield and income using IPWRA.
- e-Crop based smart fertigation system for tuber crops.
- Mobile app 'Krishi Krithya' for doing e-Crop based smart farming.
- A workflow for the analysis of whole genome sequence data of cassava.
- R tool for identifying optimal number of clusters, clustering using K means, hierarchical clustering, computing intra and inter cluster distances at optimal number of clusters.
- Certified Agritech Startup Professional (CAgtSP) System: A professional student certification system of ICAR-CTCRI ABI, KAU and Kerala Startup Mission.
- Satellite Incubation Center (SIC): A collaborative value-chain based entrepreneurship development model for startups, FPOs, agripreneurs and other entrepreneurs.

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	101
2.	M.Sc. project work	13
3.	B.Sc.-M.Sc. (Integrated) Biotechnology	01
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.	Ms. R. Noora Beegum	M.Sc. Botany, Iqbal College, Peringammala, University of Kerala	Precocity, genetic vigour and seed quality traits of wild and cultivated variety of yam bean (*Pachyrhizus erosus*)	Dr. P. Murugesan
2.	Ms. S.A. Aswani	B.Sc.-M.Sc. (Integrated) Biotechnology, College of Agriculture, Kerala Agricultural University, Vellayani	Assessment of genetic variability among accessions of Chinese potato (*Solenostemon rotundifolius* (Poir.) J.K. Morton) using morphological and molecular markers	Dr. K.I. Asha
3.	Ms. B.R. Sruthi	M.Sc. Biotechnology, Sree Narayana College of Technology, Kollam, University of Kerala	Identification of true F_1 hybrids in cassava using simple sequence repeat (SSR) markers	Dr. C. Mohan
4.	Ms. Remya Rajendran	M.Sc. Biotechnology, Sree Narayana College of Technology, Kollam, University of Kerala	Genetic variability in high starch cassava varieties using molecular markers	

5.	Ms. Arya Ajaykumar	M.Sc. Biotechnology, Mar Thoma College of Science & Technology, Ayur, University of Kerala	Genetic variability of cassava mosaic disease resistant lines using SSR Markers	Dr. C. Mohan
6.	Ms. P.S. Amrutha	M.Sc. Biotechnology, Mar Thoma College of Science and Technology, Ayur, University of Kerala	Micropropagation studies in some important aroids and standardization of SSR markers in tannia (*Xanthosoma sagittifolium* (L.) Schott.)	Dr. A. Asha Devi
7.	Mrs. Swathy Sadanandan	M.Sc. Botany, St. Josephs College Irinjalakuda, University of Calicut	Morphological and molecular characterization of sweet potato (*Ipomoea batatas* (L.) Lam.	Dr. Shirly Raichal Anil
8.	Ms. Akhila Sureshbabu	M.Sc. Biotechnology, Bhagwan Mahavir College of Science and Technology, Vesu, Surat	Genotypic variations implicating antimicrobial activities in *Curcuma angustifolia* Roxb	Dr. N. Krishna Radhika
9.	Mrs. Subeena	M.Sc. Biotechnology, Mar Thoma College of Science and Technology, University of Kerala	Validation of post-harvest physiological deterioration linked markers and genetic diversity analysis using SSR markers in cassava	Dr. C. Visalakshi Chandra
10.	Mrs. Surumi Zakkeer	M.Sc. Botany, Iqbal College, Peringammala, University of Kerala	Genetic diversity analysis of cassava genotypes segregating for Post-harvest Physiological Deterioration (PPD) tolerance using SSR markers	
11.	Mr. Siddhanta Mishra	M.Sc. Applied Microbiology, Utkal University, Bhubaneswar	Development of biofertilizer consisting *Azotobacter* and assessment of their effects on *in-vitro* produced plantlets of Chinese potato (*Plectranthus rotundifolius* Poir.)	Dr. V.B.S. Chauhan
12.	Ms. Sonia Bhuyan	M.Sc. Applied Microbiology, Utkal University, Bhubaneswar, Odisha	Formulation of phosphorous solubilizing biofertilizer and assessment of their effects on *in-vitro* produced plantlets of sweet potato ((*Ipomoea batatas* (L.) Lam.)	
13.	Ms. S. Ansiya	M.Sc. Biotechnology, Sree Narayana College of Technology, Kollam, University of Kerala	Molecular genetic diversity analysis of cassava germplasm using molecular markers	Dr. K.M. Senthilkumar

14.	Ms. S. Rifa Rafi	M.Sc. Biotechnology, Sree Narayana College of Technology, Kollam, University of Kerala	Genetic diversity analysis of cassava using SSR markers	Dr. K.M. Senthilkumar
15.	Mr. R. Chetan Rao	M.Sc. Applied Microbiology, Trident Academy of Creative Technology (Affiliated to Utkal University), Patia, Bhubaneswar	Soil microbes and enzyme activities as influenced by organic and inorganic fertilization in relation to yield of greater yam (*Dioscorea alata* L.)	Dr. K. Laxminarayana
16.	Mr. Dibyajit Pattanayak	M.Sc. Applied Microbiology, Trident Academy of Creative Technology (Affiliated to Utkal University), Patia, Bhubaneswar	Enumeration of soil microbes and enzyme activities in relation to chemical properties under various land use systems in Balasore district	
17.	Mr. V. Vamshi Krishna	M.Sc. (Ag.) Soil Science & Agricultural Chemistry, College of Agriculture, OUAT, Bhubaneswar	Organic and inorganic fertilization on soil fertility and yield of greater yam (*Dioscorea alata*) in Alfisols of coastal Odisha	
18.	Mr. Dipesh Meena	M.Sc. (Ag.) Soil Science & Agricultural Chemistry, College of Agriculture, OUAT, Bhubaneswar	Nutrient management in biofortified sweet potato (*Ipomoea batatas* L. Lam) under Alfisols of coastal Odisha	
19.	Ms. H. Naseeha	M.Sc. (Biochemistry), National College, Manacaud, University of Kerala	Effect of different doses of NPK on staggered harvest ,stolon yield and quality of swamp taro	Dr. J. Suresh Kumar
20.	Ms. R. Riswana	M.Sc. (Biochemistry), National College, Manacaud, University of Kerala	Effect of nitrogen application on yield of cassava	
21.	Ms. C.S. Jancy	B.Sc.–M.Sc.(Integrated) Biotechnology, College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram	Identification of virus(es) and phytoplasma associated with mixed infection of mosaic and yellowing disease in elephant foot yam	Dr. T. Makeshkumar
22.	Ms. Rashmi Rekha Ray	M.Sc. Applied Microbiology, Trident Academy of Creative Technology, Bhubaneswar	Mass production of *Trichoderma* spp in organic substrates of tropical tuber crops	Dr. R. Arutselvan

23.	Ms. Priyanka Priyadarshini	M.Sc. Applied Microbiology, Utkal University, Bhubaneswar	Studies on fungal diseases of tropical tuber crops and its management	Dr. R. Arutselvan
24.	Ms. Nishitha Komal Sahu	M.Sc. Applied Microbiology, Utkal University, Bhubaneswar	Development of *Trichoderma* based formulation for the eco-friendly disease management of tuber crops	
25.	Ms. Samir Kumar Jena	M.Sc. Applied Microbiology, Utkal University, Bhubaneswar	Studies on post-harvest bacterial rot disease in greater yam and its management	
26.	Ms. A.R. Kavya	M.Sc. Biochemistry, National College, Ambalathara, Thiruvananthapuram	Comparative evaluation of the biochemical composition of tubers and the physicochemical and functional properties of starch isolated from different varieties of lesser yam (*Dioscorea esculenta*)	Dr. A.N. Jyothi
27.	Ms. Esha Lakshmi	M.Sc. Food Science & Technology, School of Health Sciences, Calicut University, Malappuram	Evaluation of high viscosity cassava starch phosphate as thickener in soup and edible jelly	
28.	Mr. R. Nandu	M.Sc. Food Technology and Quality Assurance, Mount Royal College, Munnar, Idukki	Development of biodegradable thermoplastic sheet from cassava starch and sugarcane bagasse	Dr. M.S. Sajeev
29.	Mr. Zianab Kunjimon	M.Sc. Food Science and Technology, School of Health Sciences, Calicut University, Malappuram	Development of Indian rice cake (Idli) from cassava based composite flour	
30.	Ms. R. Raniya	M.Sc. Food Science and Technology, Pondicherry University, Pondicherry	Development of gluten free pasta from cassava based composite flour using egg as binding agent	
31.	Mr. G. Amal	M.Sc. Food Processing, PGP College of Arts and Science, Namakkal	Effects of different packaging materials on the storage quality of cassava flour	Dr. T. Krishnakumar
32.	Ms. Haritha V. Sankar	M.Sc. Food Science & Technology, School of Health Sciences, Calicut University, Malappuram	Development of probiotic and beta carotene rich orange-fleshed sweet potato based frozen yogurt	Dr. C. Pradeepika

33.	Ms. Mariya Shoji	M.Sc. Food Science & Technology, D.G.M. MES College, Mampad, Calicut University	Development of probiotic and anthocyanin rich purple-fleshed sweet potato based frozen yogurt	Dr. C. Pradeepika
34.	Ms. Aparna Sibi	M.Sc. Food Science & Technology, D.G.M. MES College, Mampad, Calicut University	Development of probiotic rich sweet potato based frozen yogurt	

Training Programmes

A total of 749 farmers, 727 officials and 315 students 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.	ICAR sponsored short course on Exploitation of genetic resources of underutilized tuber crops	02-11 February 2022	27 participants from different states of India
2.	ICAR sponsored short course on Novel Processing and value addition technologies for augmenting entrepreneurial opportunities in tuber crops	15-24 February 2022	36 participants from different states of India
3.	Training on Improved technologies of tuber crops	26 April 2022	50 progressive farmers from Madurai under ATMA, Govt. of Tamil Nadu
4.	Online training programme on Extension strategies for scaling up of biofortified crops sponsored by MANAGE, Hyderabad, Telangana	23-27 May 2022	60 participants from different states of India
5.	Training on Smart farming using Electronic Crop *(e-Crop)* (TOSFUE-2022)	16 June 2022	200 farmers of Thiruvananthapuram
6.	Internship training programme on Improved technologies of tuber crops	23 June 2022 to 09 July 2022	7 B.Sc. (Ag.) students from VIT, Vellore, Tamil Nadu
7.	National awareness campaign on Organic farming (All India Network Programme on Organic Farming (AINP-OF))	04 August 2022	74 delegates, including farmers, students and academicians from Kerala

8.	Training on Improved processing technologies of tropical tuber crops	20-22 September 2022	15 officers from Department of Horticulture, Salem district, Tamil Nadu
9.	Certified Agritech Start-up Professional (CAgtSP) Programme in collaboration with KAU and Kerala Start-up Mission	10-12 October 2022	155 students from College of Agriculture, Vellayani, Thiruvananthapuram
10.	Internship training on Improved technologies of tropical tuber crops	07-12 November 2022	15 B.Sc. (Agriculture) students from Karunya Institute of Technology and Sciences, Coimbatore
11.	ICAR sponsored winter school on Sustainable exploitation of genetic resources of neglected and underutilized tuber crops for enhancing climate resilience and nutritional security	29 November to 19 December 2022	21 participants from different states of India
12.	National workshop on smart management of agricultural resources to transform Indian farms (Smart IF)	15-17 December 2022	210 participants from different states of India

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	12 January 2022	13 VFPCK farmers from Kollam, Kerala
		25 February 2022	21 VFPCK farmers from Chathannoor, Kollam, Kerala
		08 March 2022	20 Women from Rotary Club, Thiruvananthapuram, Kerala
		15 March 2022	29 farmers from Krishi Bhavan, Elakamon, Thiruvananthapuram, Kerala
		24 March 2022	12 farmers from Krishi Bhavan, Perinthalmanna, Malappuram, Kerala
		31 March 2022	20 farmers from different districts of Kerala
		04 May 2022	26 farmers from Attappadi, Kudumbasree, Muvattupuzha FPO, Kerala
		19 May 2022	17 farmers from VFPCK Kollam, Kerala
		06 June 2022	14 officials from FPO under NMDCS Ltd, Wayanad, Kerala
		08 June 2022	21 farmers from ATMA, Malappuram, Kerala
		09 June 2022	10 farmers from ATMA, Palluruthy Block, Ernakulam, Kerala
		17 June 2022	41 farmers from ATMA, Sasthamkotta, Kollam, Kerala
		02 August 2022	37 farmers from ATMA, Chathannoor, Kollam, Kerala

2.	Value added products for farmer centric entrepreneurship	09 August 2022	20 officials from NABARD, Thiruvananthapuram, Kerala
		23 August 2022	33 farmers from Kerala
		24 August 2022	22 participants from SAMETI, Anayara, Thiruvananthapuram, Kerala
		15 September 2022	20 participants from Thiruvithamkore Farmers Producers Organisation, Vazhoor, Kottayam, Kerala
		23 September 2022	12 farmers from KVK, Kanyakumari, Tamil Nadu
		24 September 2022	22 participants from FPO Kannur and Cooperative Bank, Malappuram, Kerala
		11-17 October 2022	13 farmers and officials from Manipur, AICRP TC NEH programme
		18-19 October 2022	04 officials from Chirakadav Cooperative Bank, Kottayam, Kerala
		04 November 2022	48 participants from DIC, Thiruvananthapuram, Kerala
		15 November 2022	27 farmers from Peermade Development Society FPOs, Idukki, Kerala
		17 November 2022	27 participants from Women Welfare Association, Vaduvanchal, Wayand, Kerala
		18 November 2022	14 trainees from SAMETI, Anayara, Thiruvananthapuram, Kerala
3.	Quick cooking tubers	22 November 2022	03 MoU signees, APCOS, Muvattupuzha, Ernakulam, Kerala
4.	Value addition and entrepreneurship development in tuber crops	07-08 December 2022	37 officials from Cooperative Banks, Kerala
		12 December 2022	30 officers and farmers from BIO mountain FPO, Thalassery, Kannur, Kerala
		13 December 2022	25 CFRD students, Konni, Pathanamthitta, Kerala
		20 December 2022	15 participants from DIC Kollam, Kerala
		21 December 2022	26 participants from Teachers Training Programme under DST project
		22-23 December 2022	03 MoU signees from Mythri FPO, Uzhavoor, Kottayam, Kerala
		27 December 2022	26 farmers from Krishi Bhavan, Vaikkom, Kottayam, Kerala

Trainings at Regional Station, ICAR-CTCRI, Bhubaneswar

Sl. No.	Particulars of training	Date	Details of participants
1.	Tuber crops technologies	18 May 2022	65 B.Sc. (Ag.) students from Agricultural College, Naira, Srikakulam of Acharya NG Ranga Agricultural University, Andhra Pradesh
2.	Tuber crops technologies and on-going programmes	27 October 2022	30 B.Sc.(Ag.) students from SOA Deemed to be University, Sri University, Cuttack and Jagannath University, Rajasthan

3.	Tuber crops technologies	28 October 2022	18 students of B.Sc. (Ag.) from SOA Deemed to be University as a part of RAWE internship training programme
4.	Agro-techniques and value addition in tropical tuber crops	03 November 2022	28 Agricultural Officers, VAWs, and ATMs representing Puri, Kendrapada, Khorda, Nayagarh, Cuttack, Jagatsingpur, Jajpur districts of Odisha organized by State Institute of Training & Extension, Bhubaneswar
5.	Agro-techniques and value addition in tropical tuber crops	13 December 2022	72 Agricultural Officers, VAWs, and ATMs representing all the 30 districts of Odisha as organized by State Institute of Training & Extension, Bhubaneswar

Resource person in training programmes

More than 250 classes on varieties, quality planting materials, production, 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 visit cum training programme

One day exposure visit cum training on 'Improved technologies of tuber crops' was organized for the benefit of 563 farmers, 1720 students and 173 officials across the nation at ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram. A total of 823 farmers and other stakeholders were trained at ICAR-CTCRI, Regional Station, Bhubaneswar.

Trainings attended by ICAR-CTCRI Staff

Scientific staff

Sl. No.	Name of scientist	Particulars of the training	Period
1.	Dr. C. Visalakshi Chandra	Advanced statistical techniques for data analysis using R at ICAR-Indian Rice Research Institute, Hyderabad, Telangana	03-15 January 2022
2.	Dr. C. Pradeepika	Short course on Exploitation of genetic resources of underutilized tuber crops at ICAR-CTCRI, Thiruvananthapuram, Kerala	02-11 February 2022
3.	Dr. Sheela Immanuel	Competency enhancement programme for effective implementation of training functions by HRD Nodal officers of ICAR organized by ICAR-NAARM, Hyderabad, Telangana (Online mode)	21-23 February 2022
4.	Dr. K.M. Senthilkumar	Short course on *Phytophthora*: From isolation to functional genomics at ICAR-IISR, Kozhikode, Kerala	02-11 March 2022

5.	All Scientists	Training programme on Intellectual property rights as part of awareness programme under national intellectual property awareness mission organized by Intellectual Property Office, New Delhi at ICAR-CTCRI, Thiruvananthapuram, Kerala	14 March 2022
6.	Dr. T. Krishnakumar	Advancement and challenges in food packing industry, organized by PHD Chamber of Commerce and Industry, New Delhi	23-24 March 2022
7.	Dr. H. Kesava Kumar	Capacity building workshop in Nematode taxonomy organized by Chaudhary Charan Singh University, Meerut, Uttar Pradesh	21-28 March 2022
8.	Dr. E.R. Harish	Trainer's training on mass production and release techniques of *Anagyrus lopezi* for the classical biological control of cassava mealybug in India at ICAR- NBAIR, Bengaluru, Karnataka	31 May 2022
9.	Dr. T. Krishnakumar	Statistical techniques for agriculturists organized by Indian Institute of Technology, Khanpur (Online mode)	16 June-26 July 2022
10.	Dr. K.M. Senthilkumar	National workshop-cum-webinar on Genome Editing, Glostem, Chandigarh	27 June-03 July 2022
11.	Dr. T. Krishnakumar	Training programme on Agripreneurship through banana based technologies-An avenue for Atma Nirbhar Bharat by MANAGE, Hyderabad, Telangana & ICAR-National Research Centre for Banana, Trichy, Tamil Nadu (Online mode)	15-17 July 2022
12.	Dr. K.M. Senthilkumar	Genetically Engineered (GE) plants: Biosafety considerations, policies, challenges and detection strategies at ICAR-NBPGR, New Delhi (online mode)	19-25 July 2022
13.	Dr. T. Krishnakumar	National campaign workshop on Conservation of fish biodiversity & protection of farmer rights organized by Zonal Technology Management & Agribusiness Incubation (ZTM-ABI) Centre, ICAR-CIFT in association with KVK, CMFRI, Kochi, Kerala (Online mode)	25 July 2022
14.	Dr. T. Krishnakumar	Engineering interventions in post-harvest fisheries sector organized by ICAR-CIFT, Kochi, Kerala	29 July 2022
15.	Dr. M.N. Sheela	Training on IP awareness organized by Office of the Comptroller General of Patents, Designs and Trade Marks, Government of India (Online mode)	05 August 2022
16.	Dr. C. Pradeepika	Workshop on Response surface methodology organized by ICAR-NAARM, Hyderabad, Telangana (Online Mode)	18-20 August 2022

17.	Dr. P. Sethuraman Sivakumar	Advanced certificate course on International trade & customs laws organised by The Confederation of Indian Industry (CII), Southern Region, Chennai, Tamil Nadu (Online Mode)	14 October- 04 November 2022
18.	Dr. K.I. Asha Dr. A . Asha Devi Dr. Shirly Raichal Anil	Training workshop on Analysis of multi-environment trials organized by ICAR-NAARM, Hyderabad, Telangana (Online Mode)	03-08 November 2022
19.	Dr. B.G. Sangeetha Dr. T.P. Sujatha	ICAR sponsored winter school on Sustainable exploitation of genetic resources of neglected and underutilised tuber crops for enhancing climate resilience and nutritional security at ICAR-CTCRI, Thiruvananthapuram, Kerala	29 November- 19 December 2022
20.	Dr. T. Krishnakumar	Workshop on Energy transition in agricultural sector organized by Energy Management Centre, Thiruvananthapuram, Kerala	28-29 December 2022

Technical staff

Sl. No.	Name of the staff	Particulars of the training	Period
1.	Smt. B.S. Deepa	Knowledge management for agricultural librarians and information professionals organized by MANAGE, Hyderabad (Online mode)	16-17 February 2022
2.	Smt. B.S. Deepa	Advanced training programme on D space software organized by Knowledge Centre, Digital University of Kerala	09-13 May 2022

Awards and Recognitions

Awards

1. ICAR-CTCRI bagged the 14th Rank among all ICAR Institutes in the combined list of Ranking of Institutes of Indian Council of Agricultural Research for the year 2019-20 and 2020-21 (Combined) as per the reference F.No. 13(37) /2017 /Cdn (Tech) dated 28 September 2022 from ICAR, New Delhi. (Editors of the ranking document during 2019-20: Drs. Byju, G., Jaganathan, D., Sanket J. More and Senthilkumar, K.M. and during 2020-2021: Drs. Murugesan, P., Koundinya, A.V.V. and Jaganathan, D.).
2. Dr. J. Suresh Kumar bagged the Young Scientist Award-2022 from the Society of Tropical Agriculture, New Delhi at the 14th International Conference on Agriculture, Horticulture and Food Sciences (ICAHFS) 2022, held during 17-18 December 2022 at New Delhi.
3. Dr. J. Suresh Kumar bagged the Best Paper Award-2022 from the Society of Tropical Agriculture, New Delhi at the 14th International Conference on Agriculture, Horticulture and Food Sciences (ICAHFS) 2022, held during 17-18 December 2022 at New Delhi.
4. Dr. C. Visalakshi Chandra bagged the Best Oral Presentation Award for the research paper titled 'Evaluation of cassava hybrids for postharvest physiological deterioration tolerance and other important traits for varied industrial uses' (Authors: Visalakshi Chandra, C., Sheela, M.N., Sreekumar, J. and Jyothi, A.N.) in the International Conference on Advances in Agriculture and Food Systems towards Sustainable Development Goals held during 22-24 August 2022 at University of Agricultural Sciences, Bengaluru.
5. Dr. Kalidas Pati bagged the Best Research Paper Award for Scientist (2021) as first author for the paper titled 'Element profiling of thirty genotypes of yam bean in eastern India by using proton induced X-ray emission (PIXE)', published in Journal of Food Composition and Analysis (NAAS score: 9.72) during ICAR-CTCRI Foundation Day Celebrations on 27 July 2022.
6. Dr. P. Murugesan received the Fellow of Society for Promotion of Oil Palm Research and Development for the year 2022 for his outstanding contributions to plantation crops-Oil palm.
7. Dr. S.S. Veena received the Fellow of Indian Phytopathological Society (FPSI 2021) from Indian Phytopathological Society, New Delhi.
8. Dr. M. Nedunchezhiyan bagged the Distinguished Horticultural Scientist Award-2020 for his significant contributions to Horticultural Sciences, on 27 April 2022 from the Society for Horticultural Research and Development, New Delhi.
9. Dr. V.B.S. Chauhan was awarded the Best Poster Award for the research paper titled 'Screening of taro (*Colocasia esculenta* L.) genotypes for salt tolerance under *in vitro* condition' (Authors: Chauhan, V.B.S., Reshmi Das, Kalidas Pati, Arutselvan, R. and Nedunchezhiyan, M.) in the International Conference on Agriculture for Sustainable Future (Agrivision 2022) held during 06-08 March 2022 at Ravenshaw University, Cuttack, Odisha.
10. Dr. Kalidas Pati was awarded the Best Oral Presentation Award for the research paper titled 'Molecular and biochemical characterization of

tuberous legume crop yam bean [*Pachyrhizus erosus* (L.) Urban]' (Authors: Kalidas Pati, Jeen Linkan Meher, Biswajit Jena, Anant Kumar, Nedunchezhiyan, M., Chauhan, V.B.S. and Arutselvan, R.) in the International Conference on Agriculture for Sustainable Future (Agri Vision -2022) held during 06-08 March 2022 at Ravenshaw University, Cuttack, Odisha.

11. Ms. S.U. Shilpa received the Best Oral Presentation Award for the research paper titled 'Studies on endophytes isolated from taro having antagonistic activity against *Phytophthora colocasiae*' (Authors: Shilpa, S.U., Jeeva, M.L., Amrutha P.R. and Tom Cyriac) in National Webinar on Advances in Industrial Biotechnology held during 03-04 February 2022 at Department of Biotechnology, University of Kerala.

12. Dr. D. Jaganathan bagged ICAR-CPCRI Best Scientific Team Research Award 2022 on 05 January 2022 during Foundation Day Celebrations of ICAR-CPCRI, Kasaragod for the team research on EPN for the management of root grubs in arecanut and coconut gardens in Karnataka and Kerala.

Recognitions

Crop Improvement

Dr. M.N. Sheela

- Member, Expert Subject Working Group on 'Constraints to technology adoption and potential to raise productivity in Kerala Agriculture' for the formulation of the fourteenth Five year Plan of Kerala, State Planning Board.
- External expert for the peer review of research and development activities of Crop Improvement Division of Rubber Board, Kottayam, Kerala.
- Chairman, Assessment Committee for considering assessment promotion of technical personnel of ICAR-CPCRI, Kasaragod.
- Member, Institute Management Committees of ICAR-CPRI, Shimla; ICAR-IIHR, Bengaluru and ICAR-DCR, Puttur.
- Delivered an invited lecture on 'Hitech Agriculture' in the National Seminar on Vision-2047 Science and Technology organized on 27 August 2022 by Bharatheeya Vichara Kendram as a part of 'Azadi Ka Amrit Mahotsav' celebrations.
- External examiner for evaluation of thesis and conduct of final examination of three Ph.D. programmes on Plant Breeding & Genetics, College of Agriculture, Vellayani, Thiruvananthapuram.

Dr. K.I. Asha

- External examiner for evaluation of thesis and conduct of final viva voce of the M. Sc. programme in Plant Biotechnology, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala.
- Evaluator for the K-DISC (Kerala Development and Innovation Strategic Council) in the Young Innovators Programme 2021-2022 and evaluated 26 ideas.
- Evaluator of research proposal for KSCSTE, Govt. of Kerala.

Dr. P. Murugesan

- Expert member, DG Nominee for CAS in the discipline of Spices, Plantation, Medicinal and Aromatic Plants at ICAR-IISR, Kozhikode.
- Reviewer of KSCSTE research projects under Engineering & Technology Programme in agricultural research.
- Delivered an invited lecture in 10 days ICAR short course on 'Ecosystem service analysis in diversified coconut and arecanut gardens' held during 21 February to 02 March 2022 at ICAR-Central Coastal Agricultural Research Institute, Old Goa.
- Expert member of the consultative group of geographical indications registry to grant GI for Salem sago (*Savvarisi)*.
- Keynote speaker, 2nd Indian Horticulture Summit-2022 held during 27-29 April 2022 and delivered a talk entitled 'Biodiversity, improvement and

prospects in minor tuber crops', Navsari Agricultural University, Navsari, Gujarat.

- Member, Assessment Committee for considering assessment promotion of technical personnel in the functional group of 'Workshop including engineering workshop category III of ICAR-CPCRI constituted by the Chairman, ASRB in the meeting held on 07 July 2022.
- Delivered an invited lecture on 'Biodiversity, improvement and prospects in underutilized tuber crops' on 12 August 2022 at Horticulture College and Research Institute, Coimbatore, Tamil Nadu.
- Expert member for the Ph.D. viva voce at Department of Plant Breeding & Genetics, Faculty of Agriculture, Annamalai University on 30 September 2022.
- Reviewer, International Journal of Environment and Climate Change.
- Expert, Pradhan Mantri Kissan Samruddhi Kendras-Model Fertilizer Retail Shop @ FACT Agro Service Centre, Thiruvananthapuram and delivered a lecture on 'Advances in tuber crops cultivation and improved varieties'.
- Member, Editorial Board, International Journal of Oil Palm.

Dr. C. Mohan

- Reviewer, Molecular Genetics and Genomics, Asian Journal of Plant and Soil Sciences, Indian Journal of Genetics and Plant Breeding and Plant Cell Biotechnology and Molecular Biology.
- External examiner for four Ph.D. students, Calicut University.

Dr. A. Asha Devi

- Adjudicator, oral presentation of M.Sc. students in the International Conference on Advanced Biology 2022 organized by the Inter University Centre for Evolutionary and Integrative Biology (ICEIB), University of Kerala.
- External examiner, evaluation of thesis and conduct of final viva of a Ph.D. student, Department of Plant Biotechnology, College of Agriculture, KAU, Vellanikkara, Thrissur.
- Reviewer, South African Journal of Botany.
- Expert member, Technical Paper Evaluation Committee for the 35th Kerala Science Congress in the area of Agriculture & Food Science during December 2022.

Dr. Shirly Raichal Anil

- Question paper setter and evaluator of Ph.D. course work examination at Department of Botany, University of Kerala, Thiruvananthapuram.
- External examiner for assessment of CSIR-JRF Ph.D. scholars for promotion to SRF at S.D. College, Alleppey on 06 October 2022 (online mode).

Dr. Kalidas Pati

- External member of the interview board for the selection of Research Associate under DST funded project entitled 'Decrypting the chemical interaction of rice and its specialist herbivore, *Scirpophaga incertulas'* at ICAR-NRRI, Cuttack.
- External member of the interview board for the selection of Junior Research Fellow and Project Assistant under DST funded project entitled 'Nanoherbicide: A control release formulation to improve rice production' at ICAR-NRRI, Cuttack.
- External member of interview board for selection of Junior Research Fellow under DST funded Project entitled 'Identification and characterization of low starch digestibility rice based on types of resistant starch and cooking quality' at ICAR-NRRI, Cuttack.

Dr. T.P. Sujatha

- Associate Editor, Journal of Rice Research.
- Assistant Editor, Applied Biochemistry and Biotechnology, Section: Biological processes and genomics, Springer.

- Reviewer, Industrial Crops and Products and BMC Plant Biology.

Dr. C. Visalakashi Chandra

- Evaluated the research proposal entitled 'Exploration of biosynthesized nanoparticles and nano-urea mediated growth regulation with regards to the physiology and yield of agricultural crop confers by hydroponic farming and under drought stress' submitted for consideration under the 'Back-to-Lab' Post-Doc Fellowship Scheme-2022, KSCSTE, Government of Kerala.

Dr. K.M. Senthilkumar

- Reviewer, Molecular Biotechnology, Indian Journal of Agricultural Sciences, Journal of Plant Biochemistry and Biotechnology and Journal of Cereal Research.

Dr. V.B.S. Chauhan

- Reviewer, Asian Journal of Plant and Soil Sciences.
- Delivered an invited lecture in the Winter School on 'Underexploited vegetables: Unexplored treasure trove for food, nutritional and economic security' on 19 February 2022 organized by ICAR- Indian Vegetable Research Institute, Varanasi, Uttar Pradesh.

Crop Production

Dr. M. Nedunchezhiyan

- Invited speaker at second Indian Horticultural Summit – 2022 held at Navsari, Gujarat and delivered talk on 'Weed management for higher productivity in root and tuber crops' on 28 April 2022.

Dr. G. Suja

- Subject expert for tuber crops, 17th Scientific Advisory Committee meeting, ICAR-KVK, Kollam.
- Observer I for AO/FAO Competitive Examination at online Tier I (CBT) of AO/FAO Examination 2021 held on 10 May 2022 at Thiruvananthapuram centre.
- Expert panel member, Faculty interviews for the selection of faculty members of Agronomy, VIT School of Agricultural Innovation & Advanced Learning, Vellore.
- Evaluator for Young Innovator's Programme of Kerala Development & Innovation Strategic Council (KDISC) and evaluated 27 ideas.
- Reviewer and evaluator of a pre-proposal assigned by KSCSTE (Science Research scheme) and submitted evaluation metrics in Google form.
- Reviewer, Rubber Science, Journal of Tropical Agriculture and Journal of Root Crops.
- External examiner for 11 Ph.D. and three M.Sc. Agronomy students, Tamil Nadu Agricultural University, University of Raichur and Kerala Agricultural University.

Dr. K. Susan John

- Evaluator of extended abstracts for 34th and 35th Kerala Science Congress.
- Technical expert, Committee for the purchase of chemicals, glasswares and equipments, Central Soil Analytical Laboratory, Department of Soil Survey and Soil Conservation, Government of Kerala.
- Moderator, Discussion on 'Central budget and Agriculture sector with special reference to Kerala' on 07 February 2022 under the Farm and Home section of All India Radio, Thiruvananthapuram.
- Adjudicator for the evaluation of Ph.D. thesis, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore and its public defence.
- Evaluator, Young Innovator's programme, K-DISC, Government of Kerala.
- Observer II for AO/FAO Competitive Examination at online Tier I (CBT) of AO/FAO Examination 2021 held on 10 May 20222 at Thiruvananthapuram 2 centre.
- Evaluator, pre-project proposal, KSCSTE (Research Scheme: Product and Process Development) for funding.

- External examiner for four Ph.D. students, Kerala Agricultural University, Tamil Nadu Agricultural University and Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Iruvakki, Shivamogga, Karnataka.
- Received recognition and memento from Minister of Animal Husbandry, Government of Kerala on 24 September 2022 for being a speaker for the Benziger Community Radio for the last four years on agriculture related topics.

Dr. S. Sunitha

- Advisory committee member, Ph.D. student programme in Agronomy, College of Agriculture, KAU, Vellanikkara, Thrissur, Kerala.
- External examiner for three Ph.D. students and 21 M.Sc. (Ag.) students, Kerala Agricultural University.
- External expert for the defence seminar of one Ph. D. student from College of Agriculture, KAU, Vellayani, Thiruvananthapuram, Kerala.

Dr. K. Laxminarayana

- External examiner for two Ph.D. students, Odisha University of Agriculture & Technology, Bhubaneswar.
- Member, Technical Evaluation Committee of RKVY, Govt. of Odisha for evaluation of project proposals.
- Reviewer, Communications in Soil Science and Plant Analysis, Applied Soil Ecology, Archives of Agronomy & Soil Science and Pedosphere.

Dr. V. Ramesh

- External examiner for three Ph.D. and three M.Sc. (Ag.) students, Kerala Agricultural University.
- Evaluated five research papers for 35th Kerala Science Congress.
- Observer I for AO/FAO Competitive Examination at online Tier I (CBT) of AO/FAO Examination 2021 held on 10 May 20222 at Tirunelveli centre.
- Mentor, Young Innovators Programme, K-DISC, Government of Kerala.

Dr. K. Sunilkumar

- Reviewer., Current Journal of Applied Science and Technology, Indian Journal of Agricultural Research, Annual Research and Review in Biology.
- Reviewer, pre-project proposal under Engineering and Technology Programme of KSCSTE, Government of Kerala.
- Evaluator of a project proposal for KSCSTE, Government of Kerala.
- External examiner, M.Sc. (Hort.) student, Kerala Agricultural University.

Dr. J. Suresh Kumar

- External examiner, M.Sc. student, Tamil Nadu Agricultural University, Coimbatore.

Crop Protection

Dr. C.A. Jayaprakas

- Keynote speaker, 2nd Global Conference on Plant Science and Agricultural Research & Global Conference on Food Science and Nutrition-IRIS Scientific Group on 24 March 2022.
- Lead talk, VII Meeting of the Indian Grain Storage Working Group (IGSWG) at NASC Complex, New Delhi on 20 May 2022.
- Invited talk, OPEN HOUSE programme of KSCSTE-Malabar Botanical Garden & Institute for Plant Sciences, Kozhikode on 25 May 2022.
- Lead talk, National e-Conference on 'Biotic Stress Management Strategies for Achieving Sustainable Crop Production and Climate Resilience' at ICAR-NCIPM, New Delhi on 21 May 2022.
- Lead talk, National Virtual Conference on 'Technological Advancements in Crop Protection', Vellore Institute of Technology, Vellore, Tamil Nadu on 08 October 2022.
- Lead talk, National Conference on 'Enhancing Competitiveness of Horticulture through Technology

Innovations' at ICAR-CPCRI, Kasaragod on 17 November 2022.

Dr. M.L. Jeeva

- Resource person, online training and interactive session on emerging problems in cassava cultivation, RARS, Kumarakom on 10 August 2022.
- Resource person, Farmers awareness programme on production and utilization technologies of tropical tuber crops, KVK, Namakkal, 28 to 30 September 2022.
- External examiner for two Ph.D. and three M.Sc. students, Tamil Nadu Agricultural University, Coimbatore.

Dr. S.S. Veena

- Panelist, Selection committee for the recruitment of Scientist B, Kerala Forest Research Institute, Peechi, Thrissur, Kerala.
- Evaluator, M.S. Pavgi and A.K. Sarbhoy Memorial Awards, Indian Phytopathological Society, New Delhi.
- External examiner for three Ph.D. and six M.Sc. students, Indian Agricultural Research Institute, New Delhi; University of Calicut and Kerala Agricultural University.
- Evaluator, pre-project proposal, Science Research Scheme, KSCSTE, Government of Kerala.
- Member, Advisory Committee, two Ph.D. students, Kerala Agricultural University.
- Observer II for AO/FAO Competitive Examination at online Tier I (CBT) of AO/FAO Examination 2021 held on 10 May 20222 at Thiruvananthapuram 1 centre.
- Delivered a lead talk on 'Ecosmart ways for the management of postharvest rot in aroids' in the National E-conference on Biotic Stress Management Strategies for Achieving Sustainable Crop Production and Climate Resilience during 19-21 May 2022 organized by Society of Plant Protection Sciences, New Delhi in association with ICAR-NCIPM, New Delhi and ICAR-IARI, New Delhi.
- Convenor, Session 2B, National E-conference on Biotic Stress Management Strategies for Achieving Sustainable Crop Production and Climate Resilience, the Society of Plant Protection Sciences, New Delhi in association with ICAR-NCIPM, New Delhi and ICAR-IARI, New Delhi during 19-21 May 2022.
- Reviewer, Scientia Horticulturae, Rhizosphere, Indian Journal of Agricultural Sciences, Indian Phytopathology, Journal of Horticultural Sciences, Indian Journal of Mycology and Plant Pathology.
- Member, Agriculture Knowledge Centre, Assistant Director of Agriculture, Attingal, Thiruvananthapuram, Kerala.
- Evaluator, Young Innovators Programmme, K-DISC, Government of Kerala.

Dr. T. Makeshkumar

- Panelist, Selection committee for recruitment of Scientist B, KFRI, Peechi, Thrissur, Kerala.
- External expert for recruitment of Assistant Professor (Research), VIT (VAIAL), Vellore.
- Evaluator, M.J. Narasimhan Best Research paper published in Indian Phyotopathology.
- External expert for the recruitment of Project Associate, ICAR-Indian Institute of Spices Research, Kozhikode.
- Member, Advisory Committee, two Ph.D. students, Rajiv Gandhi Centre for Biotechnology, Thiruvananthapuram.
- External examiner, Ph.D. student, ICAR-IARI, New Delhi and M.Sc. (Ag.) students, Kerala Agricultural University; Tamil Nadu Agricultural University and Acharya N.G. Ranga Agricultural University.

Dr. E.R. Harish

- Executive committee member, Association for Advancement of Entomology.
- Reviewer, Springer Nature, Journal of Root Crops, Trends in Horticultural Entomology (Book) for Entomon.
- External examiner, two M.Sc. (Ag.) students, Kerala Agricultural University, Thrissur.
- Expert for the evaluation of project proposals, KSCSTE, Government of Kerala.

Dr. H. Kesava Kumar

- Expert, XIV Scientific Advisory Committee Meeting, ICAR-Krishi Vigyan Kendra, Thirupathisaram, Nagercoil, Kanyakumari, Tamil Nadu.
- Member, Advisory Committee, M.Sc. (Ag.) Programme, Kerala Agricultural University.
- Member, Working Group, Open Access India 2022.

Dr. B.G. Sangeetha

- Member, Advisory Committee, Kerala Agricultural University.
- External examiner, Ph.D. student, Department of Plant Biotechnology, University of Agricultural Sciences, GKVK, Bengaluru.
- Delivered an invited lecture on 'Applications of biotechnology in agriculture', S.N. College, Sivagiri, Varkala, Thiruvananthapuram on 18 November 2022.

Crop Utilization

Dr. M.S. Sajeev

- External expert, District level committee meeting of PMFME-ODOP programme, DIC, Kollam, Kerala, on 09 February 2022.
- External expert, CAS meeting of scientist and technical staff, ICAR-CPCRI, Kasaragod, Kerala
- Co-chairman, Session on Agricultural Processing on 09 November 2022, 56th Annual Convention of Agricultural Engineers, 09-11 November 2022, TNAU, Coimbatore, Tamil Nadu.
- Co-guide, Ph.D. programme on Semi automation of non-centrifugal sugar production units-Process optimisation, modeling and scale up studies, CSIR-NIIST, Thiruvananthapuram, Kerala.

Dr. A.N. Jyothi

- Member, Technical Committee, State Pesticide Testing Laboratory, Department of Agriculture, Government of Kerala.
- External expert for the evaluation of the Ph.D. thesis and conduct of the viva voce of one research scholar from Post Graduate School, IARI, New Delhi.
- Evaluator for the Young Innovators Programme by K-DISC, Government of Kerala.
- External examiner for M.Sc. students, Department of Community Sciences, Kerala Agricultural University, Vellanikkara, Thrissur.
- Member, Advisory committee, Ph.D. programme, Department of Communication Science, College of Agriculture, Vellanikkara, Thrissur, Kerala.
- Member, Advisory committee, Ph.D. programme, Department of Food Process Engineering, School of Bioengineering, SRM Institute of Technology, Kattankulathur, Tamil Nadu.
- Reviewer, Starch/Starke and LWT - Food Science & Technology.

Dr. T. Krishnakumar

- Member, Technical Committee (FAD 16), Bureau of Indian Standards (BIS), New Delhi.
- Question paper setter for TNAU, TANUVAS & APJ Abdul Kalam Technical University, Thiruvananthapuram, Kerala.
- External examiner for the Ph.D. viva-voce, Food Science and Nutrition, Periyar University, Tamil Nadu.

- Reviewer, Vegetos (An International Journal of Plant Research and Biotechnology), Springer.

Extension & Social Sciences

Dr. Sheela Immanuel

- Reviewer, Indian Journal of Fisheries, Journal of Marine Biological Association of India and Agricultural Research.
- Evaluator for Young Innovators Programme, K-DISC, Government of Kerala.
- Resource person for PGDAEM-MANAGE correspondence courses.
- External expert for evaluation of 20 applications under Research Incubation Programme funded by Kerala Startup Mission.
- Question paper setter for KUFOS for M.Sc. (Fisheries Extension).
- External examiner for six Ph.D. students of Agricultural Extension, Kerala Agricultural University.

Dr. J. Sreekumar

- Resource person for the online training programme on Data digitization and visualization held during 22-24 February 2022 at ICAR-Indian Institute of Spices Research, Kozhikode and delivered lecture on 'Statistical protocols for field experiments and data analysis' on 23 February 2022.
- External examiner for two Ph.D. students in Agricultural Statistics and Bioinformatics, ICAR-Indian Agricultural Research Institute, New Delhi and two M.Sc. students, Kerala Agricultural University.
- Member in the selection panel for the recruitment of Scientist B in the discipline of Forest Statistics by Kerala Forest Research Institute, Thrissur, Kerala.
- Member, Editorial Board, Journal of Tropical Agriculture, Kerala Agricultural University.

Dr. P. Sethuraman Sivakumar

- Expert for the Working Group on Agri-Biotechnology of Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand during May 2022.
- Judge for the student poster award programme of 'The Society for Judgement and Decision Making', United Kingdom during February 2022.
- Chairman of the technical session on 'Types of production systems (home gardens, roof top gardens, community gardens), marketing systems in localized urban food systems and application of controlled environment in urban agriculture' on 22 March 2022 in the International Seminar on Sustainable Urban Agricultural Systems and Community Resilient Cities, College of Agriculture, Vellayani, Thiruvananthapuram.
- Jury member for MANAGE award committee for selection of best Ph.D. thesis in Agricultural Extension sponsored by MANAGE, Hyderabad, Telangana.
- Expert in the KAU-IIT Palakkad Technology IHub Foundation pre-proposal workshop on Skill Development Training for Rural Development during 18-19 November 2022 at RARS, Ambalavayal, Wayanad, Kerala.
- Expert for contributing video lessons for the PGDAEM course on Facilitation for Development (3 Credits), MANAGE Hyderabad, Telangana.
- Business expert for screening business plans presented in the IDEA FEST organized by the Kerala Startup Mission on 02 August 2022 and screening applications for the projects viz., Research Incubation Programme (RINP) of the MG University, Kottayam and the Kerala Startup Mission during October 2022 and Entrepreneurship Development by SC/ST Women in STEM (ED/SC-ST-WISTEM) 2022-2023 by KSCSTE during November 2022.

- Resource person for PGDAEM-MANAGE correspondence course.
- External examiner for three Ph.D. students in Agricultural Extension, Kerala Agricultural University and Agricultural Communication and Extension, GB Pant University of Agriculture and Technology, Pantnagar and five M.Sc. (Ag.) students, Agricultural Extension, Kerala Agricultural University.

Dr. D. Jaganathan

- Expert in Scientific Advisory Committee meeting of ICAR-KVK, Thiruvananthapuram and Ernakulam.
- Resource person for PGDAEM-MANAGE correspondence courses.
- External examiner for three Ph.D. and 10 M.Sc. (Ag.) students, Kerala Agricultural University.
- External expert for the defence seminar of a Ph.D. scholar, Kerala Agricultural University.
- Reviewer, Journal of Agricultural Economics and Rural Development, Journal of Global Agriculture and Ecology, Journal of Economics and Development, Asian Journal of Agricultural Extension, Economics & Sociology and Journal of Experimental Agriculture International.

Dr. P. Prakash

- Resource person, e-Training course on ICAR JRF/SRF, NET/ARS Exam preparation for students of Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Ahmednagar, Maharashtra.
- Reviewer, Indian Journal of Economics and Development and Journal of Cogent Food & Agriculture.

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. College of Agriculture, Kerala Agricultural University, Vellayani, Thiruvananthapuram, Kerala
2. National Institute of Food Technology, Entrepreneurship and Management, Thanjavur (NIFTEM-T), Tamil Nadu
3. Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh
4. Dr. YSR Horticultural University, Andhra Pradesh
5. Coconut Development Board, Government of India
6. Odisha University of Agriculture & Technology, Bhubaneswar, Odisha
7. M/s SAGOSERVE, Salem, Tamil Nadu
8. Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), Chennai, Tamil Nadu

Linkage through collaborative research and extension activities

1. ICAR-Indian Institute of Horticultural Research, Bengaluru
2. ICAR-Central Institute of Women in Agriculture, Bhubaneswar
3. ICAR-National Rice Research Institute, Cuttack
4. ICAR-Central Institute of Fisheries Technology, Kochi
5. ICAR-Central Plantation Crops Research Institute, Kasaragod
6. ICAR-Indian Institute of Farming Systems Research, Modipuram
7. ICAR Research Complex for NEH Region, Barapani
8. ICAR-National Academy of Agricultural Research Management, Hyderabad
9. ICAR-Indian Institute of Spices Research, Kozhikode
10. ICAR-Sugarcane Breeding Institute, Coimbatore
11. Agricultural Technology Application Research Institute, Bengaluru
12. Kerala Agricultural University, Thrissur
13. Tamil Nadu Agricultural University, Coimbatore
14. Department of Horticulture and Department of Agriculture, Government of Odisha
15. Department of Agriculture, Government of Kerala
16. Department of Horticulture, Government of Tamil Nadu
17. ICAR-National Research Centre for Banana, Trichy, Tamil Nadu
18. ICAR-Central Institute of Agricultural Engineering Regional Office, Coimbatore
19. National Institute of Technology, Trichy
20. ICAR-Central Institute for Research on Cotton Technology, Mumbai
21. CIPET: Institute of Petrochemicals Engineering & Technology (IPT), Kochi

Linkage 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. Department of Atomic Energy, Government of India
6. National Bank for Agriculture and Rural Development (NABARD), Government of India
7. Coconut Development Board, Government of India
8. Rashtriya Krishi Vikas Yojana (RKVY), Government of Odisha and Government of Kerala
9. Department of Agriculture and Farmers' Welfare, Government of Kerala
10. Kerala State Planning Board, Government of Kerala
11. Kerala State Council for Science, Technology and Environment (KSCSTE), Government of Kerala
12. Kerala State Horticulture Mission, Government of Kerala

Others

1. ICAR-CTCRI with its Institute Technology Management Unit & Professional Services Cell (ITMU & 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, 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, Jajpur and Mayurbhanj 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

1. Acharya, V., Arutselvan, R., Pati, K., Rout, A.K., Dehury, B., Chauhan, V.B.S. and Nedunchezhiyan, M. 2022. Structural insights into the RNA interaction with Yam bean mosaic virus (coat protein) from *Pachyrhizus erosus* using bioinformatics approach. *PloS One*, **17**(7): e0270534. (*NAAS score: 9.24*).

2. Amrutha, P., Jeeva, M.L., Sreelatha, G.L., Mohan, A.K., Cyriac, T. and Shilpa, S.U. 2022. Potential microbes from medicinal plants against *Colletotrichum gloeosporioides* causing anthracnose in greater yam (*Dioscorea alata* L.). *South Asian J. Exp. Biol.*, **12**(6): 875-889. https://orcid.org/0000-0001-7690-6114.

3. Ana Raj, J., Jaganathan, D., Prakash, P. and Sheela Immanuel. 2022. Women's empowerment index in cassava: An innovative tool for gender mainstreaming. *Indian J. Ext. Educ.*, **58**(4): 42-45. http://doi.org/10.48165/ IJEE.2022.58409. (*NAAS score: 5.95*).

4. Arutselvan, R., Prasad, R., Devi, G.U. and Sarada, C. 2022. Management of graymold disease of castor using fungicides. *Indian Phytopathol*. https://doi.org/10.1007/s42360-022-00556-y. (*NAAS score: 5.95*).

5. Behera, S., Chauhan, V.B.S., Pati, K., Bansode, V., Nedunchezhiyan, M., Verma, A.K. and Naik, S.K. 2022. Biology and biotechnological aspect of sweet potato (*Ipomoea batatas* L.): a commercially important tuber crop. *Planta*, **256**: 40. https://doi.org/10.1007/s00425-022-03938-8. (*NAAS score: 10.12*).

6. Damodaran, V., Jerard, B.A., Sanjay Kumar Pandey, Zachariah George, Singh, S.K., Jaisankar, I., Singh, L.B., James George and Sunitha, S. 2022. Traditional knowledge on Nicobari aloo (*Dioscorea alata* L.) among Nicobari tribal community of Car Nicobar Island, India. *Indian J. Tradit. Knowl.*, **21**(4): 834-843. DOI: 10.56042/ijtk. v21i4.32197. (*NAAS score: 6.76*).

7. Elisabeth, D.A.A., Utomo, J.S., Byju, G. and Ginting, E. 2022. Cassava flour production by small scale processors, its quality and economic feasibility. *Food Sci. Technol. Campinas*, **42**, e41522, DOI: https://doi.org/10.1590/fst.41522.

8. Elizabeth Mary John, Sreekumar, J. and Jisha, M.S. 2022. Remediation of chlorpyrifos in soil using immobilized bacterial consortium biostimulated with organic amendment, *Biocatal. Biotransformation*. DOI: 10.1080/ 10242422.2022. 2085033. https://doi.org/10.1080/10242422.2022.2085033. (*NAAS score: 8.33*).

9. Femina, F.N., Veena, S.S., Karthikeyan, S. and Sreelatha, G.L. 2020. Growth promotion in elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson) consequent to colonization by the root endophytic fungus, *Piriformospora indica*. *J. Root Crops,* **46**(2): 94-100.

10. Harish, E.R. and Archana Vijayan. 2022. Identification of distinct endosymbionts of whiteflies- infesting cassava (*Manihot esculenta* Crantz), using diagnostic PCR and Sanger Sequencing. *Int. J. Bio-resour. Stress Manag.*, **13**(12): 1348-1354. https://doi.org/10.23910/1.2022.3267.

11. Jeeva, M.L., Veena, S.S., Makeshkumar, T., Karthikeyan, S., Amrutha, P.R. and Shilpa, S.U. 2020. Emerging cassava root and stem rot: A challenge to wetland farmers in Kerala. *J. Root Crops,* **46 (**2): 114-117.

12. Laxminarayana, K. 2022. Effect of organic and inorganic fertilization on soil enzyme activities in relation to yield and proximate composition of Colocasia (*Colocasia esculenta*) in alfisols of eastern India. *Commun. Soil Sci. Plant Anal.,* **53**(9): 2635-2651, DOI: 10.1080/00103624.2022.2072862. (*NAAS score: 7.58*).

13. Mahanta, S., Prusty, M., Sivakumar, P.S., Mishra, D., Sahu, R.P., Goswami, C., Chawla, S., Goswami, L., Elangovan, S. and Panda, S.K. 2022. Novel *Levilactobacillus brevis*-based formulation for controlling cell proliferation, cell migration and gut dysbiosis, LWT- *Food Sci. Technol.*, **154**: 112818. DOI: https://doi.org/10.1016/j.lwt.2021.112818.

14. Mahanta, S., Sivakumar, P.S., Parhi, P., Mohapatra, R.K., Dey, G., Panda, S.H., Sireswar, S. and Panda, S.K. 2022. Sour beer production in India using a coculture of *Saccharomyces pastorianus* and *Lactobacillus plantarum*: optimization, microbiological, and biochemical profiling. *Braz. J. Microbiol.,* **53**: 947-958. DOI: https://doi.org/10.1007/s42770-022-00691-8. (*NAAS score: 8.21*).

15. Meenu Kumari, Naresh, P., Acharya, G.C., Laxminarayana, K., Singh, H.S., Raghu, B.R. and Aghora, T.S. 2022. Nutritional diversity of Indian lablab bean (*Lablab purpureus* L. Sweet): An approach towards biofortification. *S. Afr. J. Bot*., **149**: 189-195. https://doi.org/10.1016/j.sajb.2022.06.002. (*NAAS score: 9.11*).

16. Nedunchezhiyan, M., Pati, K., Chauhan, V.B.S., Arutselvan, R., Laxminarayana, K., Byju, G. and Veena, S.S. 2020. Growth, dry matter production and yield characteristics of greater yam + maize intercropping system under varied drip irrigation and fertigation levels. *J. Root Crops,* **46**(2): 14-22.

17. Nedunchezhiyan, M., Pati, K., Chauhan,V.B.S., and Arutselvan, R. 2023. Analysis of benefit:cost ratio in drip irrigation and fertigation in greater yam (*Dioscorea alata*) + maize (*Zea mays*) intercropping system. *Current Hortic.,* **11**(1): 57-60. (*NAAS score: 4.53*).

18. Nedunchezhiyan, M., Suja, G. and Ravi, V. 2022. Tropical root and tuber crops based cropping systems-A review. *Current Hortic.*, **10**(1): 14-22. http://doi.org/10.5958/2455-7560.2022.00003.6. (*NAAS score: 4.53*).

19. Negi, P.K., Sharma, R.R., Kumar, R. and Chauhan, V.B.S. 2022. Combining ability for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). *Progress. Hortic.,* **54**(1): 107-110. (*NAAS score*: 4.49).

20. Pradeepika, C., Namrata, G., Krishnakumar, T., Sajeev, M.S. and Shanavas, S. 2022. Development of low-fat and anthocyanin-rich purple sweet potato vacuum fried chips. *J. Food Sci*., **87**: 2894-2907. (*NAAS score: 9.17*).

21. Pradhan, B., Panda, D., Bishi, S.K., Chakraborty, K., Senthilkumar, K.M. and Lenka, S.K. 2022. Progress and prospects of C4 trait engineering in plants. *Plant Biol*., **24**(6): 920-931. (*NAAS score: 9.08*).

22. Prakash P., Jaganathan D., Sheela Immanuel, Sivakumar, P.S., Muthuraj, R., Krishnakumar, T. and Prabhat Kishore. 2022. Socio-economic impact of improved variety and production technologies of Chinese potato in Tamil Nadu. *Indian J. Agric. Econ.*, **77**(3): 497. (*NAAS score: 5.30*).

23. Prakash, P., Jaganathan, D., Sheela Immanuel, Achal Lama, Sreekumar, J. and Sivakumar, P.S. 2022. Forecasting of sweet potato (*Ipomoea batatas* L.) prices in India. *Indian J. Ext. Educ.*, **58**(02): 15-20. (*NAAS score: 5.95*).

24. Prakash, P., Kumar, P., Reddy, K.V., Kumar, K.N.R., Konduru, S., Paramesh, V., Rajanna, G.A., Shankarappa, S.K., Jaganathan, D., Sheela Immanuel, Kamble, A.L., Selvakumar, R., Immanuelraj, K.T., Manogaran, B.R., Perumal, A., Maruthanayagam, U. and Niranjan, S. 2022. Protected cultivation of horticultural crops as a livelihood opportunity in Western India: An economic assessment. *Sustain*, ***14***: 7430. https://doi.org/10.3390/su14127430. (*NAAS score: 9.89*).

25. Prakash, P., Kumar, P., Kar, A., Singh, A.K. and Anbukkani, P. 2022. Economic analysis of carnation (*Dianthus caryophyllus*) under protected cultivation in Maharashtra. *Indian J. Agric. Sci.,* **92**(04): 460-463. (*NAAS score: 6.37*).

26. Prakash, P., Kumar, P., Kishore, P., Jaganathan, D., Sheela Immanuel and Varadha Raj, S. 2022. Determinant of access to credit and availing subsidies for protected cultivation in Maharashtra. *Indian J. Ext. Educ.*, **58**(02): 167-172. (*NAAS score: 5.95*).

27. Raji, P. and Byju, G. 2022. QUEFTS model - a tool for site-specific nutrient management of crops: a review. *Commun. Soil Sci. Plant Anal.,* https://doi.org/10.1080/00103624.2022.2071924. (*NAAS score: 7.58*).

28. Raji P., Sunitha, S., Mithra, V.S.S. and Byju, G. 2021. Impact of climate change on water requirement of tropical root and tuber crops in India. *Int. J. Innov. Hortic.* **10**(2): 170-172. 10.5958/2582-2527.2021.00019.1. (*NAAS score: 3.40*).

29. Raji, S. N., Saravanan, R. and Ravi, V. 2021. Impact of fluctuating actinic high light stress on biomass and yield of cassava. *J. Root Crops*, **47**(1): 3-9.

30. Randhe, R.D., Murtaza Hasan, Singh, D.K., Pramod Kumar and Prakash, P. 2022. Economic feasibility of grow bag-based cucumber and capsicum cultivation under green house. *Indian J. Hortic.,* **79**(4): 458-463. (*NAAS score: 6.16*).

31. Ravi, V., More, S.J., Muthuraj, R. and Suja, G. 2022. Assessment of photosynthetic efficiency of greater yam and white yam subjected to elevated carbon dioxide. *S. Afr. J. Bot*., https://doi.org/10.1016/j.sajb.2021.12.041. (*NAAS score: 9.11*).

32. Sahoo, B., Sunita, K., Nedunchezhiyan, M. and Acharyya, P. 2022. Remunerative crop substitution in coastal humid tropics: Biomass production and partitioning, yield and quality of elephant foot yam as influenced by fertility levels. *J. Community Mobilization Sustain. Dev.,* **3** (Seminar Special Issue): 822-828.

33. Sandra, J., Pavaya, R.P., Suresh Kumar, J. and Malav, J.K. 2022. Influence of different combinations of NPK and micronutrients on nutritional status and quality parameters of sesame under loamy sand of Gujarat. *Pharma Innovation,* **11**(11): 1846-1851. (*NAAS score: 5.23*).

34. Sangeetha, G., Dolly, P., Arutselvan, R., Nagendran, K., Naresh, P., Gobind, C.A. and Krishna Reddy, M. 2022. First report of cucumber mosaic virus infecting *Centella asiatica* L. in India. *J. Plant Pathol*., **104**: 1191. DOI:10.1007/s42161-022-01160-9. (*NAAS score: 7.73*).

35. Saravanan, R., Stephen, R. and Ravi, V. 2020. Post-harvest physiological deterioration of cassava roots (*Manihot esculenta* Crantz) during storage under different temperatures. *J. Root Crops*. **46**(2): 3-7.

36. Seena Radhakrishnan, A. R., Suja, G. and Sreekumar, J. 2022. How sustainable is organic management in cassava? Evidences from yield, soil quality, energetics and economics in the humid tropics of South India. *Sci. Hortic.*, **293**, https://doi.org/10.1016/j.scienta.2021.110723. (*NAAS score: 9.46*).

37. Shirly Raichal Anil, Babitha Babu, Krishna Radhika, N., Asha Devi, A., Prakash Krishnan, B.S. and Sreekumar, J. 2020. Identification of duplicates in the germplasm of sweet potato (*Ipomoea batatas* (L.) Lam.) using morphological and molecular markers. *J. Root Crops*, **46**(2): 3-13.

38. Sivakumar, P.S., Nedunchezhiyan, M., Adhiguru, P. and Jata, S.K. 2022. Estimation of farmers' willingness-to-pay for quality planting material of greater yam (*Dioscorea alata* L.). *Indian J. Ext. Educ.*, **58**(2): 135-139. http://doi.org/10.48165/IJEE.2022.58226. (*NAAS score: 5.95*).

39. Sivakumar, P.S., Thirugnanavel, A. and Prabhakar, M.E. 2022. Eating attitudes and body image dissatisfaction among Naga girl students. *Int. J. Indian Psychol.,* **10**(1): 711-723.

40. Sivan, S., Arya, K., Sheela, M.N., Revathi, B.S. and Abhilash, P.V. 2022. Correlation studies and path analysis on root traits contributing to nitrogen use

efficiency in cassava genotypes. *Pharma Innovation*, **11**(11): 1040-1042. (*NAAS score: 5.23*).

41. Sreekumar, J., Muhammed Sadiq, P.A., Raju, S. and Archana Mukherjee. 2022. *In silico* analysis of carotenoid biosynthesis pathway in cassava (*Manihot esculenta* Crantz). *J. Genet.,* **101**(2). https://doi.org/10.1007/s12041-021-01345-8. (*NAAS score: 7.51*).

42. Stephen, K., Beena, R., Kiran, A.G. Shanija, S. and Saravanan, R. 2022. Changes in physiological traits and expression of key genes involved in sugar signaling pathway in rice under high temperature stress. *3 Biotech,* **12**(9):183. https://doi.org /10.1007/s13205-022-03242-y. (*NAAS score: 8.89*).

43. Suja, G., Subramanian, P., Surekha, R., Jaganathan, D., Lintu Maria, C. and Rakhi K. Raj. 2022. Organic management is a viable alternative for yams intercropped in coconut plantation: evidences from a validation trial in the coastal humid tropics of Kerala, India. *Indian J. Agric. Sci*., **92**(8): 966-969. (*NAAS score: 6.37*).

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45. Sujathamma, P., Nedunchezhiyan, M. and Naik, B.S.K. 2022. Response of super early varieties of pigeonpea to crop geometry under rainfed conditions. *Indian J. Agric. Res.*, DOI: 10.18805/IJARe.A-5978. (*NAAS score: 5.20).*

46. Sunitha, S., Suresh Kumar, J., Sreekumar, J., Suja, G., Ramesh, V. and Byju, G. 2022. Water requirement of upland taro (*Colocasia esculenta*) under humid tropical zones of India. *Indian J. Agric. Sci*., **92**(11): 1364-1368. https://doi.org/10.56093/ijas.v92i11.125277. (*NAAS score: 6.37*).

47. Sunitha, S., Suresh Kumar, J., Sreekumar, J., Nedunchezhiyan, M., Mamatha, K., Kamalkumaran, P.R., Pradnya, G., Ketan, D. and Shanker, D. 2022. Influences of intercropping on productivity and profitability of greater yam (*Dioscorea alat*a L.). *J. Crop Weed*, **18**(2): 85-93. https://doi.org/10.22271/09746315.2022.v18.i2.1577. (*NAAS score: 5.46*).

48. Suresh Kumar, J. and Pandit, M.K. 2022. Genetic variability, diversity, heterosis and combining ability in sponge gourd [*Luffa cylindrica* (Roem.) L.]. *Int. J. Bio-resour. Stress Manag.,* **13**(10): 1047-1056. DOI: 10.23910/1.2022.3117.

49. Suresh Kumar, J., Sandra Jose, Akash, A.U., Sunitha, S., Sunilkumar, K. 2022. Hydroponics as an advanced agricultural production system for cultivation of vegetables and short duration high value crops. *Int. J. Trop. Agric.,* **40**(3-4): 289-307. (*NAAS score: 5.46*).

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4. ICAR-CTCRI. 2022. *Research Highlights 2021*. ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 40 p.

Radio Talks

1. Santhosh Mithra, V.S. 2022. *Vilayeriya 75 varshangal in Vartha tharangini* (Malayalam), All India Radio, Thiruvananthapuram on 25 August 2022.
2. Suja, G. 2022. *Importance of tropical tuber crops in food security*. Farm & Home Section, All India Radio, Thiruvananthapuram on 17 October 2022 (on the occasion of International Poverty Eradication Day).
3. Susan John, K. *Importance of secondary and micronutrients in tuber crops*. (Discussion), Farm and Home Section, All India Radio, Thiruvananthapuram on 25 November 2022.

TV Programmes

1. Jaganathan, D., Muthuraj, R. and Prakash, P. 2022. *Improved variety of cassava 'Sree Athulya' for higher yield and farm income in Namakkal district of Tamil Nadu*, Pudhiya Thalaimurai (Tamil), on 24 December 2022.
2. Muthuraj, R. and Jaganathan, D. 2022. *Site specific nutrient management in cassava for enhancing productivity and profitability from cassava farming in Namakkal district of Tamil Nadu*, Doordarshan Podhigai, on 10 August 2022.
3. Muthuraj, R., Jaganathan, D. and Prakash, P. 2022. *Seed villages on improved varieties of cassava for quality planting material production in Namakkal district of Tamil Nadu*, Doordarshan Podhigai (Tamil), on 24 December 2022.
4. Santhosh Mithra, V.S. 2022. *Nirmitha Budhiyum Krishi Saadhyathakalum* (Malayalam), Doordarshan, on 09 April 2022.
5. Santhosh Mithra, V.S. 2022. A talk on *Ini Krishi Smartakum* (Malayalam) telecast in connection with Training on Smart Farming Using Electronic Crop *(e-Crop)* (TOSFUE-2022) at ICAR-CTCRI in Doordarshan, on 16 June 2022 and 17 July 2022.
6. Santhosh Mithra, V.S. 2022. Live phone-in programme on *2023il Krishi Smartakumo* (Malayalam) in Doordarshan, on 30 December 2022.
7. Suja, G. 2022. Live phone-in programme on *Crop management of tuber crops*, (Malayalam), Krishi Darshan, Doordarshan Kendra, Thiruvananthapuram, on 04 March 2022.
8. Susan John, K. 2022. Live phone-in programme *Valamisrithangal kizhangu vilakalil* (Malayalam), Krishi Darshan, Doordarshan Kendra, Thiruvananthapuram, on 08 April 2022.

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.	Programme on Release of Prime Minister Kisan Samman Nidhi Fund	ICAR-CTCRI, Thiruvananthapuram 01 January 2022	All Staff members
2.	Webinar on Clean Milk-Better Health and Price	ICAR-CTCRI, Thiruvananthapuram 04 January 2022	All Scientists and Technical Staff members
3.	Foundation Day celebrations of ICAR-CPCRI, Kasaragod	ICAR-CPCRI, Kasaragod, Kerala 05 January 2022	Dr. D. Jaganathan
4.	Indian Phytopathological Society Platinum Jubilee Lecture Series 20 (Online)	Indian Phytopathological Society, New Delhi 05 January 2022	Dr. S.S. Veena Dr. T. Makeshkumar
5.	Webinar on Hi-tech Horticulture for Higher Productivity and Income	ICAR-CTCRI, Thiruvananthapuram 10 January 2022	All Scientists and Technical Staff members
6.	International Conference on Sustainable Utilization of Bio Resources (ICSUB 2022)	Department of Botany, University of Kerala, Thiruvananthapuram 10-15 January 2022	Dr. K.I. Asha Dr. N. Krishna Radhika
7.	Webinar and Interaction with Plant Genome Saviour Rewardee Farmers	PPV& FRA, ICAR-CTCRI, Thiruvananthapuram 11 January 2022	Dr. K.I. Asha
8.	Webinar on Vertical Farming-Urban Farming: A Sustainable Innovation and Business Approach	ICAR-CTCRI, Thiruvananthapuram 12 January 2022	All Scientists and Technical Staff members
9.	Webinar on Novel Approaches in the Biological Control of Insect Pests	ICAR-CTCRI, Thiruvananthapuram 17 January 2022	All Scientists and Technical Staff members
10.	Webinar on Entrepreneurial Opportunities in Food Processing	ICAR-CTCRI, Thiruvananthapuram 19 January 2022	All Scientists and Technical Staff members
11.	Institute Bio-safety Committee Meeting	ICAR-CTCRI, Thiruvananthapuram 19 January 2022	Dr. M.N. Sheela Dr. M.L. Jeeva Dr. T. Makeshkumar Dr. N. Krishna Radhika Dr. K.M. Senthilkumar
12.	Webinar on Empowering Girl Child as part of National Girl Child Day Celebration	ICAR-CTCRI, Thiruvananthapuram 24 January 2022	All Scientists and Technical Staff members

13.	Webinar on Agro techniques and Nutrient Management in Sweet Potato: Recent Advances	ICAR-CTCRI, Thiruvananthapuram 27 January 2022	All Scientists and Technical Staff members
14.	Webinar on Intellectual Property Rights	College of Agriculture, Vellayani, Thiruvananthapuram 08 February 2022	Dr. S.S. Veena
15.	Webinar on Cropping Systems Involving Tuber Crops and Pulses for Health and Wealth on the occasion of World Pulse Crop Day	ICAR-CTCRI, Thiruvananthapuram 10 February 2022	All Scientists and Technical Staff members
16.	Kerala Science Congress (Online)	10-12 February 2022	Dr. S.S. Veena
17.	Orientation Programme of the Evaluators	K-DISC, Thiruvananthapuram 11 February 2022	Dr. Sheela Immanuel
18.	National Science Day Celebrations	ICAR-CTCRI, Thiruvananthapuram 24 February 2022	All Staff members
19.	AINP OF Mid-term Review Meeting on Natural Farming (Online)	ICAR-IIFSR, Modipuram, Meerut, Uttar Pradesh 25 February 2022	Dr. G. Suja
20.	National Webinar on Tuber crops and Food Security under Changing Climate	ICAR-CTCRI, Thiruvananthapuram 25 February 2022	All Scientists and Technical Staff members
21.	National Webinar on Biofortified Crops for Balanced Nutrition and Immunity Boosting	ICAR-National Institute for Plant Biotechnology, New Delhi 28 February 2022	Dr. K.M. Senthilkumar
22.	International Conference on Agriculture for Sustainable Future (Agri Vision -2022)	Ravenshaw University, Cuttack, Odisha 06-08 March 2022	Dr. M. Nedunchezhiyan Dr. Kalidas Pati Dr. V.B.S. Chauhan
23.	30th Meeting of Scientific Advisory Committee of KVK, Ganjam-1 (Online)	08 March 2022	Dr. K. Laxminarayana
24.	International Women's Day Celebrations	ICAR-CTCRI, Thiruvananthapuram 08 March 2022	All Staff members
25.	IPR Awareness/Training Programme under National Intellectual Property Awareness Mission	ICAR-CTCRI, Thiruvananthapuram 14 March 2022	Dr. S.S. Veena Dr. T. Makeshkumar
26.	Meeting of 13th Scientific Advisory Committee Meeting of ICAR-Krishi Vigyan Kendra	Krishi Vigyan Kendra, Nagercoil, Kanyakumari 16 March 2022	Dr. V. Ramesh
27.	First Meeting of IX Research Advisory Committee Meeting	ICAR-CTCRI, Thiruvananthapuram 18-19 March 2022	All Scientists
28.	58th Project Approval Committee Meeting of Technology Mission on Coconut	Coconut Development Board, Kochi, Kerala 21 March 2022	Dr. G. Byju Dr. G. Suja Dr. D. Jaganathan

29.	Webinar on Ground Water: Making the Invisible Visible-World Water Day 2022	ICAR-CTCRI, Thiruvananthapuram 22 March 2022	All Scientists and Technical Staff members
30.	Indian Phytopathological Society-8th International Conference (Hybrid Mode) Plant Pathology: Retrospect and Prospects	Indian Phytopathological Society, SKN Agriculture University, Jobner 23-26 March 2022	Dr. S.S. Veena
31.	Satellite Symposium on Advances in Nematology	Chaudhary Charan Singh University, Meerut, Uttar Pradesh 29-30 March 2022	Dr. H. Kesava Kumar
32.	Workshop on Carbon Neutral Keralam organised by Haritha Keralam Mission	Vellar, Thiruvananthapuram 01-02 April 2022	Dr. V. Ramesh
33.	World Homeopathic Day Celebration and Workshop organized by AYUSH, Govt. of Kerala	Mascot Hotel, Thiruvananthapuram 12 April 2022	Dr. J. Sreekumar
34.	Kisan Bhagidari Prathmikta Hamari Campaign	ICAR-CTCRI, Thiruvananthapuram 27 April 2022	All Staff members
35.	Second Indian Horticulture Summit-2022	Navsari Agricultural University, Gujarat 27-29 April 2022	Dr. M. Nedunchezhiyan Dr. P. Murugesan
36.	International Workshop on Climate Proofing of Watershed Development Projects with Special Reference to Soil and Water Conservation Technologies in the Context of Climate Smart Agriculture	Udhagamandalam, Tamil Nadu 02-03 May 2022	Dr. V. Ramesh
37.	22nd Annual Group Meeting of AICRP on Tuber Crops	ICAR-Research Complex for NEH region, Umiam, Barapani, Meghalaya 11-13 May 2022	Dr. M.N. Sheela Dr. G. Byju Dr. M. Nedunchezhiyan Dr. S. Sunitha Dr. K. Laxminarayana Dr. M.L. Jeeva Dr. M.S. Sajeev Dr. K.I. Asha Dr. T. Makeshkumar Dr. Shirly Raichal Anil Dr. J. Sreekumar Dr. V.S. Santhosh Mithra Dr. Kalidas Pati Dr. J. Suresh Kumar
38.	Institute Management Committee Meeting	ICAR-CTCRI, Thiruvananthapuram 17 May 2022	All IMC members

39.	National e-Conference on Biotic Stress Management Strategies for Achieving Sustainable Crop Production and Climate Resilience	ICAR-NCIPM and ICAR-IARI, New Delhi 19-21 May 2022	Dr. C.A. Jayaprakas Dr. S.S. Veena Dr. T. Makeshkumar
40.	International Webinar on Prospects of Varieties/Crops Developed through Genome Editing (regulatory framework, technologies and experience)	PPV&FRA, New Delhi in collaboration with Department of Agriculture and Farmers' Welfare, Govt. of India and Federal Ministry of Food, Agriculture and Consumer Protection, Germany 24 May 2022	Dr. K.I. Asha
41.	Workshop on Developing Appropriate Sampling Techniques and Methodology for Evolving a Practical Formula under Carbon Neutral Programme of Kerala Government	Haritha Keralam Mission, Thiruvananthapuram 03 June 2022	Dr. V. Ramesh
42.	Shri. H.H. Sree Visakham Thirunal Endowment Lecture-2022 'Climate change and renewable energy'	ICAR-CTCRI, Thiruvananthapuram 10 June 2022	All Staff members
43.	Vikasana Seminar	Parassala Block Panchayat, Parassala, Thiruvananthapuram 14 June 2022	Dr. V. Ramesh
44.	6th Dr. Y.R. Sarma Memorial Lecture (Online)	ICAR-Indian Institute of Spices Research, Kozhikode 20 June 2022	Dr. M.L. Jeeva Dr. S.S. Veena Dr. T. Makeshkumar
45.	8th International Yoga Day	ICAR-CTCRI, Thiruvananthapuram 21 June 2022	All Staff members
46.	Awareness Campaign on Balanced and Efficient Use of Fertilizers	ICAR-CTCRI, Thiruvananthapuram 21 June 2022	All Scientists
47.	RINK Demo Day on Commercializable Tuber Crops Technologies for Startups and MSMEs	ICAR-CTCRI, Thiruvananthapuram 28 June 2022	All Scientists
48.	Webinar on Climate Change: Causes, Impacts and Way Forward for Indian Agriculture	ICAR-CTCRI, Thiruvananthapuram 05 July 2022	All Scientists and Technical Staff members
49.	Live Video Webinar – Workflow for Analysis of Ethylene Oxide and 2-Chloroethanol in Food Products	ICAR-National Research Centre for Grapes and Thermo Fisher Scientific 07 July 2022	Dr. A. Asha Devi
50.	Online Awareness Lecture on Laboratory Biosafety Practices	IBSC, ICAR-CTCRI, Thiruvananthapuram 15 July 2022	All Scientists of Crop Improvement Dr. M.L. Jeeva Dr. S.S. Veena Dr. T. Makeshkumar

51.	Webinar on Protected Cultivation: Experience of Western Sydney University	ICAR-CTCRI, Thiruvananthapuram 22 July 2022	All Scientists and Technical Staff members
52.	ICAR-APAARI Knowledge Management Workshop (Online)	23 July 2022	Dr. M.L. Jeeva
53.	Webinar on IPR related issues in the Commercialisation of Microbe Based Technologies	ICAR-National Bureau of Agriculturally Important Microorganisms, Mau, Uttar Pradesh, 25 July 2022	Dr. M.L. Jeeva Dr. S.S. Veena Dr. H. Kesava Kumar
54.	Webinar on Policy Intervention in Successful Implementation of IPM in the Country	ICAR-National Centre for Integrated Pest Management, New Delhi 26 July 2022	Dr. M.L. Jeeva Dr. H. Kesava Kumar
55.	Interface Meeting with Officials of Kerala Start-up Mission, Govt. of Kerala	ICAR-CTCRI, Thiruvananthapuram 29 July 2022	HoDs/SICs
56.	Stakeholders Meeting on Consultation for India's Position on GB9 Agenda, Meeting of Researchers Working with Plant Genetic Resources	Indian Society of Plant Genetic Resources, New Delhi 05 August 2022	Dr. A. Asha Devi
57.	Workshop on Entrepreneurship Development	Office of the Assistant Executive Engineer, Munnar, Idukki 06 August 2022	Dr. V.S. Santhosh Mithra
58.	ICAR-CTCRI and NABARD Officials Interaction Meeting	ICAR-CTCRI, Thiruvananthapuram 08 August 2022	Dr. Sheela Immanuel
59.	International Conference on Advances in Agriculture and Food Systems towards Sustainable Development Goals (AAFS 2022)	University of Agricultural Sciences (UAS), Bengaluru 22-24 August 2022	Dr. C. Visalakshi Chandra Dr. C. Pradeepika Dr. B.G. Sangeetha
60.	Technical Committee Meeting	State Pesticide Testing Laboratory, Department of Agriculture, Government of Kerala 26 August 2022	Dr. A.N. Jyothi
61.	Webinar on Genetic Resources of Underutilized Tuber Crops for Nutritional Security	ICAR-CTCRI, Thiruvananthapuram 27 August 2022	All Scientists
62.	Webinar on Good Management Practices in Tuber Crops	Farmer KAU Centre, Kozhikode 31 August 2022	Dr. G. Suja
63.	Stakeholders Workshop to address the requirements of departments in water sector	Centre for Water Resources Development and Management, Kozhikode 31 August 2022	Dr. S. Sunitha
64.	Meeting of the Regional Advisory Group 2022-23 of NABARD	Regional office, Thiruvananthapuram 31 August 2022	Dr. K. Sunilkumar
65.	Open Access Resources for Research Communities	ICAR-Indian Institute of Horticultural Research, Bengaluru 14 September 2022	All Scientists

66.	FAI (Southern Region) Seminar on Fertilizer Policy: Opportunities and Challenges	Fertilizers and Chemicals Travancore, Kochi 15 September 2022	Dr. K. Susan John
67.	Regional Seminar FAI (Southern Region) Seminar on Soil Health Governance through INM	Fertilizers and Chemicals Travancore, Kochi 17 September 2022	Dr. K. Susan John
68.	Consultation Virtual Meeting 9th Session of the Governing Body of International Treaty on Plant Genetic Resources for Food and Agriculture (GB9)	ITPGRFA (GB9), New Delhi 19-24 September 2022	Dr. K.I. Asha
69.	Stakeholder Workshop on The Economics of Ecosystem and Biodiversity for Agriculture and Food Programme Initiative for Uttar Pradesh (Online)	United Nations Environment Programme and ICAR-Indian Institute of Farming Systems Research 20 September 2022	Dr. G. Suja
70.	Institute Bio-safety Committee Meeting	ICAR-CTCRI, Thiruvananthapuram 21 September 2022	Dr. M.N. Sheela Dr. M.L. Jeeva Dr. T. Makeshkumar Dr. J. Sreekumar Dr. N. Krishna Radhika Dr. K.M. Senthilkumar
71.	Executive Committee Meeting	Central University of Kerala 22 September 2022	Dr. C.A. Jayaprakas
72.	Popular Science Online Lecture on Gene Editing: The Last Ten Years by Dr. Chithra Seetharam Misra, Scientist, Applied Genomics Section, BARC, Mumbai	Indian Women Scientists Association (IWSA), Vashi, Mumbai supported by BRNS-DAE in association with Department of Botany, St. Theresa's College, Ernakulam 24 September 2022	Dr. K.I. Asha
73.	Inauguration of Botany and Biotechnology Association	Bishop Moore College, Mavelikara 07 October 2022	Dr. C.A. Jayaprakas
74.	Inter Media Publicity Committee Meeting	Press Information Bureau at Government Guest House, Thycaud, Thiruvananthapuram 10 October 2022	Dr. Sheela Immanuel
75.	International Conference on Sustainable Agricultural Innovations for Resilient Agri Food Systems	Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, 13-15 October 2022	Dr. D. Jaganathan Dr. P. Prakash
76.	XXVI Meeting of ICAR-Regional Committee-II	ICAR-National Rice Research Institute, Cuttack, Odisha 14 October 2022	Dr. K. Laxminarayana

77.	Technical Support Group Meeting	Directorate of Horticulture, Bhubaneswar 26 October 2022	Dr. K. Laxminarayana
78.	International Conference on Physiological and Molecular Mechanisms for Abiotic Stress Tolerance in Plants	University of Calicut 26-28 October 2022	Dr. R. Saravanan
79.	International Conference on Emerging and Re-emerging Viral Infections Impacting Humans, Animals, Plants, Fish and Environment (Virocon 2022)	Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar 05-06 November 2022	Dr. T. Makeshkumar
80.	International Symposium on India @2047: Agricultural Engineering Perspective	Tamil Nadu Agricultural University, Coimbatore 09-11 November 2022	Dr. M.S. Sajeev Dr. T. Krishnakumar
81.	Revitalizing ICAR: Aspirations and Action Plan	Indian Council of Agricultural Research, New Delhi 11 November 2022	All Scientists
82.	National Seminar on Developments in in Soil Science-2022	Mahatma Pule Krishi Vidyapeeth, Rahuri, Maharashtra 14-18 November 2022	Dr. K. Laxminarayana
83.	International Workshop on Complementing Current Techniques with Next Generation Technologies for Crop Health Improvement	Aligarh Muslim University, Aligarh 14-19 November 2022	Dr. H. Kesava Kumar
84.	Inter Media Publicity Coordination Committee Meeting Organized by Press Information Bureau, Thiruvananthapuram	ICAR-CTCRI, Thiruvananthapuram 21 November 2022	Dr. Sheela Immanuel Dr. T. Makeshkumar Dr. R. Muthuraj Dr. D. Jaganathan
85.	National Workshop on CeRA	HRD, Agricultural Education Division, ICAR, New Delhi 21 November 2022	Dr. V. Ramesh Smt. B.S. Deepa
86.	Third National Oil Palm Conference	SOPOPRAD and ICAR-IIOPR, Pedavegi, Andhra Pradesh 23-25 November 2022	Dr. P. Murugesan
87.	Tuber Crops Day 2022	ICAR-CTCRI, Thiruvananthapuram 07 December 2022	All Staff members
88.	Opening Ceremony for the International Year of Millets – 2023 (IYoM 2023) (Online)	Food and Agriculture Organization, Rome, Italy 09 December 2022	All Scientists
89.	Think@thone programme	Cochin University of Science and Technology 10 December 2022	Dr. V.S. Santhosh Mithra

90.	International Conference on System of Crop Intensification (ICSCI 2022) for Climate-Smart Livelihood and Nutritional Security	ICAR- Indian Institute of Rice Research, Rajendranagar, Hyderabad 12-14 December 2022	Dr. V.S. Santhosh Mithra
91.	National Workshop on Smart Management of Agricultural Resources for Transforming Indian Farms (SMARTIF)	ICAR-CTCRI, Thiruvananthapuram 15-17 December 2022	Dr. M.N. Sheela Dr. G. Suja Dr. R. Muthuraj Dr. V. Ramesh Dr. R. Saravanan Dr. K. Sunilkumar Dr. P. Murugesan Dr. K.I. Asha Dr. A. Asha Devi Dr. T.P. Sujatha Dr. K.M. Senthilkumar Dr. E.R. Harish Dr. S.S. Veena Dr. D. Jaganathan
92.	14th International Conference on Agriculture, Horticulture & Food Sciences (ICAHFS)	New Delhi 17-18 December 2022	Dr. J. Suresh Kumar
93.	Second Working Group Meeting of Parassala block panchayat	Parassala, Thiruvananthapuram 19 December 2022	Dr. V. Ramesh
94.	State Credit Seminar 2023-24	NABARD, Regional Office, Thiruvananthapuram 21 December 2022	Dr. K. Sunilkumar
95.	3rd International Weed Conference	Anand, Gujarat 20-23 December 2022	Dr. J. Suresh Kumar
96.	17th Annual Group Meeting of AINPOF	Ramakrishna Mission Vivekananda Educational & Research Institute (RKMVERI), Narendrapur, West Bengal, 29-31 December 2022	Dr. G. Suja
97.	XIV Scientific Advisory Committee Meeting	ICAR-Krishi Vigyan Kendra, Thirupathisaram, Nagercoil, Kanyakumari district 30 December 2022	Dr. H. Kesava Kumar

Visit Abroad

Name of the Scientist	Period	Place of visit	Purpose
Dr. G. Suja	13-15 October 2022	Goesan County, South Korea	Participated in the Fifth Organic Asia Congress on Transcending Borders and Generations for an Organic Asia and presented an invited lead lecture 'Organic management fosters yield, income, quality and soil health: Eighteen years of evidence in tropical tuber crops'.

Distinguished Visitors

1. Mr. V. Muraleedharan, Hon'ble Union Minister of State for External Affairs and Parliamentary Affairs, Government of India.
2. Smt. L.R. Aarathi, Mission Director, State Horticulture Mission, Government of Kerala.
3. Dr. N.K. Krishna Kumar, Former DDG (Hort. Sci.), Indian Council of Agricultural Research, New Delhi.
4. Dr. Vikramaditya Pandey, ADG (Hort. Sci.), 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, College of Agriculture, Vellayani, Thiruvananthapuram.
7. Dr. Sanjaya Kumar Dash, Dean, College of Agricultural Engineering and Technology, Odisha University of Agriculture and Technology, Bhubaneswar.
8. Dr. P.M. Govindakrishnan, Former Project Coordinator, ICAR-Central Potato Research Institute, Shimla.
9. Dr. H. Philip, Former Director (Extension), Tamil Nadu Agricultural University, Coimbatore.
10. Dr. P. Pugazhendi IFS, Additional Principal Chief Conservator of Forests, Government of Kerala.
11. Dr. C. Anandharamakrishnan, Director, CSIR–National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram.
12. Mr. Anoop P. Ambika, Chief Executive Officer, Kerala Start-up Mission.
13. Dr. Roy Stephen, Dean of Faculty, College of Agriculture, Vellayani, Thiruvananthapuram.
14. Shri. Rishi Raj Singh IPS, Retired Director General of Police, Government of Kerala.
15. Mr. A. Nizamudeen, Commissioner, Kerala State Land Use Board, Government of Kerala.
16. Dr. Jacob John, Director of Extension, Kerala Agricultural University, Vellanikkara, Thrissur.
17. Dr. G. Gopakumaran Nair, Chief General Manager, NABARD, Kerala and Lakshadweep region.
18. Dr. Manoj P. Samuel, Executive Director, Centre for Water Resources Development and Management, Kozhikode.
19. Prof. J. Adinarayana, Professor, Centre for Studies in Resources Engineering, Indian Institute of Technology, Bombay.
20. Prof. K.G. Satheesh Kumar, Visiting Professor, Digital University Kerala.
21. Prof. (Dr.) G.M. Nair, Director, Central Laboratory for Instrumentation and Facilitation Centre (CLIFF), University of Kerala.

Personnel

Scientific Staff

Headquarters, Thiruvananthapuram	
Dr. M.N. Sheela	Director (Acting)
Division of Crop Improvement	
Dr. M.N. Sheela	Principal Scientist (Genetics and Plant Breeding) & Head (A)
Dr. P. Murugesan	Principal Scientist (Vegetable Science)
Dr. K.I. Asha	Principal Scientist (Economic Botany and PGR)
Dr. C. Mohan	Principal Scientist (Genetics and Plant Breeding)
Dr. A. Asha Devi	Principal Scientist (Genetics and Plant Breeding)
Dr. Shirly Raichal Anil	Principal Scientist (Genetics and Plant Breeding)
Dr. L.K. Bharathi	Principal Scientist (Vegetable Science)
Dr. N. Krishna Radhika	Senior Scientist (Agricultural Biotechnology)
Dr. T.P. Sujatha (w.e.f. 22.08.2022)	Scientist (Agricultural Biotechnology)
Dr. C. Visalakshi Chandra	Scientist (Genetics and Plant Breeding)
Dr. K.M. Senthilkumar	Scientist (Agricultural Biotechnology)
Dr. A.V.V. Koundinya (Transferred w.e.f. 02.04.2022)	Scientist (Vegetable Science)
Division of Crop Production	
Dr. G. Byju	Principal Scientist (Soil Science) & Head (A)
Dr. G. Suja	Principal Scientist (Agronomy)
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. R. Saravanan	Principal Scientist (Plant Physiology)
Dr. Sanket J. More (Transferred w.e.f. 12.08.2022)	Scientist (Vegetable Science)
Dr. J. Suresh Kumar	Scientist (Vegetable Science)
Division of Crop Protection	
Dr. M.L. Jeeva	Principal Scientist (Plant Pathology) & Head (A)
Dr. C.A. Jayaprakas	Principal Scientist (Agricultural Entomology)

Dr. S.S. Veena	Principal Scientist (Plant Pathology)
Dr. T. Makeshkumar	Principal Scientist (Plant Pathology)
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
Dr. A.N. Jyothi	Principal Scientist (Agricultural Chemicals)
Dr. C. Pradeepika	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
Dr. J. Sreekumar	Principal Scientist (Agricultural Statistics)
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 (w.e.f. 20.03.2022)
Shri. M. Kuriakose	Chief Technical Officer (w.e.f. 26.07.2022)
Shri. V.R. Sasankan	Assistant Chief Technical Officer
Shri. B. Renjith Kishor	Assistant Chief Technical Officer
Shri. V.S. Sreekumar	Assistant Chief Technical Officer (w.e.f. 24.07.2022)
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 (w.e.f. 20.03.2022)
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 (w.e.f. 03.08.2022)	Technical Assistant

Shri. T. Raghavan (Rtd. 28.02.2022)	Technical Assistant
Shri. B. Satheesan	Senior Technician
Shri. D.T. Rejin	Senior Technician
Shri. T.M. Shinil	Senior Technician
Shri. C. Krishnamoorthy (Rtd. 31.05.2022)	Senior Technician
Shri. K. Velayudhan (Rtd. 31.05.2022)	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. S. Bhadra Kumar (w.e.f. 10.08.2022)	Senior Administrative Officer (i/c)
Shri. T.D.S. Prakash	Senior Finance and Accounts Officer
Shri. P.C. Noble (Transferred w.e.f. 06.06.2022)	Assistant Administrative Officer
Shri. T. Vijayakumara Kurup	Assistant Administrative Officer
Shri. S. Sasikumar	Private Secretary
Shri. M. Padmakumar	Private Secretary
Smt. S. Sunitha	Personal Assistant
Smt. L. Saritha (w.e.f. 27.01.2022)	Personal Assistant
Smt. B. Presanna	Assistant
Shri. P.S. Suresh Kumar	Assistant
Shri. J. Unni	Assistant
Shri. K. Unnikrishnan Nair	Assistant
Shri. S. Hareendrakumar (Rtd. 31.05.2022)	Assistant
Shri. Arjun Murali (Transferred w.e.f. 15.01.2022)	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.

Canteen Staff	
Shri. S. Radhakrishnan Nair	Skilled Support Staff
Skilled Support Staff	
Smt. S. Ushakumari (Rtd. 31.05.2022)	Skilled Support Staff
Shri. P. Udayakumar	Skilled Support Staff
Shri. K. Saratchandra Kumar	Skilled Support Staff
Shri. G. Madhu	Skilled Support Staff
Shri. A. Chandran (Rtd. 30.04.2022)	Skilled Support Staff
Shri. T. Lawrence	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. M. Nedunchezhiyan	Principal Scientist (Agronomy) & Scientist in Charge
Dr. K. Laxminarayana	Principal Scientist (Soil Science) & Scientist in Charge (w.e.f. 11.04.2022)
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. K. Raja (Transferred w.e.f. 30.07.2022)	Technical Assistant
Shri. Keshab Paikaray	Senior Technician

Administrative Staff	
Shri. P.K. Acharya	Principal Private Secretary
Shri. A. Lakshmana Rao	Assistant

Skilled Support Staff	
Shri. Sauri Pradhan (Rtd. on 30.06.2022)	Skilled Support Staff
Shri. Babuli Sethi	Skilled Support Staff
Shri. Samsuddin Khan (Rtd. on 31.01.2022)	Skilled Support Staff
Shri. Prakash Kumar Nayak	Skilled Support Staff

Other Information

First Meeting of the IX Research Advisory Committee

The first meeting of IX RAC of ICAR-CTCRI was held during 18-19 March 2022 at ICAR-CTCRI, Thiruvananthapuram. Dr. N.K. Krishna Kumar, Former DDG (Hort. Sci.), ICAR chaired the meeting. Dr. M.N. Sheela, Director (A), ICAR-CTCRI, welcomed the chairman and members. She 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. The action taken report of the third meeting of RAC VIII was presented and approved. The project leaders presented the salient achievements of eight ongoing Institute mega projects and 28 externally aided projects and the targets for 2022-23.

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. P.M. Govindakrishnan, Former Project Coordinator, AICRP (Potato), ICAR-CPRI, Shimla	Member
6.	Dr. H. Philip, Former Director (Extension), TNAU, Coimbatore	Member
7.	Dr. Vikramaditya Pandey, ADG (HS-I), ICAR, KAB-II, Pusa, New Delhi	Member
8.	Dr. M.N. Sheela, Director (A), ICAR-CTCRI Thiruvananthapuram	Member
9.	Dr. P. Murugesan, Principal Scientist, ICAR-CTCRI Thiruvananthapuram	Member Secretary

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 farms, museum and Techno Incubation Centre. The meeting was coordinated by Dr. P. Murugesan, Principal Scientist & Member Secretary.

48th Meeting of Annual Institute Research Council

The 48th meeting of the Annual Institute Research Council of ICAR-CTCRI was held during 20-22 April 2022 under the leadership of Dr. M.N. Sheela, Director (A). The eight ongoing Institute mega projects with 41 research projects were presented by the Principal Investigators. The projects were thoroughly discussed and the suggestions were recorded and documented in the proceedings. The meeting concluded on the third day (22.04.2022) with the plenary session. Dr. M.N. Sheela in her concluding remarks expressed happiness about the successful conduct of the 48th IRC and thanked the Co-Chairmen and Rapporteurs of all the sessions. The IRC meeting was coordinated by Dr. C. Mohan, Principal Scientist & Member Secretary.

Tuber Day

A tuber day was organized by the Regional Station, Bhubaneswar under 'Tribal Sub Plan (TSP)' on 22 March 2022 at Tikabali, Kandhamal district, Odisha. Shree Prasant Kumar Satapathy, Chief District Agricultural Officer, Kandhamal and Dr. Subrat Kumar Behera, Chief Scientist, RRTTS, OUAT, Kandhamal were the Guests of Honour. The importance of tuber crops in food and nutritional security and livelihood, method of tuber crops cultivation and value addition were highlighted in the meeting. About 500 tribal farmers participated in the programme. Dr. M. Nedunchezhiyan, Principal Scientist & Principal Investigator (TSP) highlighted the adoption of 523 tribal farmers from nine blocks covering three districts of Odisha and the details of distribution of various other crops like maize, red gram etc. including vegetable seed kits, planting materials of various tuber crops, sprayers and implements to the tribal farmers. Exhibition on tuber crops, release of leaflets and publications and felicitations of best farmers were held.

State Level Stakeholders Interface cum Farmers' Fair

The ICAR-Central Tuber Crops Research Institute organized the Nationwide Live Web Telecast of Hon'ble Prime Minister's address and State Level Stakeholders Interface cum Farmers' Fair on 31 May 2022. The programme was inaugurated by Mr. V. Muraleedharan, Hon'ble Union Minister of State for External Affairs and Parliamentary Affairs, Govt. of India. In his inaugural address, he highlighted about the growth and development of the country, by integrating economic growth with the welfare of the people under the eminent leadership of Honourable Prime Minister Shri. Narendra Modi during the last eight years. He emphasized about the latest developments in agriculture, especially the commercial production of liquid nano-urea. He congratulated the scientists of ICAR-CTCRI for developing technologies like bio-fuel from cassava. He released the PIB Report depicting the achievements of Govt. of India during the last eight years and felicitated four farmers. Dr. M.N. Sheela, Director (A), ICAR-CTCRI in her presidential address stressed the importance of technologies developed by ICAR-CTCRI for doubling farmer's income. Hon'ble Prime Minister Shri. Narendra Modi addressed the gathering through live web telecast. He said that more than 10 crore farmers of India were benefitted through direct beneficiary transfer scheme worth ₹ 21,000 crores. He emphasized the triple power of 'Jan Dhan account, Aadhaar card and Mobile linked bank accounts' in the formation of New India. Various schemes of Govt. of India are now easily accessible to the poor and economically weaker section with the adoption of technologies. With more than 45 crores Jan Dhan accounts, a total of ₹ 22 lakhs have been distributed so far since last eight years through various schemes. Technical sessions on centre and state government agricultural schemes and integrated farming systems were organized after PM's live web telecast. State Bank of India, NABARD and Indian Society for Root Crops were the collaborators. As a part of the event, exhibitions and field visits were also arranged for the farmers and other stakeholders. More than 2000 farmers from different parts of Kerala participated in this programme.

Institute Biosafety Committee Meeting (IBSC)

The Institute Biosafety Committee Meeting (IBSC) was held at ICAR-CTCRI, Thiruvananthapuram on 19 January 2022 and 21 September 2022 to review the rDNA based research projects. Dr. M.N. Sheela, Director (A), 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.L. Jeeva, Head (A), Crop Protection; Dr. T. Makeshkumar, Principal Scientist & SIC, PME; Dr. J. Sreekumar, Principal Scientist and Dr. K.M. Senthilkumar attended the meeting and reviewed the progress of rDNA based research projects of ICAR-CTCRI. The committee members appreciated the scientists for strict adherence of the biosafety guidelines at the research laboratories of the Institute.

ICAR Sponsored Short Course on Exploitation of Genetic Resources of Underutilised Tuber Crops

ICAR sponsored short course on 'Exploitation of genetic resources of underutilized tuber crops' was organized at ICAR-CTCRI, Thiruvananthapuram during 02-11 February 2022. Dr. P. Pugazhendi IFS, Additional Principal Chief Conservator of Forests, Govt. of Kerala inaugurated the short course. Twenty-seven participants (15 female and 12 male) representing Central Agricultural Universities, ICAR Institutes, SAUs and KVKs participated in the programme in hybrid mode. The participants were from nine states viz. Andhra Pradesh, Bihar, Delhi, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Tamil Nadu and Tripura. Dr. N.K. Krishna Kumar, Former DDG (Hort. Sci.) & Chairman, RAC of ICAR-CTCRI graced the valedictory function and spoke about the action plan to the participants of the training.

Training on Scaling up of Biofortified Varieties

The ICAR-CTCRI in collaboration with MANAGE, Hyderabad organised an online training programme on 'Extension strategies for scaling up of biofortified crops' during 09-13 May 2022. The purpose of the programme was to equip the participants with essential knowledge and skills in selecting and using appropriate extension strategies for scaling up biofortified crops. This programme was inaugurated by Dr. P. Krishnamoorthy, Additional Director, National Institute of Public Cooperation and Child Development, New Delhi in the presence of Dr. M.N. Sheela, Director (A) who presided over the programme. Apart from ICAR-CTCRI, resource persons from Harvest Plus, MANAGE, NAARM, KIIT University, NGOs and Startups handled the sessions. Forty two participants from six Indian states attended the programme.

XVIII Institute Management Committee Meeting

The XVIII Institute Management Committee Meeting of ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram was held on 17 May 2022. The meeting was chaired by Dr. M.N. Sheela, Director (A), ICAR-CTCRI, Thiruvananthapuram and the following Members/Dignitaries/Officers attended the meeting.

1.	Dr. M.N. Sheela, Director (A), ICAR-CTCRI	Chairperson
2.	Dr. Manoj Kumar, Joint Director & Principal Scientist, ICAR-CPRI, RS, Modipuram	Member
3.	Dr. S. Kalavathi, Principal Scientist (Rtd.) ICAR-CPCRI, RS, Kayamkulam	Member
4.	Dr. Santhosh J. Eapen, Principal Scientist (Rtd.) ICAR-IISR, Kozhikode	Member
5.	Dr. Manish Das, Principal Scientist (HS), ICAR HQ New Delhi	Member
6.	Shri. R.K. Babu, Senior Finance & Accounts Officer ICAR-CIBA, Chennai	Member
7.	Shri. P.C. Noble, Senior Administrative Officer i/c ICAR-CTCRI	Member Secretary
8.	Dr. M.L. Jeeeva, Principal Scientist & Head (A) Division of Crop Protection ICAR-CTCRI	Special Invitee
9.	Dr. M.S. Sajeev, Principal Scientist & SIC Section of Crop Utilization ICAR-CTCRI	Special Invitee
10.	Dr. (Mrs.) Sheela Immanuel Principal Scientist & SIC Section of Extension and Social Sciences, ICAR-CTCRI	Special Invitee
11.	Dr. G. Suja, Principal Scientist ICAR-CTCRI	Special Invitee
12.	Dr. T. Makeshkumar, Principal Scientist & SIC (PME Cell) ICAR-CTCRI	Special Invitee
13.	Dr. K. Sunilkumar, Principal Scientist & SIC (Farm) ICAR-CTCRI	Special Invitee
14.	Dr. S. Sunitha, Principal Scientist & SIC (AICRP TC Cell) ICAR-CTCRI	Special Invitee

15.	Shri. T.D.S. Prakash, Senior Finance & Accounts Officer ICAR-CTCRI	Special Invitee
16.	Shri. T. Vijayakumara Kurup Assistant Administrative Officer ICAR-CTCRI	Special Invitee

Shri. P.C. Noble, Member Secretary, IMC & SAO i/c, ICAR-CTCRI, Thiruvananthapuram, welcomed all the members of the Institute Management Committee. Dr. M.N. Sheela, Director (A), ICAR-CTCRI delivered the Chairperson's speech on the mandate, research activities and achievements of the Institute. This was followed by a brief presentation of the action taken report. The same was accepted and approved by the house. SAO presented the report of establishment and personnel section. Senior Finance & Accounts Officer presented the progressive expenditure of 2021-2022.

Training on Smart Farming using Electronic Crop (e-Crop) (TOSFUE-2022)

Training on smart farming using electronic crop *(e-Crop)* (TOSFUE-2022) was organised on 16 June 2022 at ICAR-CTCRI, Thiruvananthapuram. Shri. P. Prasad, Hon'ble Minister for Agriculture, Govt. of Kerala, inaugurated the event. Dr. M.N. Sheela, Director (A), ICAR-CTCRI, presided over the function. Dr. Vikramaditya Pandey, ADG (Hort. Sci.), delivered the special address during the event. Smt. Aarathi L.R., Mission Director, State Horticulture Mission, Kerala, was the Guest of honour. About 200 farmers from five panchayats of Nedumangad block, Thiruvananthapuram participated. With the help of the smart fertigation system, fertigation can be enabled using a mobile phone from any part of the world. Scientist-farmer interaction was arranged as part of the programme.

Awareness Campaign on Balanced Use of Fertilizers

The programme was organized by ICAR-CTCRI, Thiruvananthapuram on 21 June 2022. About 152 participants including farmers representing Kulathoor panchayath of Parassala block, scientists, researchers, extension officials and students participated. Dr. G. Byju, Organizing Secretary and Head (A), Division of Crop Production, delivered the welcome address and introductory remarks about nutrients, fertilizers and balanced fertilization concept. Dr. M.N. Sheela, Director (A), ICAR-CTCRI, in her presidential address highlighted the importance of soil health for agriculture with special emphasis on tropical tuber crops. The Chief Guest, Mr. A. Nizamudeen, Commissioner, Kerala State Land Use Board, Govt. of Kerala inaugurated the event and mentioned about the soil problems such as nutrient removal, alteration in soil properties, lack of response for the applied nutrients and stressed the importance of integrated and balanced applications of soil nutrients based on soil test reports. Dr. V. Ramesh, Convener of the programme, proposed the vote of thanks. Events such as film show on balanced fertilization, awareness lectures by the scientists of crop production, field and lab visits were arranged for the benefit of farmers.

RINK Demo Day on Tuber Crops Technologies

The ICAR-CTCRI Agri-Business Incubator in collaboration with Kerala Startup Mission organised an online 'RINK Demo Day' for promoting various commercializable technologies developed at ICAR-CTCRI on 28 June 2022. The programme was inaugurated by Dr. M.N. Sheela, Director (A), ICAR-CTCRI in the presence of Mr. Anoop P. Ambika, CEO, Kerala Startup Mission and other officials. During the programme, the ICAR-CTCRI scientists presented tuber crops technologies like biofortified and industry-oriented varieties, functional foods and industrial products of tuber crops, post-harvest management technologies, processing machinery, biopesticides and precision agricultural technologies. Ninety two start-ups, MSMEs, small business, industry experts, scientists, academicians and students participated in the programme.

XXVI Meeting of ICAR Regional Committee-II

The Regional Station, ICAR-CTCRI, Bhubaneswar participated in the XXVI meeting of the ICAR Regional Committee - II held at the ICAR – National Rice Research Institute, Cuttack, Odisha on 14 October 2022, which was chaired by Dr. Himanshu Pathak, Secretary, DARE

and Director General, ICAR. Shri. Kailash Choudhary, Hon'ble Union Minister of State for Agriculture & Farmers' Welfare, Govt. of India and the Chief Guest of the programme stressed the importance of seed production, quality planting material production, bridging the yield gap of various crops, natural farming, drone technology usage in agriculture and its training to the professionals, strengthening of KVKs, training to the farmers on natural farming and other newly generated technologies for harnessing higher productivity, development of climate resilient and bio-fortified crops, integrated farming, crop diversification etc.

Rashtriya Mahila Kisan Diwas

The Regional Station, ICAR-CTCRI, Bhubaneswar participated in the Rashtriya Mahila Kisan Diwas organized by ICAR-Indian Institute for Women in Agriculture, Bhubaneswar on 15 October 2022. Different technologies and value added products of tuber crops were displayed in the exhibition. About 300 women farmers from seven districts attended the event. Shri. Kailash Choudhary, Hon'ble Minister of State for Agriculture & Farmers Welfare, Govt. of India, Dr. Himanshu Pathak, Secretary, DARE & DG, ICAR participated in the programme in online mode. Farmers-Scientists interface meeting was also held along with the participation of other ICAR Institutes.

PM Kisan Samman Sammelan 2022

The Regional Station, ICAR-CTCRI, Bhubaneswar organized a webcast of PM Kisan Samman Sammelan Programme on 17 October 2022. About 80 women farmers from MGMG adopted villages from Cuttack and Khruda districts of Odisha participated in the programme. Hon'ble Prime Minister of India, Shri Narendra Modi inaugurated the two-day event in virtual mode. The event could bring together more than 13,500 farmers and about 1,500 agri-startups from across the country. Hon'ble Union Minister of Agriculture and Farmers' Welfare, Shri. Narendra Singh Tomar and other Union ministers and senior officials participated in the event. During the meeting, various Farmers Welfare Schemes implemented by union government on new and smart technologies, market facilities and nano urea commercial production etc. were highlighted. Hon'ble Union Minister of Agriculture and Farmers' Welfare, Shri. Narendra Singh Tomar briefed about the achievement and success stories in the agricultural sector and the developmental programmes implemented throughout the country.

Hon'ble Prime Minister, Shri. Narendra Modi inaugurated 600 Pradhan Mantri Kisan Samruddhi Kendras (PMKSK), Pradhan Mantri Bhartiya Jan Urvarak Pariyojana – One Nation One Fertilizer and Agri-Startup Conclave and Exhibition and released funds under the Pradhan Mantri Kisan Samman Nidhi (PM-KISAN). During the event, Prime Minister launched the 'Indian Edge', an e-magazine on status of fertilizer production and consumption. Training programme on 'Production and value addition in tuber crops' was also organized to the farmers of MGMG adopted village during the event.

MoU signed with TANUVAS for Creating Satellite Incubation Centre

The Tamil Nadu Veterinary and Animal Sciences University signed an MoU with the Agri-Business Incubator of the ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram on 19 October 2022 to create a Satellite Incubation Centre in the industrial cassava areas of Viluppuram and Namakkal districts. Considering the need to address the value chain problems through institutional collaboration, TANUVAS has signed this MoU with ICAR-CTCRI. This MoU was signed by Dr. N.K. Sudeep Kumar, Director of Extension Education, TANUVAS and Dr. M.N. Sheela, Director (A), ICAR-CTCRI, in the presence of Dr. K.N. Selvakumar, Vice Chancellor of TANUVAS and Dr. P. Tensingh Gnanaraj, Registrar, TANUVAS. As a follow up, a planning workshop was organised for developing the joint work plan between TANUVAS and ICAR-CTCRI with a focus on promoting tapioca-based animal feed in the Madras Veterinary University campus. Dr. N.K. Sudeep Kumar, Director of Extension Education, TANUVAS, inaugurated the workshop in the presence of Dr. M.N. Sheela, Director (A), ICAR-CTCRI, Dr. R. Karunakaran, Dean, Madras

Veterinary College and faculties/scientists from TANUVAS and ICAR-CTCRI. During the inaugural address, Dr. Sudeep Kumar indicated that a collaborative approach for designing and implementing farmer-focused interventions will greatly help the tapioca farmers to combat the issues faced due to unstable market and climate change. Dr. M.N. Sheela, Director (A), ICAR-CTCRI informed that ICAR-CTCRI has developed a wide range of tapioca technologies for human consumption, animal feed and industrial production and stressed the need for promoting them to address the challenges faced by tapioca farmers. During the planning workshop, a detailed plan of work for the Satellite Incubation Centre was identified, while promotion of TANUVAS tapioca animal feed technologies, creating quality planting material production system at KVK for short duration and disease resistant tapioca varieties, establishment of a facility at KVK, Kallakurichi for production of parasitoids for managing mealybug incidence and promoting technology development or validation based entrepreneurship were identified as priority areas for the Satellite Incubation Centre. Thirty stakeholders including TANUVAS faculty, KVK scientists and tapioca farmers from Kallakurichi, Dharmapuri, Salem and Namakkal attended the meeting.

National Webinar on Genetic Resources of Underutilized Tuber Crops for Nutritional Security

ICAR-Central Tuber Crops Research Institute along with ICAR-Research Complex for North Eastern Hill Regions, Meghalaya and College of Agriculture, Central University, Tripura, jointly organized a National Webinar on 'Genetic Resources of Underutilized Tuber Crops for Nutritional Security' on 27 August 2022 in virtual mode. Dr. N.K. Krishna Kumar, Former DDG (Hort. Sci.) chaired and Dr. Vikramaditya Pandey, ADG (Hort. Sci.) and Dr. M.N. Sheela, Director (A), co-chaired the sessions. The importance of genetic resources of underutilized tuber crops in the nation's nutritional security and genetic improvement strategies were discussed during the webinar.

Vigilance Awareness Week Celebrations 2022

The Vigilance Week 2022 was observed from 31 October to 06 November 2022 on the theme 'Corruption free India for a developed nation'. Preventive vigilance cum internal housekeeping activities were also conducted in different modes such as property management, management of assets and technological initiatives. A committee was formed under the chairmanship of Vigilance officer for the land development and disputes management. Barbed wire fencing was installed approximately for 900 m at Block V of the Institute. Necessary actions were taken wherever encroachment was noticed.

The week was observed as vigilance awareness week with the aim of raising the concern of growing threat of corruption and its consequences. All staff at ICAR-CTCRI were advised to take part in the e-Pledge at Central Vigilance Commission website. Dr. J. Sreekumar, Principal Scientist and Vigilance Officer of the Institute welcomed the gathering. A vigilance awareness lecture was organized on 01 November 2022 for the staff and students of ICAR-CTCRI. Dr. M.N. Sheela, Director (A) gave introductory remarks and welcomed the participants and she highlighted the importance of observing the vigilance awareness week and the need to keep away from corruption. Shri. Rishi Raj Singh, IPS, Retired DGP, Govt. of Kerala administered the Integrity Pledge and delivered awareness lecture. In his lecture, he shared his experiences in Kerala and at Central Bureau of Investigation. The interactive lecture was very informative and he reiterated that any organization or institution need to be corruption free and should refrain from any activities which will attract vigilance action.

Certified Agritech Startup Professional (CAgtSP) Programme

The ICAR-CTCRI Agri-Business Incubator in collaboration with Kerala Agricultural University and Kerala Startup Mission organized a Certified Agritech Startup Professional (CAgtSP) Programme for the students of Agriculture and allied disciplines during 10-12 October 2022. The CAgtSP is a certification programme aimed to create 'Student Ambassadors' affiliated to ICAR-CTCRI Agri-Business Incubator, who create entrepreneurial awareness among their fellow students. The programme was inaugurated by Dr. Roy Stephen, Dean of Faculty, College of Agriculture,

Vellayani, Thiruvananthapuram in the presence of Dr. M.N. Sheela, Director (A) who presided over the programme. The students were provided skill-oriented training on business plan development, which they presented in a business pitch event in the last day. About 155 students from College of Agriculture, Vellayani, Thiruvananthapuram and 10 participants from other states like Tamil Nadu participated in the programme.

ICAR Sponsored Winter School

ICAR sponsored winter school on 'Sustainable Exploitation of Genetic Resources of Neglected and Underutilized Tuber Crops for Enhancing Climate Resilience and Nutritional Security' was organized during 29 November to 19 December 2022 at ICAR-CTCRI, Thiruvananthapuram. The programme was inaugurated by Dr. P. Pugazhendi, I.F.S., Additional Principal Chief Conservator of Forests, Govt. of Kerala and he spoke about the importance of Biodiversity Act and PGR Conservation. Dr. M.N. Sheela, Director (A), ICAR-CTCRI presided over the function and Dr. Vikramaditya Pandey, ADG (Hort. Sci.), ICAR graced the inaugural programme online. The valedictory function was organized on 19 December 2022 and Dr. C. Anandharamakrishnan, Director, CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram was the Chief Guest and he emphasized the importance of nutritive values and climate resilience potential of tuber crops and distributed course completion certificates to the trainees. Dr. P. Murugesan was the Course Director and Dr. C. Mohan, Dr. K.M. Senthilkumar, Dr. N. Krishna Radhika and Dr. C. Visalakshi Chandra were the coordinators. Twenty one participants from six states participated in the winter school.

World Soil Day 2022

World Soil Day (WSD) 2022 was celebrated on 05 December 2022 at ICAR-CTCRI. Theme lecture on 'Soils: where food begins' was made by Dr. Jacob John, Director of Extension, KAU. Soil health cards were issued to SC farmers of Kizhuvilam panchayat, Thiruvananthapuram. Group song on *'Manne Vandanam'* was sung by students of Bharatiya Vidya Bhavan, Manvila, Thiruvananthapuram. The WSD pledge was taken by the participants comprising 30 farmers, 40 scientists and 32 students.

The Regional Station of ICAR-CTCRI, Bhubaneswar, Odisha also organized World Soil Day programme on 05 December 2022. Fifty women farmers from MGMG adopted Pubusahi village, Khruda Block, Dumduma and Aiginia of Khruda district participated in the programme. Dr. K. Laxminarayana, Principal Scientist and SIC of Regional Station, ICAR-CTCRI and Dr. M. Nedunchezhiyan, Principal Scientist explained about the importance of the World Soil Day celebrations especially towards biodiversity loss, soil health and importance of soil health cards being issued to the farmers. Smt. Sanghamitra Mohapatra, Sarpanch, Pubusahi, Khordha, Odisha delivered the address as Guest of Honour. The Chief guest, Dr. D. Jena, Former Professor & Head, Department of Soil Science & Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, delivered the special lecture on 'Soil fertility constraints pertinent to the state of Odisha and measures to protect the soil biodiversity for maximizing the crop productivity' to the farmers. The farmers were exposed to various tuber crops products at the Techno Incubation Centre of the Institute. Field visits were also arranged to acquaint with the technologies and agro-techniques.

Inauguration of SIC and Cookathan Contest at KVK, Kallakurichi

TANUVAS and ICAR-CTCRI Agri-Business Incubator Satellite Incubation Centre (SIC) at KVK, Kallakurichi was inaugurated on 13 December 2022 by Dr. Appa Rao, Director of Extension, TANUVAS, in the presence of scientists from ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram. The Satellite Incubation Centre will enable the farmers to develop sustainable entrepreneurship on different value chain problems of tapioca. An exhibition on various tapioca and other varieties of tuber crops, including biofortified sweet potato varieties were displayed. A special Cookathon competition for women farmers was organised and 25 diverse recipes from tapioca were prepared and displayed by participants. About 134 farmers, entrepreneurs and department officials participated in the meeting.

National Workshop on Smart Management of Agricultural Resources to Transform Indian Farms (SmartIF)

National level discussion on the potentials of AI/IoTs and other recent developments in ICT to provide technological solutions to multitude of problems faced in agriculture with special reference to tuber crops was organized during 15-17 December 2022 at ICAR-CTCRI. The workshop was inaugurated on 15 December 2022 by Dr. G. Gopakumaran Nair, Chief General Manager, NABARD, Kerala and Lakshadweep region. The meeting was presided over by Dr. M.N. Sheela, Director (A), ICAR-CTCRI. Dr. A.K. Singh, DDG (Horti. Sci.), ICAR was the Chief Guest. Dr. Manoj P. Samuel, Executive Director, Centre for Water Resources Development and Management (CWRDM), Kozhikode and Dr. J. Adinarayana, Professor, Centre for Studies in Resources Engineering, IIT Bombay, offered felicitations. Dr. J. Sreekumar, Principal Scientist, ICAR-CTCRI and Vice President, Indian Society for Root Crops (ISRC) welcomed the gathering and Dr. V.S. Santhosh Mithra, Principal Scientist, ICAR-CTCRI and Organizing Secretary, SmartIF-2022 proposed the vote of thanks. There were four technical sessions and a stakeholder interface during the workshop.

DST-SERB Sponsored Workshop on 'Cherishing Scientific Minds for Nourishing Human Health'

A DST-SERB sponsored workshop on 'Cherishing scientific minds for nourishing human health' (Under SERB Scientific Social Responsibility Policy) was organized during 20-21 December 2022 at ICAR-CTCRI. The event was inaugurated by Prof. K.G. Satheesh Kumar, Distinguished Visiting Professor, Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala), Director, Central Laboratory for Instrumentation and Facilitation Centre (CLIFF), University of Kerala. A folder on 'Biofortified tuber crop varieties' was released during the event. Dr. K. Murugan, Director, CISSAPHYTOTECH & Principal (Retd), Govt. Arts College, Thiruvananthapuram, Dr. Veda Krishnan, (Fulbright Fellow & Member INSA-INYAS) & Scientist, ICAR-Indian Agricultural Research Institute (IARI), New Delhi, Dr. A. Asha Devi, Principal Scientist, ICAR CTCRI were the main speakers. Dr. Shirly Raichal Anil was the Course Director and Dr. N. Krishna Radhika and Dr. K.M. Senthilkumar were the Course co-ordinators of the workshop. Prof. (Dr.) G. M. Nair, Director, CLIF, University of Kerala graced the valedictory session and distributed certificates to the participants on 21 December 2022.

Tuber Crops Harvest Day

The Regional Station, ICAR-CTCRI organized the tuber crops 'Harvest Day' at Punjasargi (village), Mohana (Block), Gajapati (district), Odisha, on 22 December 2022. Dr. M.N. Sheela, Director (A), ICAR-CTCRI, officials of Regional Station, Horticulture department, PREM (NGO) and more than 70 tribal farmers participated in the programme. Dr. M.N. Sheela, Director (A) stressed the importance of food and nutrition in relation to emerging diseases like covid and other illness. On the occasion, implements were distributed to farmers and dress materials to tribal children. Field visits to harvested tuber crops areas and other vegetable fields were arranged.

Stakeholders Meeting for MoU on Nutrition-sensitive Agricultural Interventions

Sakeholders meeting was organized at the College of PG Studies in Agriculture, Central Agricultural University (Imphal) on 23 December 2022 to finalize the terms for the Memorandum of Understanding (MOU) between ICAR-CTCRI, Kerala and CPGS-AS, CAU (I), Umiam. The purpose of the meeting was to develop a framework for collaboration elaborating on how the micronutrient deficiencies in Meghalaya state will be addressed through targeted intervention involving biofortified crops and the modalities of implementing the project through a satellite incubation centre, located at the CPGS-AS, Umiam. The meeting was chaired by Dr. Mayank Rai, Dean CPGS-AS, CAU (I), Umiam, while Dr. S.V. Ngachan, Former Director, ICAR-Research Complex for North Eastern Hill Regions delivered the special address. Dr. P. Sethuraman Sivakumar, ICAR-CTCRI made a detailed presentation about the Rainbow diet campaign

programme implemented in the North Eastern Hill Regions and explained about the proposed MoU. The presentation was followed by a panel discussion, in which the participants discussed various issues and offered suggestions for effective implementation of the programme. Key decisions from the workshop were setting up of a Satellite Incubation Centre of ICAR-CTCRI Agri-Business Incubator at College of PG-AS, CAU(I), Campus; establishing a formal seed system for biofortified tuber crops in Meghalaya; collaborative student research on biofortified tubers and targeted nutritional interventions to combat micronutrient deficiencies among tribal people. About 25 stakeholders including faculty members of CAU(I), ICAR-CTCRI scientists and students of CPGS-AS, CAU (I), participated in the meeting.

Nutrition-linked Social Entrepreneurship Development Programme for Promoting Biofortified Sweet potato

The ICAR-CTCRI, Thiruvananthapuram in collaboration with the MTTC&VTC, College of Fisheries, CAU (I), Lembucherra launched the 'Nutrition-linked entrepreneurship development programme' in Tripura to develop new businesses on nutritionally-enhanced varieties under ICAR-CTCRI NEH programme. As a preparatory work for the programme, the Satellite Incubation Centre of ICAR-CTCRI ABI at the MTTC&VTC, Lembucherra, Tripura organized three farmers' trainings at Gandhacherra, Karanamanipara and Bolkhali villages during December 2022. About 210 farmers participated in these programmes.

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 153rd birth anniversary of Mahatma Gandhi at ICAR-CTCRI, Thiruvananthapuram on 02 October 2022. Swacchhta Pledge (in Hindi and English) was taken and a human chain was formed by all staff in front of main building on 10 October 2022, followed by cleanliness drive at Block I, ICAR-CTCRI, Thiruvananthapuram.

The spots or places in office which need to be cleaned or cleared of scrap items were identified. During the various collective cleaning drives organized from 02-31 October 2022, plastic waste, papers, weeds, scrap items from the Institute and farm premises such as vehicle parking shed, canteen, sales counter, road sides near biopesticide lab, biotechnology lab and techno-incubation centre were removed. Old, broken and discarded furniture were removed from the corridors of staff canteen and potted plants were kept near the entrance. Old newspaper of about 324 kg were sold out from the library. ICAR-CTCRI generating a revenue of ₹ 9396. An essay competition in English and Malayalam on 'Startup for Swachh Bharat' was organised for final year B.Sc. (Ag.) students from College of Agriculture, Vellayani, Thiruvananthapuram. A poster competition and a slogan competition on Swachh Bharat were held for the staff of ICAR-CTCRI. Two outdoor campaigns at Government UPS School, Cheruvaikkal on 13 October 2022 and at Government Old Age home at Pulayanarkota, Thiruvananthapuram on 18 October 2022 were conducted as part of special campaign 2.0 on Swachhta at ICAR-CTCRI, Thiruvananthapuram led by Dr. M.N. Sheela, Director (A). All staff members collectively cleaned the school or old age home premises of trash, plastic bottles, waste papers, dried leaves, weeds etc. During the valedictory session held on 31 October 2022, the Chief Guest, Shri Shibu K. Nair, Organics Campaigner, GAIA (Global Alliance for Incinerator Alternatives) Asia Pacific, delivered a talk on 'Know your waste'. Prizes for various competitions such as slogan and poster competition, best lab, room/cabin and division of ICAR-CTCRI, Swachhta Soldier or Swachhta Sevak prize for 10 best participants for most active participation etc. were distributed. The house keeping staff of ICAR-CTCRI were also felicitated on the occasion.

The ICAR-CTCRI Regional Station, Bhubaneshwar also conducted two outdoor campaigns at Syez Mumtaz Ali Govt. High School, Dumuduma, Khandagiri, Bhubaneswar on 28 October 2022 and special swachhta campaign awareness programme at Pubusahi village, Khordha District, Bhubaneswar on 29 October 2022. Cleaning

drives were also held from 25-31 October 2022 near sub road at Regional Station, Bhubaneswar.

Swachhta Pakwada

Swachhta pledge was taken in English and Hindi at the Millennium Hall, ICAR-CTCRI, Thiruvananthapuram on 16 December 2022. A tender notice for disposal or auction of old, condemned or obsolete equipments and machineries was published in ICAR-CTCRI, Thiruvananthapuram website on 19 December 2022. Cleaning drives and weeding were organised in the office premises, near techno-incubation centre of Block I, II and III of ICAR-CTCRI, Thiruvananthapuram. The trash was segregated into plastic waste, paper wastes and crop residues. After segregation, plastic wastes were removed from the sites and the paper wastes and crop residues were cleared. The nutrient enriched vermicompost '*Sree Amrutham*' made using organic wastes, crop residues, banana pseudostem, dried leaves etc. from the Integrated Organic Farming System (IOFS) unit of ICAR-CTCRI farm was released by Dr. S.K. Chaudhari, Deputy Director General (NRM), ICAR, as part of the All India Network Programme on Organic Farming (AINP-OF) on 28 December 2022. An outdoor swachhta campaign (cleaning drive) was organized at Government Taluk Homeo hospital/clinic, Karakulam village, Nedumangad block panchayat along with the *Mera Gaon Mera Gaurav* (MGMG) programme in the MGMG adopted village (Karakulam) led by Dr. M.N. Sheela, Director (A), ICAR-CTCRI.

The swachhta pakhwada programme at ICAR-CTCRI, Regional Station, Bhubaneswar was held during 16-31 December 2022, where all the staff participated in cleaning the Institute premises, main road and sub roads.

Kisan Diwas

Kisan Diwas was organized by ICAR-CTCRI on 23 December 2022 at three different locations in tribal village at Odisha by ICAR-CTCRI, Regional Station, Bhubaneswar, in North East (Umiam, Meghalaya), and at Namakkal, Tamil Nadu. The Regional Station, ICAR-CTCRI, Bhubaneswar organized 'Kisan Diwas' at Punjasargi (village), Mohana (Block), Gajapati (district), Odisha. Dr. M.N. Sheela, Director (A), ICAR-CTCRI, Thiruvananthapuram, presided over the function. More than 70 tribal farmers participated in the Kisan Diwas at Regional Station, ICAR-CTCRI, Bhubaneswar. At Mawyrdep village, Umsning, RiBhoi district of Meghalaya, Kisan Diwas was organized by the team led by Dr. P.S. Sivakumar, Principal Scientist, ICAR-CTCRI, Thiruvananthapuram. Biofortified sweet potato was introduced and value-added product, such as sweet potato chips, and planting material of improved varieties were distributed in the village. A farmer-scientist interaction meeting on 'Biofortified sweet potato and healthy eating among farmers' was also organized. About 40 farmers participated in the programme. At Namakkal district of Tamil Nadu, as a part of Kisan Diwas, seed village demonstration plots were established and quality planting materials of cassava varieties, Sree Reksha and Sree Athulya were distributed to the farmers. The event was covered in the media including Doordarshan (DD) Tamil channel and in Tamil newspaper Dinamalar.

Hindi Corner

During the year 2022, four meetings of the Official Language Implementation Committee (OLIC) was held on 16 March, 29 June, 23 September and 13 December 2022 to review the progress of work, under the Chairmanship of Dr. M. N. Sheela, Director (A) and Chairperson of the Official Language Implementation Committee, ICAR-CTCRI, Thiruvananthapuram. The Director reviewed the progress of the activities during the year and expressed her satisfaction. During the meetings, various points related to OLIC were raised, discussed and decisions were implemented. All quarterly performance reports were sent to the Council for their compliances. Dr. A. Asha Devi, Principal Scientist and Liaison Officer and Shri. M. Padmakumar, Private Secretary & Member Secretary (OLIC) carried out the OL activities at the Institute. During the year the library purchased Hindi journals/magazines/ books etc. Necessary orders were given to the establishment section for making necessary entries in the service records of awardees of various Hindi competitions.

Hindi workshop was conducted on 25 March 2022 by Dr. Mahendra Sawant, Associate Professor and Head, Department of Yoga and Rajbhasha, LNCPE, Thiruvananthapuram on the topic, 'Official Language Policy and its Implementation in Central Government Offices' for the staff and students of the Institute. This was followed by the Valedictory function of the Hindi fortnight celebrations 2021 on 26 March 2022, where Dr. Mahendra Sawant was the Chief Guest. The Incentive Scheme Award 2022 was bagged by Shri. M. Padmakumar, for carrying out maximum official work in Hindi. Shri. Padmakumar also won accolades for doing original work in Hindi from the TOLIC-I. The Institute celebrated the Hindi fortnight during 14-28 September 2022 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. Officials from the OLIC, ICAR-CTCRI participated in the TOLIC-I meetings held on 21 February, 15 March and 16 September 2022.

International Women's Day Celebration 2022

The International Women's Day was celebrated in a befitting manner at ICAR-CTCRI, Thiruvananthapuram with many activities. The programme started at 10.00 am with all women staff assembling at the reception for a Women's Day procession holding placards highlighting the importance of the day. All the lady staff members participated with great enthusiasm following covid protocol. Mrs. Usha Kumari, Assistant Professor and Faculty Law, Mar Gregarious College, Thiruvananthapuram was the Chief Guest of the day, who also participated in the procession. The main programme started by 10.50 am. The event started with a video show made by the Recreation Club, ICAR-CTCRI, as a tribute to all the lady staff of the Institute showcasing their individual areas of work. The gathering was welcomed by Dr. M.L. Jeeva, Head (A), Division of Crop Protection and Chairperson, Women's Cell, ICAR-CTCRI. After welcoming the dignitaries and staff, she acknowledged the service rendered by the pioneers in the field of women empowerment who had struggled a lot for the cause of women upliftment around the world. She remembered the words of our former President and the renowned scientist, Dr. A.P.J. Abdul Kalam, who stressed upon women empowerment being the pre-requisite for a stable society. The event was presided by Dr. Sheela Immanuel, SIC, Extension and Social Sciences and Director i/c. In her presidential address, she stressed upon the importance of gender equality in work place and the role of women in a healthy society. The Women's day lecture was given by Mrs. Usha Kumari, Faculty Law, Mar Gregarious College, Thiruvananthapuram. She gave an in-depth insight into the law points related to various laws drafted for women empowerment and safety in the country and discussed about the common problems faced by the Indian women. She discussed in detail about the few cases, which were major turning points in the Indian judiciary, which helped in drafting many important laws like the Criminal law amendment act 1983, Law against sexual harassment against women in work places, Anti-dowry law, Protection of women against domestic violence, Prohibition of dowry, Criminal law amendment act 2013, Right to information act, etc. The importance of a gender equal society was also discussed well. This was followed by a very interesting interactive session on various law queries by the staff of the Institute. Awards were presented to eight lady achievers and staff who were retiring this year after serving the Institute for 41 long years.

Visit of the Second Sub-Committee of Parliament on Official Language

The visit of the Second Sub-Committee of Parliament on Official Language for reviewing the progressive use of Hindi in various Ministries/Departments/Subordinate Offices and Public Sector Undertakings was held on 27 September 2022 for ICAR-CTCRI. The high level committee consisting of Hon'ble Members of Parliament, Government of India evaluated the work done in Hindi on the basis of the questionnaire. The aforesaid Committee appreciated the work done in Hindi by the Institute.

State of art of Mera Gaon Mera Gaurav

ICAR-CTCRI, Thiruvananthapuram and its Regional Station implemented the MGMG programme in

collaboration with the other stakeholders' viz., Department of Agriculture and Horticulture, Krishi Vigyan Kendra, grama panchayat, progressive farmers etc. Interface meetings, training programmes, demonstration of improved practices, farm advisory visits, mobile advisory services were organized in the selected villages for the benefit of farming community. A total of 42 scientists adopted 42 villages for the overall development of the villages through various programme as given below.

Activities undertaken

Sl. No.	Name of the activity	No. of activities conducted	No. of farmers participated & benefited
1.	Visit to village by teams	24	431
2.	Interface meetings/ Gosthis	13	818
3.	Trainings organized	12	531
4.	Demonstrations conducted	6	74
5.	Mobile based advisories	111	135
6.	Literature support provided	13	1421
7.	Awareness created	10	430
	Total	**189**	**3840**

Mobile-based advisories (111 nos.), were given on improved varieties, tuber crop production, nutrient management, value addition, decision support tool for cassava nutrient management, pest and disease management in various crops, application of bio-pesticides for management of different pests and diseases, cassava marketing, vegetable cultivation and manuring in coconut. Training materials including publications and technical leaflets were supplied to 1421 farmers. Planting materials of cassava, sweet potato, yam, elephant foot yam and taro were given to 74 farmers. Soil health cards were distributed to the selected farmers in MGMG villages. Production technologies of cassava, sweet potato, yams and elephant foot yam and balanced application of fertilizers based on soil test data were advised to farmers.

Lack of awareness about biofortified and nutrient rich varieties in tuber crops, lack of awareness about valued added products in tuber crops, shortage of labour, price fluctuations, nematode and secondary fungal infection in elephant foot yam, cassava mosaic disease, root rot in cassava, red spider mite in cassava, sweet potato weevil, nonavailability of quality planting materials, banana pseudostem weevil, anthracnose in greater yam, fungal infection in elephant foot yam, nutritional deficiencies, wild animals attack and lack of storage facilities were the major problems faced in the MGMG villages.

Linkages were created with Parassala Block Panchayat; Krishi Bhavan, Venganoor; Venganoor Grama Panchayat; Krishi Bhavan, Pallichal; Mangalapuram Grama Panchayat in Kerala; Pubusahi Gram Panchayat, Khurda; Madhuban Gram Panchayat, Barang; Department of Agriculture and Horticulture, Khurda and Barang blocks in Odisha.

Frontline 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 476 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.

Participation in Exhibitions

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 cum harvest festival on Improved variety of cassava 'Sree Athulya' and Distribution of critical inputs on 25 February 2022 at Goodamalai, Salem, Tamil Nadu.
2. Exhibition in connection with Training on Improved technologies of tuber crops for enhancing farm income on 04 March 2022 at Kovvur, West Godavari, Andhra Pradesh.
3. Exhibition in connection with Stakeholders interface on Improved technologies of tuber crops on 09 March 2022 at Mekkarai, Tenkasi, Tamil Nadu.
4. Exhibition in connection with Stakeholders interface on Improved technologies of tuber crops on 10 March 2022 at P. Pothukudi, Tirunelveli, Tamil Nadu.
5. Exhibition in connection with Stakeholders interface on Mechanization in Chinese potato on 23 March 2022 at Tirunelveli and Tenkasi districts of Tamil Nadu.
6. Exhibition in connection with 75th Anniversary celebrations of ICAR-CPCRI, Regional Station, Kayamkulam on 24 April 2022 at Kayamkulam, Alappuzha, Kerala.
7. Exhibition in connection with State level stakeholders interface cum farmers fair on 31 May 2022 at ICAR-CTCRI, Thiruvananthapuram, Kerala.
8. Exhibition on value added products on 22 August 2022 at Parakkode, Kollam, Kerala.
9. Exhibition in connection with Gramolsavam of Chenkal panchayat during 05-10 September 2022 at Chenkal, Thiruvananthapuram, Kerala.
10. Exhibition in connection with Krishidarshan during 25-29 October 2022 at Mannuthy, Thrissur, Kerala.

59th Foundation Day Celebrations

ICAR-CTCRI celebrated 59th Foundation Day on 27 July 2022. Dr. M.S. Rajasree, Vice-Chancellor, APJ Abdul Kalam Technological University, Thiruvananthapuram, inaugurated the Foundation Day. Dr. M.N. Sheela, Director, ICAR-CTCRI delivered the welcome address. The Institute publications were released and Best Employee Awards were presented on the occasion. The Vice Chancellor also stressed upon the importance of block chains, robotics and artificial intelligence in today's world. She called upon the scientists from various spheres for interdisciplinary research for the betterment of the nation. Dr. K.G. Satheesh Kumar, Professor, Kerala University of Digital Sciences, Innovation and Technology, Thiruvananthapuram, delivered the Foundation Day lecture. He urged everyone to think about the future and bridge the digital divide between the rich and the poor. Dr. Vikramaditya Pandey, ADG (Hort. Sci.), ICAR, New Delhi, offered the special address. Dr. Sheela Immanuel, Principal Scientist & SIC, Extension and Social Sciences proposed the vote of thanks.

Library

Library activities are mostly confined to necessary information support services for the research and training activities of the Institute and Regional Station, Bhubaneswar. One Ph.D. thesis, 17 M.Sc. theses, 2 B.Sc. theses and 45 books (7 Hindi books, 38 scientific books and one set of ICAR publication entitled 'Inventory of Indigenous Technical Knowledge in Agriculture' were added. In addition, the following services were also made available to the users of the library. A total of 176 books were issued to the users on loan; A total of 7382 hits were received through various CeRA services like Full text/Abstracts views, ILL request and table of contents browsing etc.; About 474 users availed the facility by using reference documents like International Symposium proceedings, Thesis, Dictionaries, very old and rare books related to International Symposium on tropical root and tuber crops. Library continued to provide photocopying service to the Institute staff and other library users on official/ payment basis.

Recreation Club

The recreation club started activities for the year 2022 with New Year celebration. Cultural programme, distribution of prizes to winners of lucky dip and ceremonial cake cutting were arranged to add colour to the occasion.

World music day was celebrated on 21 June 2022 by paying tributes to the musicians who left us during 2021-22 and conducting various music competitions for the members. Onam was celebrated in full swing with Oonjal, pookkalam, cultural competitions, games, uriyadi, maveli and chendamelam. Keralapiravi day was another great occasion, which showcased the talents of staff and students of ICAR-CTCRI in various cultural programmes in Malayalam. National Cancer Awareness day was conducted in collaboration with the team from PRS Hospital, Thiruvananthapuram on 07 November 2022. Similarly, a health check up programme was organized in collaboration with Neethi Diagnostic Centre. Financial awareness programme was also conducted in collaboration with State Bank of India. In addition, farewell functions were arranged for members, who superannuated from ICAR service and those members who were transferred to other ICAR Institutes.

Webinars/Programmes organized under Azadi Ka Amrit Mahotsav

ICAR-CTCRI, Thiruvananthapuram and its Regional Station implemented the AKAM events. A total of 68 AKAM events were organized and 6800 participants including scientists, department officials, farmers and students were benefitted from the webinar/programmes. The details of the AKAM events are given below.

AKAM event No.	Date	Webinar/Programmes	No. of participants
92	01 January 2022	Programme on Release of PM Kisan Samman Nidhi Fund at headquarters	163
93	01 January 2022	Programme on Release of PM Kisan Samman Nidhi Fund at Regional Station	80
94	03 January 2022	Training programme on Livelihood improvement of tribal farmers through tuber crops technologies at KVK, Semiliguda, Koraput district, Odisha under Tribal Sub Plan	60
95	04 January 2022	Webinar on Clean milk – better health and price	38
96	04 January 2022	Training programme on Livelihood improvement of tribal farmers through tuber crops technologies at Pottangi Block, Koraput district, Odisha under Tribal Sub Plan	55
97	05 January 2022	Training programme on Livelihood improvement of tribal farmers through tuber crops technologies at Muniguda Block, Rayagada district, Odisha under Tribal Sub Plan	50
98	06 January 2022	Training programme on Livelihood improvement of tribal farmers through tuber crops technologies at Bisam Cuttack Block, Rayagada district, Odisha under Tribal Sub Plan	60
99	07 January 2022	Training programme on Livelihood improvement of tribal farmers through tuber crops technologies at Kotagarh Block, Kandhamal district, Odisha under Tribal Sub Plan	50
100	08 January 2022	Training programme on Livelihood improvement of tribal farmers through tuber crops technologies at Tumudibandh Block, Kandhamal district, Odisha under Tribal Sub Plan	70

101	10 January 2022	Training programme on Tuber crops production and value addition at Bahadasahi, Chakapada block, Kandhamal district	50
102	10 January 2022	Webinar on Hi-tech Horticulture for higher productivity and income	70
103	12 January 2022	Webinar on Vertical farming - Urban farming: A sustainable innovation and business approach	175
104	12 January 2022	Hands on training on Value addition in tuber crops	14
105	17 January 2022	Novel approaches in the biological control of insect pests	80
106	19 January 2022	Webinar on Entrepreneurial opportunities in food processing	70
107	24 January 2022	Webinar on Empowering girl child as part of National Girl Child Day celebration	101
108	27 January 2022	Webinar on Agro techniques and nutrient management in sweet potato: Recent advances	30
109	10 February 2022	Webinar on Agro techniques and nutrient management in sweet potato: Recent advances	72
110	23 February 2022	Empowerment of cassava farmers through sustainable use of resources and tuber crops technologies at Karur, Tamil Nadu	72
111	24 February 2022	Empowerment of cassava farmers through sustainable use of resources and tuber crops technologies at Salem, Tamil Nadu	60
112	24 February 2022	National Science Day lecture	25
113	25 February 2022	National webinar on Tuber crops and food security under changing climate	125
114	25 February 2022	Field day and harvest festival of high yielding variety of cassava 'Sree Athulya' at Salem	60
115	25 February 2022	Hands on training on Value addition in tuber crops	20
116	28 February 2022	Training programme on Improved technologies of tuber crops for enhancing farm income	115
117	28 February 2022	Hands on training on Value addition in tuber crops	16
118	04 March 2022	Farmers training on Improved technologies of tuber crops for enhancing farm income	87
119	05 March 2022	Tuber crops planting festival and distribution of farm inputs and implements, Mezhuveli panchayat, Pathanamthitta district, Kerala	138
120	07 March 2022	Training programme on Improved technologies of tuber crops for enhancing farm income	14

121	08 March 2022	Hands on training on Value addition in tuber crops	20
122	08 March 2022	International Women's Day Celebration at ICAR-CTCRI, Thiruvananthapuram	152
123	08 March 2022	Farmers training, Tuber crops planting festival and Distribution of farm inputs and implements, Pallichal, Thiruvananthapuram district, Kerala	110
124	14 March 2022	Training programme on Intellectual property rights as part of awareness programme under National Intellectual Property Awareness Mission (NIPAM)	33
125	14 March 2022	Training programme on Improved technologies of tuber crops under SCSP programme	28
126	15 March 2022	Training programme on Improved technologies of tuber crops under SCSP programme	39
127	22 March 2022	Tuber day programme under the project Tribal Sub Plan (TSP)	500
128	22 March 2022	Webinar on Ground water: Making the invisible visible-World Water day 2022 programme	45
129	23 March 2022	Chinese potato grader introduced to farmers of Tirunelveli and Tenkasi districts for enhancing farm income in tuber crops	185
130	24 March 2022	Training programme on Improved technologies of tuber crops for enhancing farm income	11
131	31 March 2022	Training programme on Tuber crop based value addition	11
132	25 April 2022	MGMG programme on Tuber crops seed village-Farmers training and distribution of planting materials at Venganoor, Thiruvananthapuram	60
133	04 May 2022	Hands on training on Value addition in tuber crops	26
134	07 May 2022	Scientist-Farmers interface on cassava tuber rot management (MGMG programme)	52
135	19 May 2022	Hands on training on Value addition in tuber crops	17
136	31 May 2022	Nationwide interaction programme with farmers: Live web telecast of Hon'ble Prime Minister's address & State level stakeholders interface cum farmers' fair	2000
137	03 June 2022	Farmers training on Calf rearing and management at Idichakkaplamoodu, Parassala (MGMG programme)	30
138	06 June 2022	Hands on training on Value addition in tuber crops for participants from Wayanad	16
139	08 June 2022	Hands on training on Value addition in tuber crops for participants from Malappuram	20

140	09 June 2022	Hands on training on Value addition in tuber crops for participants from Ernakulam	30
141	10 June 2022	Climate change and renewable energy-H.H. Visakham Thirunal Endowment Lecture-2022	318
142	16 June 2022	Training on Smart farming using e-crop	100
143	17 June 2022	Hands on training on Value addition in tuber crops	43
144	21 June 2022	Farmers awareness campaign on Efficient and balanced use of fertilizers (including nano-fertilizers)	152
145	21 June 2022	International Yoga day celebration cum yoga training	56
146	28 June 2022	ICAR-CTCRI and Kerala Startup Mission Online Research Innovation Network-Kerala (RINK) Demo Day	92
147	5 July 2022	Webinar on Climate change: causes, impacts and way forward for Indian agriculture	61
148	5 July 2022	Training programme on Production and value addition in tuber crops under MIDH	60
149	15 July 2022	Webinar on Laboratory biosafety practices	72
150	22 July 2022	Webinar on Protected cultivation: the experience of Western Sydney University	75
151	02 August 2022	Training programme on Improved technologies of tuber crops for enhancing farm income	37
152	03 August 2022	Scientist-Farmer Producers Organisations interface meeting	21
153	04-05 August 2022	Farmers training programmes on Tuber crops at Mangalur block, Cuddalore district, Tamil Nadu	91
154	06 August 2022	Farmers interface and distribution of farm implements, cassava chipping machines, cassava slicers and planting materials to farmers of Chenkal, Kulathoor, Karode and Parassala panchayats of Kerala	65
155	23-24 August 2022	Training programme on Improved technologies of tuber crops for enhancing farm income	55
156	20-22 September 2022	Improved processing technologies of tropical tuber crops to technical officers from Horticulture department, Salem, Tamil Nadu	15
157	23 September 2022	Training on Value addition in tuber crops	12
158	24 September 2022	Training on Value addition in tuber crops	22
159	04 November 2022	Training on Value addition in tuber crops	48
		Total	**6800**

वर्ष 2022 के दौरान इस संस्थान में आयोजित राजभाषा कार्यान्वयन से संबन्धित कार्यक्रम

राजभाषा कार्यान्वयन समिति (राभाकास) की बैठक का आयोजन

इस संस्थान के निदेशक महोदया (कार्यकारी) डॉ. एम. एन. षीला एवं निदेशक महोदय डॉ. जी. बैजु की अध्यक्षता में प्रत्येक तिमाही (23 मार्च, 30 जून, 30 सितंबर और 23 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। नई हिंदी समिति का गठन हुआ और डॉ. आशा देवी ए, प्रधान वैज्ञानिक एवं संपर्क अधिकारी और श्री. पद्मकुमार एम, निजी सचिव को सदस्य सचिव (रा.भा) के रूप में संस्थान में राजभाषा गतिविधियों का उत्तरदायित्व सोंप दिया गया। राजभाषा बैठक में लिए गए कुछ अहम फैसले:

- पुस्तकालय को हिंदी पत्रिकाएं/पुस्तकें क्रय करने के निर्देश दिया गया, तदनुसार कार्रवाई की गई है।
- विभिन्न हिंदी प्रतियोगिताओं के पुरस्कार विजेताओं के सेवा अभिलेखों में आवश्यक प्रविष्टियां करने के लिए स्थापना अनुभाग को आवश्यक आदेश दिया गया और उस पर कार्रवाई की गई है।
- सेवा पुस्तिकाओं में द्विभाषी रूप में प्रविष्टियां करने का निर्देश स्थापना अनुभाग को दिये गये हैं, तथा कार्रवाई की जा रही है ।

नगर राजभाषा कार्यान्वयन समिति द्वारा वर्ष 2022 के दौरान आयोजित सभी बैठकों में इस संस्थान के संपर्क अधिकारी (राजभाषा) एवं सदस्य सचिव (राजभाषा) ने भाग लिया।

हिन्दी कार्यशाला का आयोजन

केंद्र सरकार की राजभाषा नीति के अनुपालन में इस संस्थान के सभी कर्मचारियों के लिए दिनांक 25.03.2022 को "राजभाषा नीति और केंद्र सरकार के कार्यालयों में इसका कार्यान्वयन" पर एकदिवसीय हिन्दी कार्यशाला आयोजित की गई। डॉ. जी. बैजु, निदेशक (प्रभारी) एवं अध्यक्ष (राभाकास), भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान, तिरुवनंतपुरम ने अध्यक्षीय भाषण में हिन्दी के महत्व एवं सरकार के कार्यालयों में हिन्दी अधिक से अधिक उपयोग में लाने के बारे मे प्रकाश डालते हूए कार्यशाला का उद्घाटन किया। डॉ. आशा देवी, प्रधान वैज्ञानिक एवं संपर्क अधिकारी (राजभाषा) ने सभा का स्वागत किया। डॉ. महेंद्र सावंत, एसोसिएट प्रोफेसर एवं प्रमुख (योगा और राजभाषा विभाग), एलएनसीपीई, तिरुवनंतपुरम ने केंद्र सरकार के कार्यालयों में राजभाषा नीति और इसके कार्यान्वयन पर व्याख्यान दिया। श्री एम. पद्मकुमार, सदस्य सचिव (राजभाषा) ने धन्यवाद प्रस्ताव प्रस्तुत किया। कुल 35 प्रतिभागियों ने कार्यशाला मे भाग लिया ।

संसदीय राजभाषा समिति की दूसरी उप-समिति द्वारा निरीक्षण

विभिन्न मंत्रालयों/विभागों/अधीनस्थ कार्यालयों और सार्वजनिक क्षेत्र के उपक्रमों में हिंदी के प्रगामी प्रयोग की समीक्षा के लिए गठित संसदीय राजभाषा समिति की दूसरी उप-समिति ने दिनांक 27 सितंबर 2022 को भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान, तिरुवनंतपुरम का निरीक्षण किया। माननीय संसद सदस्यों, भारत सरकार की उच्च स्तरीय समिति ने प्रश्नावली के आधार पर हिन्दी में किये गये कार्यों का मूल्यांकन किया। उक्त समिति ने संस्थान द्वारा हिंदी में किए गए कार्यों की सराहना की। समिति को दिए गए आश्वासनों पर अनुवर्ती कार्रवाई पहले ही शुरू हो चुकी है और इसकी रिपोर्ट परिषद को भेज दी गई है।

चित्र. 129. संसदीय समिति का निरीक्षण - संस्थान के अधिकारियों के साथ - झलकियां

हिंदी पखवाड़ा समारोह का आयोजन

संस्थान में 14 से 28 सितंबर, 2022 के दौरान हिंदी पखवाड़ा समारोह आयोजित किया गया। इस कार्यक्रम का उद्घाटन डॉ. एम.एन. षीला, निदेशक (कार्यवाहक) द्वारा किया गया । इस संस्थान के अधिकारियों एवं कर्मचारियों के लिए विविध हिन्दी प्रतियोगिताएं आयोजित की गई जैसे निबंध लेखन, अनुवाद (हिंदी से अंग्रेजी और इसके विपरीत), श्रुतलेख, सुलेख, कविता पाठ, सिर्फ एक मिनट, स्मृति परीक्षण और अंताक्षरी आदि। इनमें वैज्ञानिक, तकनीकी, प्रशासनिक, कुशल सहायक कर्मचारियों, छात्र एवं अस्थायी कर्मचारियों ने भाग लिया।

वर्ष 2021 में आयोजित हिन्दी पखवाड़ा प्रतियोगिताओं के विजेताओं को 25 मार्च, 2022 को पुरस्कार प्रदान किया गया।

क्षेत्रीय स्टेशन, उड़ीसा में 14-28 सितंबर के दौरान हिंदी पखवाड़ा मनाया गया। कर्मचारियों के लिए विभिन्न प्रतियोगिताएं आयोजित की गईं और कार्यालयीम कार्यों में हिंदी भाषा के उपयोग के लिए जागरूकता पैदा की गई।

विशेष प्रोत्साहन योजना

नगर राजभाषा कार्यान्वयन समिति, सर्किल-1, तिरुवनंतपुरम के अंतर्गत, अधिक से अधिक सरकारी कार्य हिन्दी में करने पर विशेष प्रोत्साहन योजना वर्ष 2021-22 के दौरान, अधिक से अधिक सरकारी कार्य हिंदी में करने के लिए चयनित दस अधिकारियों और कर्मचारियों की सूची में श्री पद्मकुमार एम, निजी सचिव एवं सदस्य सचिव (राजभाषा) दूसरा स्थान प्राप्त किया, कुल 55 केंद्रीय कार्यालयों में से। उन्हें नकद पुरस्कार, **स्मृति चिन्ह और नराकास से प्रमाण पत्र भी प्राप्त हुआ है।**

Important Events

Sl. No.	Name of the event	Date
1.	Institute Biosafety Committee Meeting (IBSC)	19 January 2022
2.	ICAR Sponsored Short Course on Exploitation of Genetic Resources of Underutilized Tuber Crops	02-11 February 2022
3.	9th Research Advisory Committee (RAC-IX) Meeting	18-19 March 2022
4.	Tuber Day at Regional Station, Bhubaneswar	22 March 2022
5.	48th Annual Institute Research Council Meeting	20-22 April 2022
6.	22nd Annual Group Meeting of the All India Coordinated Research Project on Tuber Crops at ICAR-RC for NEH region	11-13 May 2022
7.	Training on Scaling up of Biofortified Varieties	09-13 May 2022
8.	State Level Stakeholders Interface cum Farmers' Fair	31 May 2022
9.	Training on Smart farming using Electronic Crop (e-Crop) (TOSFUE-2022)	16 June 2022
10.	Awareness Campaign on Balanced Use of Fertilizers	21 June 2022
11.	RINK Demo Day on Tuber Crops Technologies	28 June 2022
12.	59th Foundation Day Celebrations	27 July 2022
13.	National Webinar on Genetic Resources of Underutilized Tuber Crops for Nutritional Security	27August 2022
14.	Institute Biosafety Committee Meeting (IBSC)	21 September 2022
15.	XXVI Meeting of ICAR Regional Committee-II at ICAR-National Rice Research Institute, Cuttack, Odisha	14 October 2022
16.	Rashtriya Mahila Kisan Diwas	15 October 2022
17.	PM Kisan Samman Sammelan 2022	17 October 2022
18.	MoU signed with TANUVAS for creating Satellite Incubation Centre (SIC)	19 October 2022
19.	Certified Agritech Startup Professional (CAgtSP) Programme	10-12 October 2022
20.	Vigilance Awareness Week Celebrations 2022	31 October 2022 to 06 November 2022
21.	ICAR Sponsored Winter School on Sustainable Exploitation of Genetic Resources of Neglected and Underutilized Tuber Crops for Enhancing Climate Resilience and Nutritional Security	29 November 2022 to 19 December 2022
22.	World Soil Day 2022	05 December 2022
23.	Inauguration of SIC and Cookathan Contest at KVK, Kallakurichi	13 December 2022
24.	National Workshop on Smart Management of Agricultural Resources to Transform Indian Farms (SmartIF)	15-17 December 2022
25.	DST-SERB Sponsored Workshop on Cherishing Scientific Minds for Nourishing Human Health	20-21 December 2022
26.	Tuber Crops Harvest Day at Regional Station, Bhubaneswar	22 December 2022
27.	Stakeholders Meeting for MoU on Nutrition-sensitive Agricultural Interventions	23 December 2022

Weather Data 2022

ICAR-CTCRI, Headquarters, Thiruvananthapuram, Kerala

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Min.	Max.	FN	AN		
January	23.29	30.71	89.90	67.74	4.06	1
February	24.00	30.92	88.46	65.86	54.10	2
March	24.94	31.92	85.81	64.73	0.76	0
April	24.80	32.02	89.17	71.11	202.69	11
May	25.13	30.88	89.30	74.71	312.42	16
June	24.82	30.31	88.16	75.92	138.18	12
July	24.26	29.59	88.43	77.32	125.48	12
August	24.29	29.05	89.43	78.61	184.14	11
September	24.77	30.19	89.08	77.13	105.92	7
October	24.25	30.02	90.36	75.34	311.91	12
November	23.73	30.15	91.40	70.76	91.95	6
December	23.56	30.50	90.69	69.60	82.30	5

ICAR-CTCRI, Regional Station, Bhubaneswar, Odisha

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)	No. of rainy days
	Min.	Max.	FN	AN		
January	14.90	26.90	94	50	29.10	4
February	17.70	30.50	95	70	41.10	1
March	23.60	35.40	94	72	0.00	0
April	26.50	37.70	93	75	57.40	2
May	26.60	35.90	94	80	128.50	7
June	26.80	34.80	93	85	206.40	12
July	26.20	32.40	96	91	342.10	17
August	25.80	32.40	94	89	278.40	15
September	25.50	31.70	95	90	332.30	16
October	23.20	32.10	92	82	50.90	5
November	18.40	30.40	82	48	0.00	0
December	16.00	29.10	87	43	0.00	0

CTCRI/QSF/RP/400

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