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ICAR–CTCRI
Six decades of innovation and service in the tropical tuber crops sector

Since its establishment in 1963, the ICAR–Central Tuber Crops Research Institute (CTCRI), headquartered at Thiruvananthapuram with a regional station in Bhubaneswar, has spearheaded research, innovation, and development in tropical tuber crops. Over six decades, ICAR-CTCRI has transformed cassava, sweet potato, elephant foot yam, yams, taro, and a few other crops from underutilized crops into vital contributors to India's food, nutrition, and livelihood security. The institute has conserved over 5,000 germplasm accessions, released 77 improved varieties, and developed biofortified crops to combat micronutrient malnutrition. It has pioneered climate-smart production practices, IoT-enabled smart farming, pests and disease management strategies, and quality seed systems. Value addition technologies, industrial linkages, and start-up incubation have generated livelihoods, with women and youth empowered through tuber-based enterprises. Farmer participatory research, training, and collaborations strengthened outreach across India. Today, ICAR-CTCRI stands as a global leader in tuber crop science, driving food security, health, and rural prosperity, while shaping a sustainable agro-industrial future.

Keywords: Agrobiodiversity, Biofortification, Germplasm, ICAR-CTCRI, Regenerative, Seed systems

The tropical tuber crops (TTC) are important staples for over one billion people in the developing world and are key to climate-resilient agriculture due to their ability to tolerate biotic and abiotic stresses. They offer high biological efficiency (cassava yields 250 kcal/ha/day compared to 155 kcal/ha/day for rice) and superior energy production efficiency (1,000 MJ/kg N in cassava vs. 350 MJ/kg N in rice). Highly versatile crops, they are food for the household, feed for livestock and raw materials for a wide array of value-added products, from coarse flour to high-tech starch gels to alcohol to biofuel to bioplastics. Many of the world's nature dependent and food insecure people are highly dependent on these crops as contributing, if not principal, sources of food, nutrition and family income. Though earlier considered as 'food of the poor', they have become multipurpose crops that respond to the priorities of developing countries, to trends in the global economy and to the challenges of climate change. They are candidate crops for ecosystem-based approach of production intensification that aims at greening the Green Revolution through farming practices that draw on nature's contributions to crop growth, such as soil organic matter, organic and bio-fertilizers and bio-control of insect pests and diseases.

In 2023, world produced 534.9 million tonnes (mt) of TTC harvested from 52.8 million hectare (mha) of land in about 135 out of 195 countries, mostly in tropical and sub-tropical Africa, Asia, Latin America and Pacific islands. Importance of global TTC production is evidenced by the fact that it is 67%, 67% and 140% of global rice, wheat and potato production respectively. India produced 9.66 million tonnes of TTC (1.8% of world production) from 0.388 mha of land (0.73% world area) in 2023 whose present market value is ₹125 billion. They are the source of sustenance and livelihood security of 200 million people across 20 different states of India, mainly Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Odisha, West Bengal, Bihar, Uttar Pradesh, Chhattisgarh, Gujarat, Goa, Maharashtra and North-eastern states.

The ICAR–Central Tuber Crops Research Institute (ICAR–CTCRI) began its journey on 1 July 1963, with its headquarters at Thiruvananthapuram, Kerala. Recognising the need for region-specific research, a Regional Station was set up in Bhubaneswar, Odisha in 1976, mostly to serve the Eastern and North-eastern regions. In its formative years, the Institute focused on crop improvement and production, and protection technologies for tropical tuber crops–an under-researched group vital to the food security of resource-poor farming communities.

The 15 mandate crops of the institute are cassava (*Manihot esculenta* Crantz), sweet potato (*Ipomoea batatas* (L.) Lam.), elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson), greater yam (*Dioscorea alata* L.), white yam (*Dioscorea rotundata* Poir.), lesser yam (*Dioscorea esculenta* (Lour.) Burk.), taro (*Colocasia esculenta* (L.) Schott), tannia (*Xanthosoma sagittifolium* (L.) Schott), giant taro (*Alocasia macrorrhiza* (L.) Schott), swamp taro (*Cyrtosperma chamissonis (Schott) Merr.)*, Chinese potato (*Plectranthus rotundifolius* (Poir.) Spreng.), yam bean (*Pachyrrhizus erosus* (L.) Urban), west Indian arrowroot (*Maranta arundinacea* L.), Queensland arrowroot (*Canna edulis* Ker-Gawler) and east Indian arrowroot (*Curcuma angustifolia* Roxb.).

RESEARCH STRENGTHS AND ACHIEVEMENTS

Agrobiodiversity conservation and crop improvement

ICAR–CTCRI serves as the National Active Germplasm Site (NAGS) for tropical tuber crops, playing a pivotal role in the collection, characterisation and conservation of the genetic diversity, with emphasis on indigenous types and exotic lines primarily from Africa, Latin America and the Pacific. The institute conserves 5,234 accessions comprising 1,216 of cassava, 905 of sweet potato, 801 of yams, 655 of edible aroids and 387 of minor tuber crops. Including 1,270 accessions conserved at the Regional Station, Bhubaneswar, Odisha, i.e. 113 of cassava, 380 of sweet potato, 51 of yams, 554 of edible aroids and 172 of minor tuber crops.

The institute began releasing improved varieties in 1971 with three cassava hybrids (H-97, H-165 and H-226) and two sweet potato hybrids (H-41 and H-42), and since then it has developed and released 77 improved varieties across the major tropical tuber crops. In cassava, 22 varieties have been developed for traits such as high yield, industrial relevance (high starch and high yield), cooking quality, short duration, nutrient use efficiency, drought tolerance and resistance to cassava mosaic disease.

In sweet potato, 21 varieties have been released with attributes like high yield, good cooking quality, early bulking, drought and salinity tolerance, biofortification with β-carotene and anthocyanins, suitability for processing, and diverse plant types including spreading, semi-spreading, semi-erect and semi-compact. In yams, 18 varieties have been developed – 10 in greater yam, six in white yam and two in lesser yam – addressing traits such as high yield, cooking quality, short duration, dwarf or bushy stature, desirable tuber shape, pest and disease resistance, drought tolerance and anthocyanin enrichment. For elephant foot yam, two varieties have been released for traits such as high yield, low acridity, cooking quality and disease tolerance. In taro, 10 varieties have been developed for traits like high yield, low acridity, desirable cormel shape, tolerance to drought, tolerance/resistance to diseases, and longer shelf life. Three varieties of arrowroot have been released for traits like high yield and starch content, while in Chinese potato, one variety has been released with high yield and round tuber shape.

Quality planting materials and seed systems

While seeds of most crops can multiply exponentially (often 100 times or more), vegetative planting materials such as that of tropical tuber crops multiply at a much slower rate (5-10 times), thereby restricting the rapid dissemination of improved varieties. This inherently low multiplication ratio, coupled with the bulkiness and perishability of planting materials, pose major challenges to the seed sector. To overcome this constraint, the institute initiated experiments in 2000, that eventually led to the development and perfection of minisett technology across most tropical tuber crops. Protocols for development of virus free plants were also standardised.

Between 2005–06 and 2024–25, the institute produced and distributed 15.67 lakh cassava stems, 128.17 lakh sweet potato vine cuttings, 392 tonnes of elephant foot yam corms, 326 tonnes of greater yam tuber, 44.2 tonnes of taro cormels, and 2.37 lakh Chinese potato vine cuttings. Recently, minisett protocols for quality planting material production have been further refined by standardising their production in protrays. Additionally, innovative soilless cultivation methods such as 'recirculatory dripponics' have also been developed to further enhance propagation efficiency.

To strengthen the seed system further, in 2014 ICAR–CTCRI conceptualised a novel Seed Village programme (SVP) aimed at ensuring large-scale, localised availability of planting materials and facilitating rapid area expansion under improved varieties. During 2014-15 to 2024-25, the institute identified 323 cassava farmers as planting material producers. As a further refinement, since 2021, the institute has introduced the recognition of Decentralised Seed Multipliers (DSMs) by certifying farmers who successfully sustain quality seed production. During the three-year period, 2021–2025, a total of 256 tuber crop farmers cultivating improved varieties over 146 acres were certified as DSMs.

Building on these progressive models, the institute convened a 'National Brainstorming Workshop on the Formalisation of Seed System of Tropical Tuber

Crops' on 03 December 2024. The recommendations from this workshop have been documented and available as Technical Bulletin No. 109/2025, providing clear guidelines for future interventions. Subsequently, a five-year roadmap for 2025–2030 was prepared to guide the systematic strengthening of the tuber crop seed sector.

Regenerative, climate-smart and precision production practices

Agroecological zone/region/unit-specific agro-techniques, customised cropping systems (13.5-15% higher yield; 45-54% higher profit), integrated farming systems (up to 26% higher yield), and regenerative/low-carbon farming practices such as organic farming (10-20% higher yield; 20-40% higher profit), natural farming (22-24% reduction in production cost) and conservation agriculture (13% higher yield) have significantly enhanced farmers' productivity and profitability besides providing many ecosystem services. These advancements have been strongly supported by the knowledge base generated in crop physiology. Similarly, integrated weed management (15-20% higher yield and 40-50% labour saving) and innovative water-saving methods (50% saving of water, 23-35% higher yield) and precision water management under 'per drop more crop' (PDMC) initiatives (40-50% higher yield, 70-80% water saving), not only boosted yields but also reduced the overall carbon footprint. Development of cassava harvester also helped enabling less drudgery and more profit.

Soil fertility management in tuber crops has evolved considerably over the past four decades. The blanket fertilizer recommendations and their soil test based adjustments developed during the 1980s provided a substantial yield advantage in the initial phase. Insights from long-term fertility experiments improved the understanding of nutrient dynamics, paving the way for the development of Integrated Plant Nutrient Management Systems (IPNMS). Later, more knowledge-intensive approaches such as Site-Specific Nutrient Management (SSNM) using modified QUEFTS models (2000s, 17–23% higher yield), drip fertigation (2010s, 25-33% nutrient saving), and AI-, sensor-, and crop-model–based e-Crop based smart farming (ECBSF) (2020s, 25-50% saving of water and nutrients) revolutionised nutrient management. These approaches substantially improved input-use efficiency, reduced dependence on external chemical fertilizers, lowered the carbon footprint, and enhanced farm profitability. To address micronutrient imbalances across tuber crop regions, multi-micronutrient formulations developed and commercialised by the institute have proven highly effective (5-9% higher yield). Furthermore, customised fertilizers designed using modified QUEFTS-based recommendations and related findings have consistently delivered significant yield gains.

Climate change preparedness has been another major research focus. By employing simulation models such as ECOCROP, WOFOST, MaxEnt, CROPWAT, and AquaCrop, the institute precisely forecasted future climate impacts on tuber crop productivity and identified potential new cultivation zones for 2030s, 2050s, and 2070s. Additionally, climate-resilient agricultural practices (14% higher yield) involving nutrient smart, water smart and carbon and energy smart practices were standardised, helping reduce external input requirements while enabling crops to withstand changes due to climatic stresses such as soil acidification and salinisation, soil erosion, periodical soil submergence, elevated CO_2, drought and heat.

Pests and diseases management

Diseases of serious concern include cassava mosaic disease (Indian cassava mosaic virus - ICMV and Sri Lankan cassava mosaic virus - SLCMV), stem and root rot of cassava (*Fusarium solani*), collar rot (*Sclerotium rolfsii*), dasheen mosaic virus (DsMV), and leaf and pseudostem rot of elephant foot yam (causal agents tentatively identified as *Colletotrichum* sp. and *Fusarium* sp., confirmation pending), anthracnose of yam (*Colletotrichum gloeosporioides*), and leaf blight of taro (*Phytophthora colocasiae*).

Serious insect-pests include cassava mealybugs (*Paracoccus marginatus, Ferrisia virgata* and *Phenacoccus manihoti*), cassava red spider mite (*Tetranychus* sp.), sweet potato weevil (*Cylas formicarius*), and nematodes–predominantly *Pratylenchus* sp. in elephant foot yam, and *Meloidogyne* incognita in Chinese potato.

Significant achievements include the identification and characterization of 13 pests and 18 diseases through both basic and molecular techniques; development of integrated management strategies for 15 pests and diseases and organic management protocols for 5 diseases; development of 70 diagnostic tools for the early detection of 14 diseases; identification of 25 sources of resistance against pests and diseases; and DNA barcoding of three insect pests (cassava and sweet potato whitefly, spiralling whitefly infesting cassava and arrowroot, and sweet potato leaf miner).

19 bioactive molecules have been isolated and identified from endosymbiotic bacteria associated with nematodes. Other noteworthy developments include three biocapsules containing *Trichoderma* and *Bacillus* spp. (both rhizospheric and endophytic), one *Trichoderma* powder formulation (*Sree Pragathi*), one liquid formulation of growth-promoting and disease-suppressing endophytic bacterium (*Sree Jala*), and one liquid formulation of growth-promoting and disease-suppressing *Trichoderma asperellum* (*Sree Syama*).

Other notable achievements are the development of genetic transformation protocols for cassava and elephant foot yam; creation of transgenic cassava with an RNAi construct conferring resistance to Sri Lankan cassava mosaic virus; complete genome sequencing of Indian cassava mosaic virus (two genomes), Sri Lankan cassava mosaic virus (four genomes), sweet potato leaf curl virus (six genomes), dasheen mosaic virus (one genome), and the taro leaf blight pathogen.

Secondary agriculture

Value-added food and industrial products and post-harvest machinery have significantly contributed to entrepreneurship development in the tropical tuber crops sector. Among food products, noteworthy technologies include snack foods, bakery items, pasta, noodles, instant food mixes, nutribars, vacuum-fried chips, sweet potato vine, and rice analogues. Major industrial products include modified starches, resistant starches, minimally processed tuber crops, functional sago, starch-graft copolymers, composites and nanocomposites for food and pharmaceutical applications, adhesives, superabsorbent polymers, thermoplastic starch sheets, biofilms, biodegradable disposable articles, bioethanol, and wax coatings for enhanced shelf life.

In post-harvest machinery, key achievements include cassava peeler, cassava chipping machines, raspers, mobile starch extraction units, feed granulators, Chinese potato size-based grader, portable self-propelled cassava sett cutter, and tractor-operated Chinese potato harvester.

The development, patenting, and commercialization of three bioactive molecules from crop residues (leaf and tender stem)–*Nanma*, *Menma*, and *Shreya*–represent a particularly significant achievement. Additionally, the development of nutrient-rich organic manure *('thippi compost')* from cassava starch factory solid waste and biochar from tuber crop residues are two other important technologies for effective waste utilization in tuber crop production and processing sectors.

The Techno-Incubation Centre (TIC) provides entrepreneurship training and capacity building for youth, women, start-ups, Farmer Producer Companies (FPCs), and other groups interested in tuber crop-based food enterprises. The agri-business incubator (ABI) supports entrepreneurs in establishing start-ups and enterprises based on ICAR-CTCRI technologies. Between 2007 and 2025, the institute commercialized 30 technologies, granted 80 licenses, and undertook 24 contract research and manufacturing projects, generating a revenue of ₹145.68 lakhs. The licensed technologies include value-added food products, micronutrient formulations, variety, bioformulations, technology to increase shelf life, It is noteworthy that there has been a significant surge in technology commercialization and contract research in recent years, as evidenced by the fact that 42% of this revenue (₹61.84 lakhs out of ₹145.68 lakhs) has been earned since 2023,–an indicator of the institute's enhanced commitment to technology transfer and commercialization.

IMPACT IN IMPROVING LIVELIHOODS

ICAR-Central Tuber Crops Research Institute (CTCRI) has significantly advanced the promotion of tropical tuber crops by linking research with field-level impact in the last six decades. Seed villages and large-scale demonstrations in different states under general, scheduled caste sub-plan (SCSP), tribal sub-plan (TSP) and north-east hill (NEH) sub-schemes have accelerated the adoption of technologies. A classical example is the 'Rainbow diet campaign' project, covering nutriseed villages, schools, and incubation centres in Kerala, Tamil Nadu, Odisha and Northeast, which encouraged healthier diets by integrating tubers and millets. Skill-building initiatives, particularly for collective women like *Kudumbashree*, have trained over a thousand beneficiaries in processing, value-addition, and entrepreneurship in the recent past. Between 2018 and 2024, about 450 training programmes and 2,600 on-farm trials/demonstrations benefitted nearly 40,000 farmers and stakeholders, highlighting ICAR-CTCRI's strong outreach.

Equally important is the institute's championing efforts in farmer-participatory technology development, sustainable livelihood assessments, gender mainstreaming, and scaling of technologies for food and nutrition security. It examines how technologies influence food systems and livelihoods at household, farm, and landscape levels. These studies provide critical insights for strengthening resilience, improving incomes, and shaping supportive policies. By fostering agribusiness incubation, encouraging women's participation, and building capacities of farmers, startups, FPCs, and SHGs, ICAR-CTCRI has created pathways for inclusive growth. Together, these initiatives reinforce the institute's role in improving food and nutrition security while driving rural development.

The impact studies highlighted the institute's significant returns on research investment. Using 13 cassava technologies (1971–2018) and 13 sweet potato technologies (1968–2018), along with 12 newer technologies (post-2010), a partial budgeting analysis estimated ₹1.97 billion in direct annual benefits to producers and consumers. The benefit: cost ratio was 9.75, with an internal rate of return (IRR) of 54%. Another study showed that CTCRI cassava varieties now cover 30% of India's cassava area, generating a net present value of ₹7.14 billion annually, with a benefit: cost ratio of 39.99 and IRR of 44%. These varieties increased yield by 13%, created 11.3% more employment, and boosted net income by 17%.

From 1963 to 2023, India's total tuber crops production rose from 3 to 9.66 million tonnes annually. The economic value of the produce grew from ₹40 to ₹130 billion, driven mainly by productivity growth averaging over 4% per year–far exceeding the global average of 0.56%. The tuber crops value chain now generates 75 million man-days of employment annually. Overall, the social benefits of CTCRI's technologies over the past six decades are currently valued at ₹1.40 billion annually.

CONCLUSION

Over six decades, ICAR–CTCRI has transformed tropical tuber crops from subsistence staples into high-value, climate-resilient, and nutritionally significant components of India's agriculture. Its sustained efforts in germplasm conservation, varietal development, technology innovation, and farmer empowerment have positioned it as a global leader in this domain. As it moves into its seventh decade, the institute remains committed to advancing scientific excellence, enhancing farmer livelihoods, and contributing to the nation's nutritional and economic security through sustainable tuber crop development.

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