

Impact Assessment of Improved Varieties and Technologies of ICAR-CTCRI



भाकृअनुप- केंद्रीय कंद फसल अनुसंधान संस्थान

(भारतीय कृषि अनुसंधान परिषद्)

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ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE

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Sreekariyam, Thiruvananthapuram - 695 017, Kerala, India



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From the Director



Tropical tuber crops such as cassava, sweet potato, yams, aroids and other minor tuber crops contribute significantly to food, nutrition, income and livelihood security for about 200 million people across various states in India. In 2023–24, India produced 9.97 million tonnes of these tubers from 0.40 million hectares accounting for 5% of the country's total vegetable production.

The ICAR-Central Tuber Crops Research Institute has been playing a pioneering role in the development and dissemination of improved varieties and technologies. Since its inception, the Institute has released 77 high yielding varieties and many important technologies encompassing production, protection, value addition and mechanization. These technologies have significantly enhanced crop productivity and quality, improved farm income, generated employment and promoted environmental sustainability.

To understand the true value of research investments and to formulate future policies, it is imperative to measure the economic, social and environmental impacts of these technologies. This technical bulletin presents an ex-post impact assessment of selected varieties and technologies of ICAR-CTCRI using robust quantitative approaches such as Economic Surplus Model, Propensity Score Matching, Partial Budgeting Analysis and IPWRA techniques. The use of diverse quantitative methods strengthens the reliability and policy relevance of the findings.

Earlier studies estimated that varieties and technologies developed by ICAR-CTCRI generated a total economic benefit of ₹ 12321 crores from 1971 to 2018. This bulletin is based on studies conducted subsequently to understand the adoption patterns, socio-economic impacts, farmer preferences, and the contribution of tuber crops technologies to the Sustainable Development Goals (SDGs).

I appreciate the authors for their meticulous research and effort in bringing out this valuable publication. I am confident that this bulletin will serve as a useful resource material for policymakers, researchers, extension professionals, donor agencies and all other stakeholders involved in tuber crops research development and impact evaluation.

01 July 2025
Thiruvananthapuram


G. Byju

Introduction

India hosts one of the largest publicly funded agricultural research and extension systems in the world (Evenson et al., 1999). Since the economic liberalization policies initiated in 1991, concerns about fiscal constraints and diminishing returns to public research have raised critical questions regarding the adequacy of investment in agricultural R&D particularly for non-cereal crops like tropical tubers. Despite this, agricultural research remains central to India's food security and rural development goals. The World Bank recommends that countries invest at least 1% of their agricultural GDP in research. While developed countries typically invest up to 2.5%, India invests only about 0.41%. At independence, India's agricultural R&D spending was less than 0.1% of agri-GDP. This rose to 0.2% in the 1960s and has fluctuated between 0.45–0.5 percent since the early 1980s. During 2019-21, India's agricultural R & D spending was 0.3% (Plastina and Townsend, 2023). The demand for greater returns on limited public investments in agriculture necessitates systematic documentation and impact assessment of research outcomes. Donors and policymakers increasingly seek evidence of economic and social returns from past investments as justification for future funding. Research programmes that demonstrate strong historical performance in generating tangible benefits tend to attract more financial and other resources. In India, agricultural research and education have contributed significantly to economic growth spanning from the Green Revolution's high-yielding cereal varieties to advancements in hybrid horticultural crops, livestock productivity, and fisheries. Policy support and public investment have played an instrumental role in these achievements. However, the post-1990s slowdown in productivity and public investment prompted renewed efforts to improve dissemination and effectiveness of agricultural technologies.

The ICAR–Central Tuber Crops Research Institute (ICAR–CTCRI) stands as a global leader in tropical tuber crops research. The Institute has so far released 77 improved varieties and many technologies, including innovations in production, protection, processing, and pre-/post-harvest mechanization. These varieties are widely adopted due to their unique traits such as high yield, pest and disease resistance, drought and salinity tolerance, superior starch quality, and consumer-preferred characteristics. Despite these achievements, the extent of technology adoption and its impact on farm

income and rural livelihoods requires scientific evaluation. In view of this, an ex-post impact assessment was undertaken to quantify the economic returns from improved varieties and associated technologies developed by ICAR–CTCRI. The assessment used the economic surplus model to estimate net benefits, internal rate of return (IRR), and benefit-cost ratio (BCR). The study also integrates socio-economic analysis, as many of these technologies have been adopted over time at varying levels by farmers across multiple states.

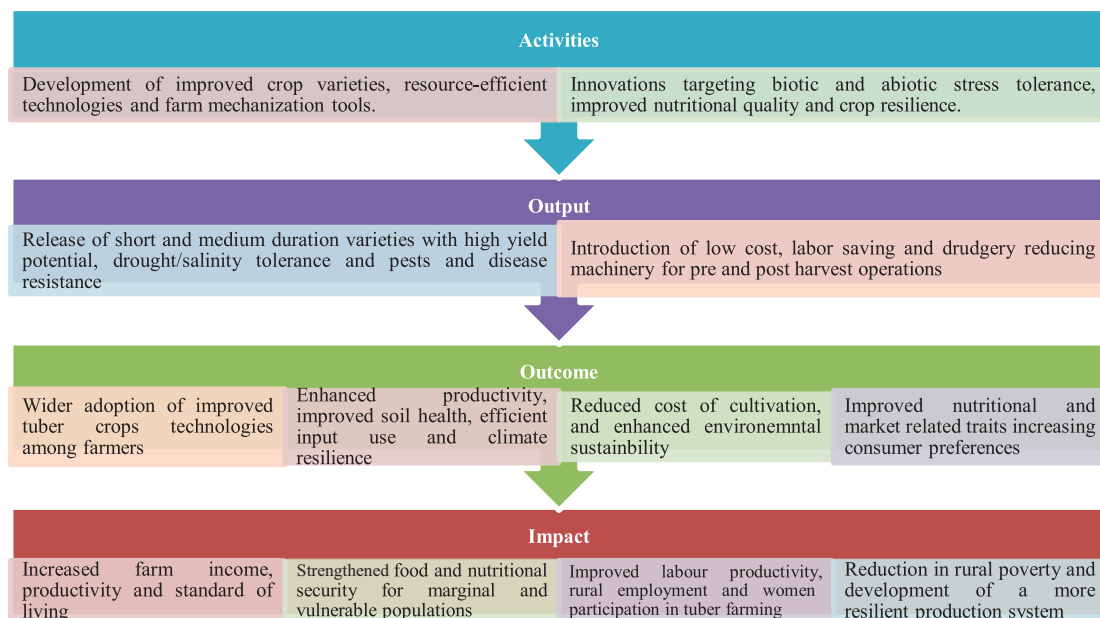
Framework for socio-economic impact assessment

The socio-economic impact assessment is broadly classified into two categories such as ex-ante and ex-post assessment. The ex-ante assessment is done before introduction of technology while, ex-post is done after introduction of technology. The socio-economic impact assessment is further classified into micro and macro level. Micro level studies are done at farm level and macro level studies are done at region and or country level.

Level	Approaches	Ex-ante assessment	Ex-post assessment
Micro	Adoption	Simulation	Logit/Probit, Tobit, Heckman and double hurdle model
	Impact	Simulation and Economic surplus model	Partial budgeting analysis (PBA), Propensity score matching (PSM), Randomized control trial (RCT), Economic surplus model (ESM), Difference in Difference (DID), Instrumental variable (IV) and Regression adjustment
Macro	Adoption	Systematic review and Simulation	Systematic review
	Impact	Systematic review and Economic surplus model	Systematic review and Total factor productivity (TFP)

Research to Impact Framework (Activities - Outputs - Outcomes – Impacts)

To understand the pathway through which ICAR-CTCRI research translates into societal benefit, the following results based framework, outlines the logical sequence from research activities to measurable impacts.



Research to Impact framework

Methodology

Data and parameters

For the impact assessment, tuber crop varieties and technologies released by ICAR–CTCRI since 1971 were reviewed to identify the most widely adopted interventions. Based on adoption extent and relevance, eight varieties of two crops, along with one key technology, were selected for detailed analysis. To estimate the economic surplus generated by these technologies, data were gathered on both technological and economic parameters. The technological parameters included yield advantage, cost savings, adoption pattern and the research and development (R&D) lag period. These data were obtained from literature, scientists and primary surveys with farmers, using a well-structured questionnaire. The literature survey was done based on published sources such as books, journal articles and research reports. The literature survey also helped to determine the extent of technology adoption across different states.

The study mainly relied on farm household survey to assess the impact of ICAR-CTCRI varieties and technologies. Detailed information on the socio-economic profile of farmers, extent of technology adoption and the associated costs and returns were collected. Data were also gathered from key informants, including progressive farmers, village leaders and officials from state departments. Adoption studies were conducted in the states of Tamil Nadu, Kerala, Andhra Pradesh, Karnataka and Odisha, focusing on important tuber crops such as cassava, sweet potato, elephant foot yam and Chinese potato. A total of 1044 farmers were surveyed during the study period from 2021–2022 to 2024–2025.

The economic data included cassava prices, area under cultivation and output quantities in the key target states viz., Kerala, Tamil Nadu, and Andhra Pradesh. These were collected from various secondary sources such as the Department of Economics and Statistics, Government of Kerala, Directorate of Economics and Statistics, Government of India, and Agmarknet. Data on percentage adoption, maximum adoption ceiling, cost and yield changes due to adoption, and elasticity parameters (elasticity of supply and demand for cassava) were derived from both primary surveys and published sources (Alston et al., 1995; Srinivas et al., 2006; Nderim Rudi, 2008).

To assess the impact of the micronutrient liquid foliar formulation developed for tuber crops, data on sales volume, prices, production costs, input use patterns, yield increment and technology adoption were collected through both primary and secondary sources. All necessary data inputs for economic surplus estimation, partial budgeting and other impact assessment models were compiled from the primary surveys conducted during 2021–2022 to 2024–2025.

Impact assessment tools

To evaluate the economic impact of improved tropical tuber crop varieties and technologies, an ex-post impact assessment approach was employed, which is appropriate when the technologies under study are already in use by farmers. While both ex-ante and ex-post approaches are commonly used in impact assessment literature, this study focused on the ex-post method, as it captures the realized benefits and adoption dynamics of technologies already disseminated in the field. A range of analytical tools which are commonly employed in impact assessment are

- Partial budget analysis (PBA)
- Economic surplus model (ESM)
- Randomized control trial (RCT)
- Propensity score matching (PSM)
- Difference in Difference approach (DID)
- Regression adjustment and other econometric techniques

For this study, a combination of the most suitable tools was used to assess the economic and social impacts of the most widely adopted varieties and technologies of tropical tuber crops released by ICAR–CTCRI.

Economic Surplus Model (ESM)

Economic surplus model was used to estimate the potential economic benefits arising from the adoption of improved cassava varieties. This model quantifies the change in producer and consumer surplus resulting from the adoption of yield enhancing or cost reducing technologies. In the absence of significant international trade in cassava, we assumed a closed economy framework. Under such conditions, an increase in supply due to improved technology leads to a reduction in market price for consumers and a cost saving for producers. It was assumed that the output supply function was unitary elastic and linear with a parallel research – induced supply shift and the demand function was linearly inelastic. These assumptions are widely used, especially in contexts where reliable estimates of scale economies or supply response are unavailable. According to Alston and Wohlgenant (1990), when a parallel shift in the supply curve is assumed, the specific functional form becomes less critical a linear model provides a reasonable approximation of the true behavior of supply and demand.

In Figure 1, S_0 represents supply function before the technical change, and D represents demand function. The initial price and quantity are P_0 and Q_0 , respectively. Suppose research generates yield increasing or input saving technologies, these effects can be expressed in terms of reduction in production cost, K , that are modelled as a parallel shift down in the supply function to S_1 . This research-induced supply shift leads to an increase in production and consumption to Q_1 ($\Delta Q = Q_1 - Q_0$), and the market price falls to P_1 (by $\Delta P = P_0 - P_1$). The change in consumer surplus which is the

measure of the consumer benefit is equal to area P_0abP_1 . The change in producer surplus which is the measure of the producer gain is equal to area P_1bI_1 - area P_0aI_0 .

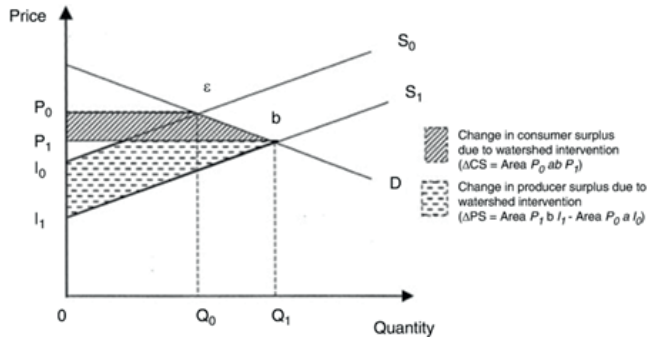


Figure 1: Economic Surplus Model

Source: Ashok et al., 2017; Shyam et al., 2020

Change in total surplus comprise both the changes in producer and consumer surplus resulting from the shift in supply. Consumers are better off because they consume more at a lower price. Although producers are receiving a lower price for their tubers, they are able to sell more, so their benefits increase, unless supply is perfectly elastic or demand is perfectly inelastic, in which case their revenue remains the same. The change in total surplus can be thought of as the maximum potential benefits to a technology (for example an improved crop variety).

$$\Delta TS = KP_0Q_0(1+0.5Z\eta) \quad \Delta CS = P_0Q_0Z(1+0.5Z\eta) \quad \Delta PS = P_0Q_0(K-Z)(1+0.5Z\eta)$$

Where, P_0 =base year output price; Q_0 =base year output quantity; $Z=K\epsilon/(\epsilon+\eta)$ relative reduction in price due to supply shift; ϵ = supply elasticity; η = demand elasticity; K = shift of the supply curve as a proportion of the initial price. The proportionate shift of the supply curve K can be calculated as $K = (E(Y)/\epsilon - E(C)/(1+E(Y)))pA_t(1-d_t)$.

Where, $E(Y)$ = expected proportionate yield Δ (per ha) from adoption of new technology; $E(C)$ = expected proportionate Δ in variable input cost (per ha) from adoption; p =probability of success of achieving the expected yield Δ from adoption; A_t = adoption rate of technology in time t ; d_t =rate of depreciation of the new technology.

Economic feasibility measures

To assess the economic viability of the improved cassava varieties and associated technologies, net present value (NPV), benefit-cost ratio (BCR) and internal rate of return (IRR) were used. A discount rate of 5% was applied to calculate the present value of costs and returns over time.

Net present value (NPV)

NPV is the difference between the present value of benefits and the present value of costs over the investment period. It represents the incremental net benefit (or net cash flow) generated by the technology. A positive NPV indicates that the investment is economically viable.

$$NPV = \sum_{t=1}^n \frac{B_t}{(1+r)^t} - \sum_{t=1}^n \frac{C_t}{(1+r)^t}$$

Benefit-cost ratio (BCR)

BCR is the ratio of the present value of benefits to the present value of costs. A BCR greater than 1 indicates that the benefits outweigh the costs.

$$BCR = \frac{\sum \frac{B_t}{(1+r)^t}}{\sum \frac{C_t}{(1+r)^t}}$$

Internal rate of return (IRR)

IRR is the discount rate at which net present value (NPV) becomes zero. It represents the break even interest rate or the maximum return that can be earned on the investment. A higher IRR indicates greater profitability of the technology.

$$IRR = \sum \frac{B_t}{(1+r)^t} - \sum \frac{C_t}{(1+r)^t} = 0$$

Where, B_t is the benefit in year t , C_t is the cost in year t , r is the discount rate, t is the number of years.

Table 1. Assumptions and data sources used for economic surplus analysis of cassava varieties

Sl. No.	Parameters	Assumptions/Sources
1	Year of release of varieties	H -165 – 1971; H-226 – 1971; Sree Jaya – 1998; Sree Athulya – 2014; Sree Pavithra – 2015; Sree Reksha – 2017; Sree Kaveri - 2023
2	Year of research began for development of varieties	H - 165 – 1966; H-226 – 1966; Sree Jaya – 1991; Sree Athulya – 1998; Sree Pavithra – 2006; Sree Reksha – 2006; Sree Kaveri - 2008
3	R & D and dissemination costs	Reports/projects covering salaries, trials, demonstrations, training and extension activities
4	Change in yield (%)	Previous studies and field survey data
5	Change in cost (%)	Previous studies and field survey data
6	Adoption rate (%)	Previous adoption studies and field survey estimates
7	Maximum adoption rate (%)	Expert assessments
8	Area under variety	Primary survey estimates
9	Quantity of production	Primary survey estimates; Secondary sources (https://eands.da.gov.in/); (https://www.indiastatagri.com/)
10	Supply elasticity	Literature
		Alston et al. (1995)
		Ashok et al. (2017)
11	Demand elasticity	Literature
		Tsegai and Kormawa (2002)
		Nderim Rudi (2008)
12	Price of output	Primary survey estimates
		Secondary source
		https://agmarknet.gov.in/
13	Discount rate (%)	5 (Birthal et al.,2012)

Partial budgeting analysis (PBA)

Partial Budget Analysis is a widely used tool to estimate changes in costs and returns resulting from the adoption of new agricultural technologies (Roth, 2002). It focuses on the incremental costs and benefits that arise from a change in the production system. This method is particularly useful when the change affects only a part of the overall farm enterprise. In this study, PBA was employed to compare existing/local varieties and practices with improved tuber crop varieties and technologies. The analysis captures changes in yield, input costs, and farm income associated with technology adoption.

The estimation of contemplated changes in partial budgeting is done by considering the costs in the debit side and the benefits in the credit side. The elements of both credit side and debit side are expressed as

$$\text{Credit} = \text{Added returns} + \text{Reduced costs}$$

$$\text{Debit} = \text{Reduced returns} + \text{Added costs}$$

$$\text{Net benefit} = [\text{Credit} - \text{Debit}]$$

The net benefit which yields the quantified value of impact is obtained by subtracting the credits from the debits. A positive change in the net benefit indicates that the technological change was beneficial and vice-versa.

Propensity score matching (PSM)

Propensity score matching is used to assess the impact of technology. In case of observational studies where treatment is not assigned in random, it is difficult to estimate the impact. This happens as adoption or non-adoption of technology which is determined by a set of socioeconomic variables and hence, the decision to adopt technology can lead to self-selection bias (Becerril & Abdulai, 2010; Wu et al., 2010).

PSM helps match adopters with non-adopters who have similar observable characteristics (covariates), thereby mimicking a randomized control setting (Essama-Nssah, 2006). The propensity score, i.e., the probability of adopting a technology, is estimated using a binary choice model such as a Probit or Logit regression:

$$Y_i = \alpha + \sum \beta_j X_{ij} + \mu_i$$

Where, Y_i is dummy variables ($Y_i=1$ if adopted the technology; $Y_i=0$ otherwise), X_i is the vector of explanatory variables, β_j is the vector of estimated parameters and μ_i is the error term which is normally distributed.

After estimating the propensity score, matched pairs are created, and the Average Treatment Effect on the Treated (ATT) is computed as:

$$ATT = E\{Y_{i1}/T = 1\} - E\{Y_{i0}/T = 0\}$$

Where Y_1 and Y_0 represent outcomes with and without the technology respectively and i is the number of farm households.

Inverse probability weighted regression adjustment (IPWRA)

IPWRA is used to assess the impact of technology. IPWRA is a robust estimator that combines regression adjustment (RA) and inverse probability weighting (IPW). It accounts for both treatment assignment bias and outcome model bias, making it a doubly robust estimator. Even if either the treatment model or the outcome model is misspecified, the estimator still yields consistent results (Wooldridge, 2003; Zheng and Ma, 2021).

For adopter farmers, a weight of 1 is used and for non-adopter farmers, the weight is calculated as:

$$\frac{\bar{p}(x)}{1 - \bar{p}(x)}$$

Where, $\bar{p}(x)$ are the estimated propensity scores i.e. the predicted probability of adopting the technology (Hirano and Imbens, 2001).

The combined weight formula used for all observations is (Manda et al., 2018).

$$W_i = T_i + (1 - T_i) \frac{\bar{p}(x)}{1 - \bar{p}(x)}$$

The regression adjustment model estimates the average treatment effect by comparing predicted outcomes for adopters and non adopters.

$$ATT_{RA} = n_A^{-1} \sum_{i=1}^n T_i [r_A(X, \delta_A) - r_N(X, \delta_n)]$$

Where n is the number of adopters (A) and $r_A(X, \delta_A)$ and $r_N(X, \delta_n)$ are the predicted outcomes for adopters and non adopters respectively based on the covariates X and estimated parameters δ_A, δ_N .

The IPWRA estimator combines this regression model with inverse probability weighting, and calculates ATT as

$$ATT_{IPWRA} = n_A^{-1} \sum_{i=1}^n T_i [r_A^*(X, \delta_A^*) - r_N^*(X, \delta_N^*)]$$

IPWRA improves the accuracy of impact estimates by addressing both selection bias and model misspecification, making it as a preferred method in observational studies.

Adoption of Improved Varieties and Technologies

The ICAR-CTCRI has released 77 high yielding and improved varieties of tropical tuber crops through its crop improvement programme. These varieties are characterized by traits such as high yield potential, high starch content, resistance to pests and diseases, shorter duration, drought and salinity tolerance and suitability for cropping systems. In addition to agronomic advantages, many of these varieties also offer superior cooking quality, attractive color and size, market preference and nutritional benefits. These distinct traits have contributed to the widespread adoption of ICAR–CTCRI varieties by farmers across different states in India, enabling them to enhance productivity and manage various agronomic constraints.

Cassava

In India, there is no well established formal seed market system for cassava planting material. Cassava is propagated vegetatively through stem cuttings and several key stakeholders involved in its dissemination are given below.

1. Farmers (retaining and reusing their own planting materials)
2. Neighboring farmers (limited farmer-to-farmer exchange)
3. Research Institutes such as ICAR–CTCRI and AICRP on Tuber Crops
4. Krishi Vigyan Kendras (KVKs) and public/private extension agencies
5. Starch and sago industries

Results of the present study showed that, cassava varieties released by ICAR–CTCRI has covered 29.69% of the total area under cassava cultivation in India. Local varieties cover approximately 65.01%, while varieties from State Agricultural Universities (SAUs) cover 5.30% of the total area (Figure 2).

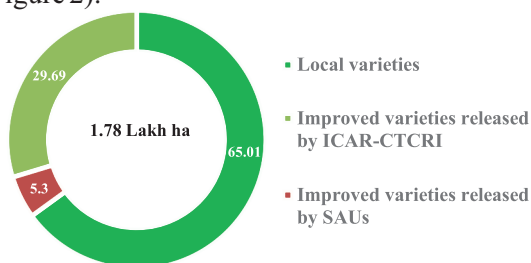


Figure 2. Percent of adoption of cassava varieties in India

State wise adoption of cassava varieties (Figure 3).

1. **Tamil Nadu:** 38.69% adoption of improved varieties released from ICAR-CTCRI and 8.62% from SAUs; 52.69% under local varieties.
2. **Kerala:** 14% of farmers have adopted improved varieties released from ICAR-CTCRI, while 86% adopted local varieties.
3. **Andhra Pradesh:** 30% adoption of improved varieties released from ICAR-CTCRI; 70% under local varieties.

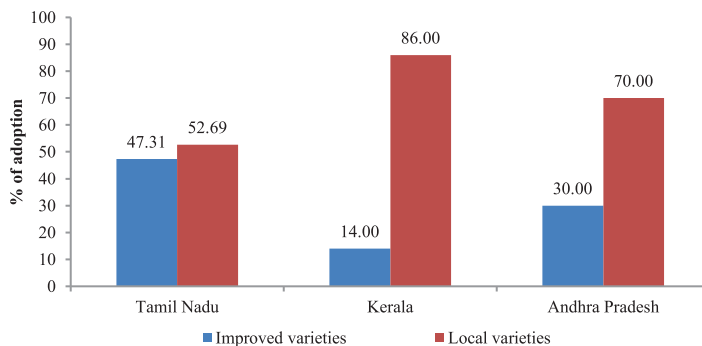


Figure 3. State wise adoption of cassava varieties in India

Tamil Nadu

The study was conducted in cassava growing districts viz., Salem, Tiruchirappalli, Namakkal, Cuddalore, Dharmapuri and Pudukkottai districts with a sample size of 300 farmers selected from 30 villages across 14 blocks. In Tamil Nadu, farmers generally cultivate 17 varieties of cassava in these districts. Among them, improved varieties released by ICAR-CTCRI such as H-165, H-226, Sree Athulya, Sree Jaya, Sree Reksha, Sree Kaveri account for 38.69% of the area. Another 8.62% of the area is under improved varieties released by SAU (*Mulluvadi*, YTP I, YTP II and CO 4). The remaining 52.69% is under local varieties. Among the improved varieties, H-226 and Sree Athulya are the most widely adopted, covering 29% of the total cassava area. Among local varieties, *White Thailand* and *Kunkumarose* are the most popular, covering 44% of the area (Figure 4). These local varieties are favored for their availability of planting materials and well adapted to the local environment with optimum yield and starch content.

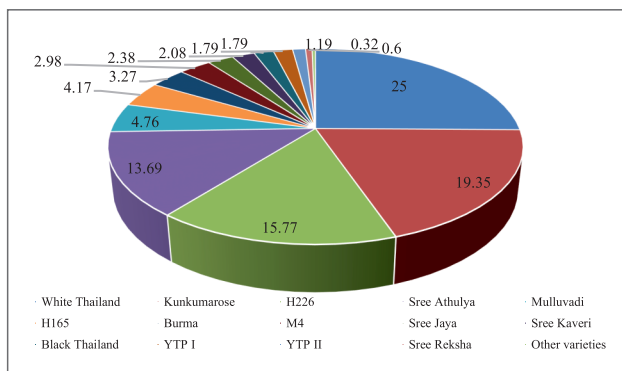


Figure 4. Adoption of cassava varieties in Tamil Nadu

Kerala

The study was conducted in Parassala, Nemom and Kilimanoor blocks of Thiruvananthapuram district with a sample of 142 farmers selected from eleven villages. Farmers in Thiruvananthapuram are growing improved varieties released by ICAR-CTCRI such as Sree Pavithra, Sree Reksha, Sree Jaya, Sree Vijaya, and Sree Visakham covering 14% of the cultivated area. The remaining 86% is under local varieties. Among the improved types, Sree Pavithra and Sree Reksha are the most adopted, covering around 10% of the area. Popular local varieties include *Ullichuvala* (21%), *Noorumuttan* (15%), *Karuthakanthari* (8%), *Kottayam Black* (7%) and *Kottayam Green* (7%). These are preferred due to their planting material availability, cooking quality and market preference.

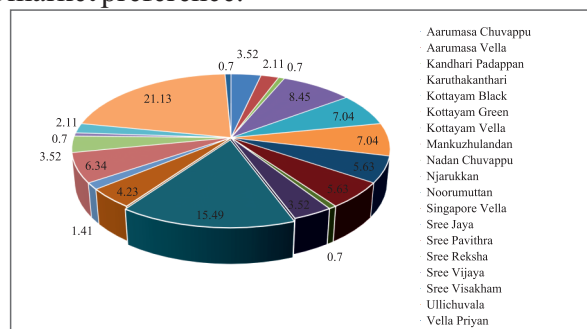


Figure 5. Adoption of cassava varieties in Kerala

Andhra Pradesh

The study was conducted in Kakinada and East Godavari districts with a sample of 80 farmers selected from six villages. In Andhra Pradesh, farmers primarily cultivate three varieties of cassava such as Sree Reksha, Sree Jaya and local white. Improved varieties released by ICAR-CTCRI such as Sree Reksha and Sree Jaya occupy 30% of the area, while 70% is covered by local varieties.

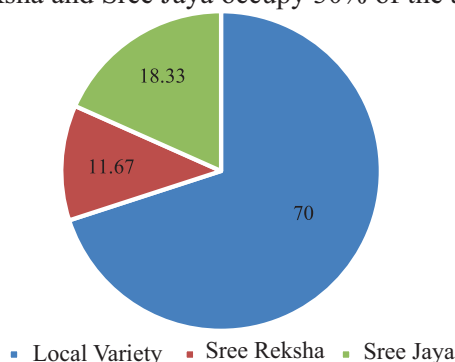


Figure 6. Adoption of cassava varieties in Andhra Pradesh

Sweet potato

Sweet potato is an important crop for food, feed and nutritional security in several Indian states due to its adaptability, short duration and high β -carotene content particularly in orange-fleshed varieties. It is widely grown in Odisha, West Bengal, Uttar Pradesh and Karnataka, often by small and marginal farmers under rainfed and low-input systems. Adoption studies conducted both in Odisha (Sanakhemundi and Sheragada blocks) and Karnataka (Belagavi and Khanapur taluks) with a sample of 212 farmers from 15 villages, revealed that 42.45% of the total area surveyed was under improved varieties such as Kanhangad (41.04%) and Kishan (1.42%), while the remaining 57.55% was cultivated with local varieties like *Malakkapuri* (10.85%) and other local varieties (46.69%) (Figure 7). Studies by Srinivas and Nedunchezhiyan (2020) in Odisha, Uttar Pradesh and West Bengal indicated that 77.61% of the area covered with high-yielding varieties (5.26% from ICAR-CTCRI, 72.35% from SAUs/Others), with the remaining 22.39% planted with local varieties (Annexure II). Similarly, research by Prakash et al. (2017) in Koraput, Ganjam, Kalahandi, and Kandhamal districts of (Odisha showed that 12% of the area adopted improved varieties released by ICAR-CTCRI Orange fleshed sweet potato (OFSP)-11% and Gouri-1%), with the remaining 88% using local varieties.

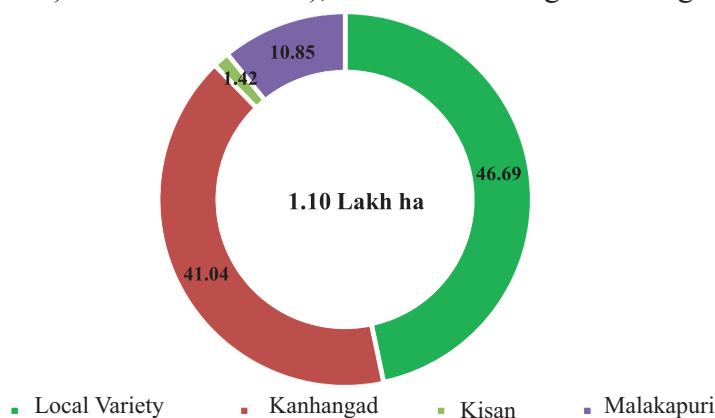


Figure 7. Adoption of sweet potato varieties cultivated in India

Elephant foot yam

The study was conducted in Konaseema and East Godavari districts of Andhra Pradesh and Tenkasi and Kallakurichi districts of Tamil Nadu covering a sample of 110 farmers from seven blocks across 11 villages. Farmers in the study area cultivated both improved and local varieties of elephant foot yam. Improved varieties such as Gajendra (69.09%) and Sree Padma

(12.73%) are widely adopted, covering 81.82% of the total area. These varieties are preferred for their high yield and marketability. The remaining 18.18% of the area was under local varieties (Figure 8) mainly due to their adaptability to specific agro-climatic conditions.

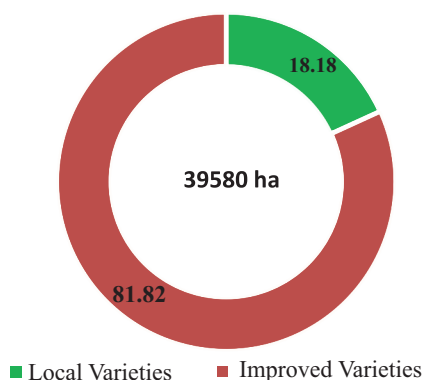


Figure 8. Adoption of elephant foot yam varieties in India

Chinese potato

The Sree Dhara variety released by ICAR-CTCRI is predominately cultivated in large areas and popular among farming community in Kerala and Tamil Nadu. In the study areas of Tenkasi and Tirunelveli districts in Tamil Nadu covering four blocks and 12 villages with a sample of 200 farmers, 38% of the total cultivated area was under Sree Dhara released by ICAR-CTCRI, while 62% was under local varieties (Figure 9). Farmers prefer Sree Dhara for its yield stability, good shape and size, market value and tolerance to nematode infestation.

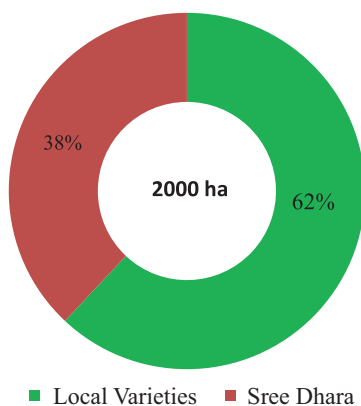


Figure 9. Adoption of Chinese potato varieties in India

Micronutrient liquid foliar formulations

The adoption of micronutrient liquid foliar formulation for cassava/tapioca, sweet potato, elephant foot yam, yams and Chinese potato has shown an upward trend across Kerala, Tamil Nadu and Andhra Pradesh over the past six years. In 2019, the formulation was adopted over 228 hectares, marking the initial phase of its introduction. However, in 2020, the area under adoption declined sharply to 93 hectares, possibly due to disruptions caused by the COVID-19 pandemic or supply constraints. A significant recovery was observed in 2021, with the adoption area increased to 419 hectares in 2021 and in 2024 it was adopted in 712 hectares (Figure 10). This increasing trend showed greater awareness among farmers about the formulation's benefits, including improved crop yield, quality and resistance to micronutrient deficiencies.

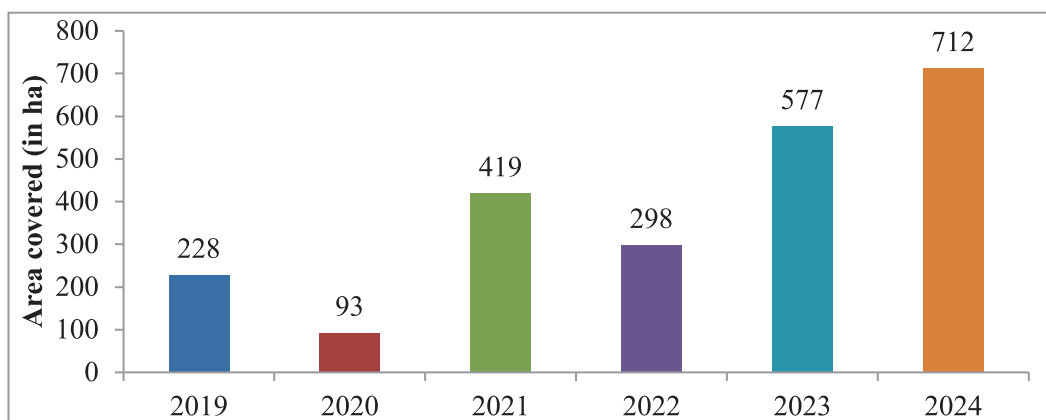


Figure 10. Adoption of micronutrient liquid foliar formulations in tuber crops

Economic Impact of Improved Varieties and Technologies

The adoption of improved varieties and technologies developed by ICAR–CTCRI has led to significant economic benefits for farmers cultivating cassava, elephant foot yam and Chinese potato and adoption of microfood. These benefits are reflected in terms of increased yields, reduced production costs, higher profitability and better market acceptance.

Research cost incurred in cassava production technologies

The research cost and present value of research cost on cassava production technologies through different research projects undertaken at ICAR-CTCRI and work carried out by All India Coordinated Research Project on Tuber Crops through its Centres in different agricultural universities were estimated (Annexure IV). The present value of research cost was calculated using the wholesale price index (WPI) with a base year of 2011-2012. The research cost incurred from 1966 to 2000 were obtained from research papers published by Srinivas (2009), while costs from 2001 to 2022 were estimated from various reports of ICAR-CTCRI.

ICAR-CTCRI varieties account for over 30% of total area under cassava cultivation in India. These varieties significantly boost gross returns compared to other existing varieties, generating an additional income of ₹ 732 crores for the farming community due to their high-yielding and other characteristics as of 2025. Among these, Sree Athulya (₹ 346 crores), Sree Reksha (₹ 127 crores), H 226 (₹ 115 crores), H 165 (₹ 37 crores), Sree Kaveri (₹ 63 crores), Sree Pavithra (₹ 40 crores) and Sree Jaya (₹ 0.97 crores) have generated the highest additional income (Figure 11). Sree Kaveri is projected to continue contributing significant returns for another 10 years, given its sustained adoption and performance characteristics.

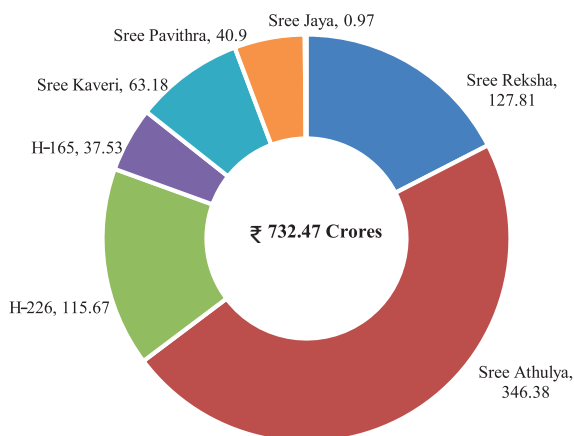


Figure 11. Additional income gained from ICAR-CTCRI varieties (₹ Crores)

The economic impact assessment of improved cassava varieties revealed that the present value of benefits was estimated at ₹ 732.48 crores, while the present value of costs was ₹ 18.31 crores. The present value of benefits represents the cumulative additional income generated by farmers through the adoption of improved cassava varieties, considering the time value of money. The present value of cost refers to the total research investment incurred over time, covering varietal development, multiplications trials and dissemination, considering the time value of money. The total economic gains or Net Present Value (NPV) is calculated as the difference between the present value of benefits and costs, amounted to ₹ 714.17 crores (₹ 732.48 crores - ₹ 18.31 crores), indicating substantial net returns from the research investment. This investment yielded a benefit-cost ratio (BCR) of 29.77:1 and a high internal rate of return (IRR) of 44 percent (Table 3).

Table 3. Total economic surplus from cassava varieties

Economic indicator	Value (₹ in crores)
Present value of benefits	732.48
Present value of cost	18.31
Total economic gains or net present value	714.17
Benefit cost ratio	39.99
Internal rate of return (%)	44
Return on investment	29.77

Impact of adoption of improved variety of Chinese potato

The variety 'Sree Dhara', released by ICAR-CTCRI, is widely cultivated and well-accepted among the farming communities of Kerala and Tamil Nadu. It accounts for approximately 38% of the total Chinese potato cultivation area in the country. The adoption of this improved variety resulted in a yield increase of 2.97 tons/ha and an income gain of ₹ 78,600/ha for adopters compared to non-adopters, indicating that adoption of Sree Dhara increases Chinese potato yield by 23.65% and income by 24.69%. As a result, the total economic benefit to society from the adoption of Sree Dhara is estimated at ₹ 5.97 crores.

Table 4. IPWRA estimates on the impact of 'Sree Dhara' adoption on yield and income

Outcome variable	Mean value of outcome variables		
	Adopters	Non-adopters	ATET (Impact)
Yield (tons/ha)	15.53	12.56	2.975***
			(1.187)
Income (Lakh/ha)	3.99	3.20	0.786***
			(0.342)

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



Figure 12. Improved variety of Chinese potato 'Sree Dhara'

Impact of micronutrient liquid foliar formulation on tuber crops

ICAR-CTCRI has developed customized foliar liquid micronutrient formulations suitable for tropical tuber crops such as cassava, sweet potato, elephant foot yam, yams and Chinese potato to address micronutrient deficiencies. These formulations are commercially available as 'Micronol Cassava' for acid soils, 'Micronol Tapioca' for neutral and alkaline soils, and as 'Micronol Elephant Foot Yam', 'Micronol Yams', and 'Micronol Chinese Potato' for the respective crops. These can be applied as foliar sprays at a concentration of 5 ml per litre of water, applied three times during the crop growth period at 2, 3, and 4 months after planting. One litre of the formulation diluted in 200 litres of water is sufficient for spraying one acre. These site-specific nutrient solutions help improve crop yield and quality while enhancing nutrient use efficiency, reducing excess fertilizer use and promoting environmental sustainability.



Figure 13. Micronutrient foliar formulations

The economic impact assessment of adopting micronutrient liquid foliar formulations in Kerala, Tamil Nadu and Andhra Pradesh from 2019 to 2024 have generated ₹ 21.23 crores (Figure 14). These include cassava (₹ 14.48 crores), elephant foot yam (₹ 2.46 crores), sweet potato (₹ 1.63 crores), yams (₹ 1.61 crores) and Chinese potato (₹ 1.06 crores). In 2024 the revenue generated was ₹ 5.58 crores including ₹ 2.78 crores from cassava, ₹ 0.25 crores from sweet potato, ₹ 1.45 crores from elephant foot yam, ₹ 0.77 crores from yams, and ₹ 0.32 crores from Chinese potato.

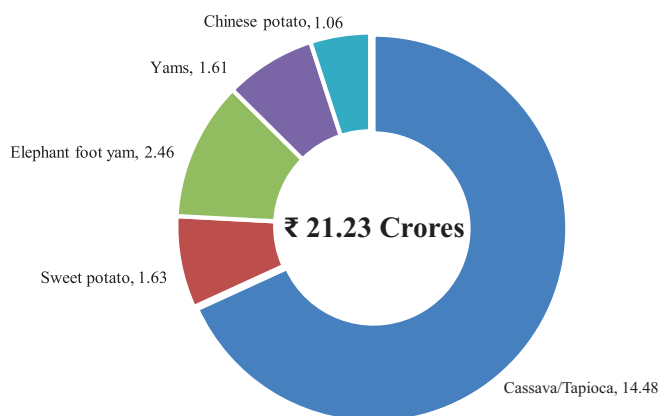
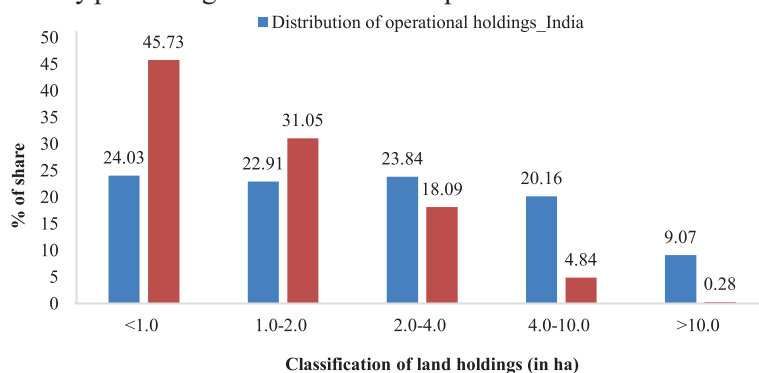


Figure 14. Additional income gained from microfood technology (₹ Crores)

An estimated ₹ 759 crores additional benefits have been realized from eight improved varieties (from two tuber crops) and microfood technologies developed by ICAR-CTCRI. These additional benefits have benefitted marginal farmers (45.73%), small farmers (31.05%) and semi-medium farmers (18.09%). The ICAR-CTCRI is not only enhancing the income of poor farmers but also contributing to the development of a more equitable and inclusive rural society. Of the 77 improved varieties released by the Institute, 10 are biofortified with essential nutrients and minerals, thereby promoting better nutrition and public health.



Source: Agricultural Census 2015-2016; Survey estimates

Social Impact of Improved Varieties

The social impact of improved cassava and Chinese potato varieties developed by ICAR-CTCRI has been substantial. Adoption of these varieties led to significant increases in household income by 17% for cassava adopters and 87% for Chinese potato adopters resulting in improved financial resilience and better living standards. Higher income enabled farmers to allocate 12–14% of additional earnings to education and health, directly supporting human capital development and household wellbeing. Market price advantages of up to 4-10%, driven by improved quality, starch content and good shape and size of tubers provided higher returns per unit area. Increased income also encouraged reinvestment in farming (up to 56%), enabling adoption of quality inputs and adoption of scientific agronomic practices. The technologies generated additional employment (11.3% increase in labour use), particularly in operations such as harvesting and grading of Chinese potato, thereby empowering rural women through gender participation in the value chain. Environmental Impact Quotient (EIQ) dropping from 54.9 to 22.35 due to the pest and disease tolerance, reducing pesticides use and promoting safer farming systems. The improved varieties also enhanced farmer's credit worthiness, improved market access and greater adoption, ultimately contributing to poverty reduction, improved quality of life and empowerment of small and marginal farmers. The socio-economic impact of high yielding varieties of cassava and Chinese potato are given below.

Table 5. Socio-economic impact of high yielding cassava varieties

Social impact dimension	Findings	Implications
Household income	Net income increased by 17% among adopters	High yielding varieties like Sree Athulya and H-226 boosted productivity and profitability compared to local varieties.
Crop yield	Yield increased by 13% (3.29 t/ha) (PSM result)	Better agronomic performance due to improved genetic traits and compatibility with irrigated systems.
Investment in family welfare	56% of income reinvested in agriculture; 12% for children's education; 14% on health	Improved financial stability led to better education, health, and productive reinvestment.
Credit worthiness	15% of farmers reported improved loan repayment capability	Enhanced income flow helped farmers meet financial obligations and reduce indebtedness.
Technology adoption	47.3% farmers adopted high-yielding and improved varieties released by SAUs and ICAR-CTCRI	Awareness programmes and demonstration plots influenced adoption in major cassava belts.
Market price advantage	Adopters received 3.6% higher price (₹ 8880/ton vs. ₹ 8576/ton)	Higher starch content in varieties like Sree Athulya attracted premium prices from starch and sago industries.

Environmental impact	EIQ reduced from 54.9 to 22.35 due to tolerance to pests and diseases like Sree Athulya	Reduced pesticide use contributes to environmental safety and sustainability.
Adoption enablers	Technical advice increased adoption probability by 18.8%	Extension services play a key role in farmer decision-making and technology diffusion.

Table 6. Socio-economic impact of improved Chinese potato variety 'Sree Dhara'

Social impact dimension	Findings	Implications
Household income	Net income increased by 87% among adopters	Adoption of Sree Dhara significantly enhanced profitability due to higher yield (25%) and better market price (10%).
Employment generation	Labour use increased by 11.3% (521 days/ha for adopters vs. 468 days/ha for non-adopters)	Labour-intensive operations, especially harvesting and grading, provided greater employment opportunities including for rural women.
Investment in education	12% of additional income spent on children's education	Higher income enabled households to allocate more resources for human capital development, reflecting long-term welfare improvement.
Health and wellbeing	10% of farm income used for healthcare and nutrition	Increased income translated into better access to health services and improved living standards.
Reinvestment in farming	55% of additional earnings reinvested into agriculture	Farmers expanded cultivation area, adopted better inputs, and improved agronomic practices, indicating a virtuous cycle of growth.
Women empowerment	Higher involvement of female labour, particularly in transplanting, harvesting, and post-harvest handling	Technology adoption supported women's participation and empowerment in tuber crop farming systems.
Market access and payments	91% of farmers received immediate payments; 71.5% sold through mandi/market	Strengthened market integration improved liquidity and reduced exploitation by middlemen, enhancing farmer confidence and market participation.

Technology Characteristics and Farmers' Preferences

Cassava in Tamil Nadu

Adoption of improved varieties of cassava in Tamil Nadu is influenced significantly by factors such as yield, access to technical advice, socio-economic characteristics, and irrigation availability (Table 7). All other variables included in the model were found non-significant. Marginal effects of yield suggest that one ton increase in yield will increase the likelihood of adopting improved varieties by 2%. Marginal effects of dummy variable showed that the accessibility of technical advice increased the probability of adoption of improved varieties by 18.8%. District dummies were significant which suggested that the adoption decision was influenced by soil types, rainfall, and cropping pattern. Irrigation dummies showed that the availability of irrigation facilities will increase likelihood of adoption of improved varieties.

Table 7. Determinants of technology adoption by Logit estimates

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

Figures in parentheses are standard errors; *** indicates significance of z statistics at 1% level.

In Tamil Nadu, cassava cultivation showcases a diverse range of varieties, with farmers opting for 17 different types. Among these, *White Thailand* takes the lead in adoption, accounting for 25% of the cultivated varieties. Noteworthy is its starch content of 28%, providing a unique advantage in minimizing tuber damage caused by rat-induced bitterness. The ease of uprooting further enhances its popularity among farmers, despite occasional challenges like lodging and susceptibility to mealybugs. *Kunkumarose* emerges as a versatile cassava variety predominantly cultivated in hilly areas. With a normal yield and medium height, it aligns well with various cultivation practices. Its adaptability to drought conditions positions it as a reliable choice, although challenges such as potential tuber damage from rats and occasional yield fluctuations

exist. *Kunkumarose* is highly regarded for its suitability for consumption, contributing to its substantial demand among traders and consumers. H-226 stands out with a substantial yield and an impressive starch content of 28%, making it a reliable option for cassava cultivation. Particularly suited for drought conditions, H-226 showcases resilience in challenging environments. However, farmers must consider its lower yield compared to some varieties and susceptibility to mealybugs. Despite these challenges, H-226 proves advantageous in areas facing water scarcity, given its adaptability to drought conditions. Sree Athulya stands out as an improved cassava variety with an impressive starch content exceeding 30%. Notably, it demonstrates a reduced susceptibility to mealybugs, contributing to its overall resilience. The variety commands a high market price, making it an attractive choice for farmers seeking both yield and profitability.

Understanding the trait preferences at the field level is crucial for effectively prioritizing varietal and seed system development in Tamil Nadu. Among the farmers in the region, several key traits emerge as high priorities. Foremost is the emphasis on high tuber yield, indicating a strong preference for varieties that demonstrate robust productivity. Additionally, resistance to prevalent pests and diseases, particularly mealybugs and red spider mites, is a significant consideration for farmers, highlighting the importance of crop resilience. Surprisingly, Cassava Mosaic Disease (CMD) is not perceived as a major concern by farmers in this context. Other highly valued traits include high starch content, reflecting a preference for varieties with favorable industrial and culinary attributes. Farmers also express preference for short-duration varieties, signaling a desire for crops that mature swiftly. Drought resistance is another critical trait, given the region's agricultural landscape, as farmers seek varieties that can thrive in water-scarce conditions. Furthermore, the importance of ease in harvesting is evident, emphasizing the practicality of cultivation practices. Notably, traits related to the storability of planting material and tubers are not prioritized by farmers. This comprehensive understanding of trait preferences provides valuable insights for tailoring varietal development strategies to align with the specific needs and priorities of farmers in Tamil Nadu.

Cassava in Andhra Pradesh

Farmers perceived several advantages of improved varieties over local varieties, particularly their early maturity, resistance to diseases like cassava mosaic disease (CMD) and mealybug, higher market price, and increased farm income. However, a key constraint was the lower starch content in improved varieties, which limited their acceptance by starch-based industries. On the other hand, local varieties were preferred for their higher starch content (25-30%) and ease of harvesting, despite being more susceptible to pests and diseases and providing lower yields. The study also identified major challenges faced by cassava farmers irrespective of the variety grown. These included low market prices for tubers (91.67% farmers), water scarcity for irrigation (83.33%), pest and disease incidence (63.33%), lack of crop insurance (53.33%),

inadequate government support (48.33%), and damage by wild animals (38.33%) (Table 8). Overall, the findings highlight the economic potential of improved cassava varieties for fresh consumption markets while emphasizing the need for varietal improvement with higher starch content and policy interventions to address market, pests, and irrigation challenges faced by cassava farmers in Andhra Pradesh.

Table 8. Farmer's perceptions about improved varieties of cassava in Andhra Pradesh

Particulars		Farmers (%)
Improved varieties over local varieties		
Advantages		
1	More yield with Sree Reksha variety (10-20%)	38.89
2	Increased farm income (10-40%)	44.44
3	Early maturing varieties (Sree Jaya)	61.11
4	Higher market price for edible purposes (Sree Jaya and Sree Reksha)	50.00
5	Resistance to CMD and tolerance to mealybug (Sree Reksha)	38.89
6	Saving of time/season due to adoption of short duration varieties	61.11
7	Improved food security	44.44
Constraints		
1	Low starch content	27.78
Local varieties preferred over improved varieties		
1	Ease of harvesting	61.90
2	Early maturity	14.29
3	Preference by starch factories due to higher starch content (25-30%)	83.33
Constraints		
1	Susceptibility to pests and diseases	85.71
2	Low yield	80.95
Major constraints in cassava cultivation		
1	Low market price for tubers	91.67
2	Insufficient water for irrigation	83.33
3	Lack of awareness about improved varieties	33.33
4	Attacks by wild animals	38.33
5	Increasing input costs	30.00
6	Incidence of pest and diseases (mealybug and red spider mite)	63.33
7	Absence of crop insurance scheme	53.33
8	Inadequate subsidy or government support	48.33
9	Shortage of labour	20.00

Chinese potato in Tamil Nadu

Adoption of an improved variety of Chinese potato was influenced by many factors identified through binary logit regression (Table 9). The logit regression model revealed that the decision of the farmers on the adoption of improved variety was positively influenced by their age, education, family size, access to extension services, farm income, and block dummies while farm size influenced negatively the adoption of improved variety. Variables viz., years of education, farm income, access to extension services, and block dummies were significant factors for the adoption of improved varieties. Shiyani *et al.*, (2002) found positive effects of education on the adoption of improved crop varieties. Sharma *et al.*, (2018) confirm that household income was positively linked to adopting new varieties. Ransom *et al.*, (2003) confirm that access to extension services was positively associated with the adoption of new crop varieties. All other variables included in the model were not significant. Analysis of marginal effects has shown that the likelihood of adopting Sree Dhara increases by 2.5 % for every year of increase in formal schooling. The estimated marginal effects of farm income suggest that a 1% increase in farm income is expected to increase the likelihood of moving to Sree Dhara by 42.5%. The estimated marginal effects of the dummy variable have shown that the availability of extension services increases the likelihood of adoption by 11.8%. Block dummies were significant, suggesting that the decision to adopt them was influenced by soil types, rainfall, and cropping models.

Table 9. Logit model explaining factors affecting adoption of Sree Dhara

Variables	Binary logit model		Marginal effects	
	Coefficients	Z	(dy/dx)	Z
Dependent variable: (1: if farmer adopted the improved variety, 0: otherwise)				
Age (years)	0.001	0.07	0.000	0.07
Education (years)	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)	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> χ^2	0.000			
Observations (n)	200			

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

All the respondents (100%) indicated that the Sree Dhara variety offers many advantages over local varieties such as higher tuber yield (69%), less incidence of nematode (58%), employment generation (53%), good shape and size of tubers (42%), early maturing (36%), fetches remunerative price (28%) and tuber rotting is less during water stagnation (21%) (Table 10). About 26% of farmers reported that they face difficulty in getting seed tubers (23%). Lack of awareness and knowledge of Sree Dhara (55%), availability of local varieties (31%), and no accessibility to seed tubers and planting materials (14%) of Sree Dhara were reported as reasons by non-adopters.

Table 10. Perception of farmers on cultivation of Sree Dhara variety

Reasons	Farmers (%)
‘Sree Dhara’ variety has advantages over local varieties	100
1. Higher tuber yield	69
2. Less incidence of nematode	58
3. Employment generation	53
4. Market-preferred shape and size of tubers	42
5. Early maturing	36
6. Fetches remunerative price	28
7. Tuber rotting is less during water stagnation	21
8. High demand among traders and consumers	19
9. Good keeping quality	8
Never tried cultivating the ‘Sree Dhara’ variety	63
1. Lack of awareness and knowledge of Sree Dhara variety	55
2. No access to seed tubers/planting materials	14
3. Local varieties meet our needs	31

Elephant foot yam in Andhra Pradesh

Most farmers (90%) reported higher yield as the primary advantage of adopting the Gajendra variety, which reflects its superior productivity compared to local varieties. Additionally, 76.67% of farmers appreciated its good keeping quality, making it suitable

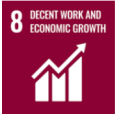
for longer storage and transportation. Other notable benefits include good size and shape (48.33%), superior quality (38.33%), less acidity (16.67%), and limited suitability for export markets (11.67%) (Table 11). These positive attributes indicate that Gajendra has gained wider acceptance primarily due to its yield advantage and quality traits. Despite its advantages, farmers face several challenges in the cultivation of elephant foot yam. The foremost constraint reported by 96.67% of farmers is the high cost of cultivation, particularly due to high planting material cost. Moreover, price instability was identified as the most critical issue, affecting 100% of the farmers, indicating fluctuations in market prices that directly impact their profitability. Inadequate marketing facilities (75%), lack of training on improved varieties and technologies (58.33%), and lack of short-duration varieties (36.67%) were also significant constraints. Other constraints include low local consumption (23.33%), lack of machinery for pit making and harvesting (30%), labour shortage (20%), flooding during heavy rainfall (21.67%), lack of government support (16.67%), and absence of crop insurance (13.33%).

Table 11. Farmer's perceptions about adoption of elephant foot yam var. Gajendra

Particulars		Farmers (%)
Advantages		
1	Higher yield	90.00
2	Good keeping quality	76.67
3	Superior quality	38.33
4	Good size and shape	48.33
5	Suitable for export	11.67
6	Less acidity	16.67
Major constraints in elephant foot yam cultivation		
1	High cost of cultivation (high seed cost)	96.67
2	Lack of training on improved varieties and technologies	58.33
3	Price instability	100.00
4	Inadequate marketing facilities	75.00
5	Lack of short duration varieties	36.67
6	Low consumption among farmers and consumers in Andhra Pradesh	23.33
7	Lack of machinery for pit making and harvesting	30.00
8	Flooding problem during heavy rainfall	21.67
9	Lack of government support	16.67
10	Non availability of labour	20.00
11	Absence of crop insurance for elephant foot yam	13.33

Contribution to Sustainable Development Goals (SDGs)

The study clearly highlights the pivotal role of ICAR-CTCRI in enhancing the productivity and nutritional quality of tropical tuber crops. Through these efforts, ICAR-CTCRI significantly contributes to income generation, nutritional security, and poverty alleviation among the most vulnerable populations in the country, thereby supporting the achievement of the Sustainable Development Goals (SDGs). The research outcomes also promote resource use efficiency, foster sustainable production systems, and strengthen the adaptive capacity of farming communities to climate change aligning closely with global development objectives.

SDGs	ICAR-CTCRI contribution to SDG targets
	Eradicating extreme poverty (Target 1.1)
	Building the resilience of the poor and vulnerability to climate change (Target 1.5)
	Ending hunger and ensure access by all people (Target 2.1)
	Ending all forms of malnutrition (Target 2.2)
	Doubling the agricultural productivity and incomes of small scale food producers (Target 2.3)
	Ensuring sustainable food production systems and implement resilient agricultural practices (Target 2.4)
	Sustaining per capita economic growth (Target 8.1)
	Achieving higher levels of economic productivity through diversification, technological upgrading and innovation (Target 8.2)
	Achieving and sustaining income growth of the bottom 40 per cent (Target 10.1)
	Achieving the sustainable management and efficient use of natural resources (Target 12.2)
	Strengthening resilience and adaptive capacity to climate related hazards (Target 13.1)

Summary

The impact assessment of improved varieties and technologies developed by ICAR-CTCRI reveals significant adoption and socio-economic benefits across major tropical tuber crops in India. The major findings are summarized below.

1. Adoption of improved varieties (crop wise)

Cassava

- In India: ICAR-CTCRI varieties covered 29.69% of total cassava area in India.
- In Tamil Nadu: ICAR-CTCRI Varieties – 38.69%, SAUs Varieties – 8.62%.
- In Kerala: ICAR-CTCRI Varieties – 14% and Andhra Pradesh: ICAR-CTCRI Varieties – 30%.

Sweet potato

- In Odisha & Karnataka: 42.45% of area under improved varieties (Kanhanged - 41.04% and Kishan-1.42%).

Elephant foot yam

- In Tamil Nadu & Andhra Pradesh: 81.82% of area under improved varieties (Gajendra – 69.09%, Sree Padma -12.73%).

Chinese potato

- In Tamil Nadu: 38% of the cultivated area under ICAR-CTCRI variety and 62% covered with other local varieties.

2. Economic impact

Cassava (7 varieties)

- Present value of benefits: ₹ 732.47 crores
- Present value of research costs: ₹ 18.31 crores
- Net present value (NPV): ₹ 714.17 crores
- Benefit cost ratio (BCR): 29.77:1
- Internal rate of return (IRR): 44%

Variety wise additional income

- Sree Athulya: ₹ 346 crores
- Sree Reksha: ₹ 127 crores
- H-226: ₹ 115 crores
- H-165: ₹ 37 crores
- Sree Kaveri: ₹ 63 crores

- Sree Pavithra: ₹ 40 crores
- Sree Jaya: ₹ 0.97 crores

Chinese potato

- Yield increase: 2.97 tons/ha (23.65%)
- Income gain: ₹ 78000/ha (24.69%)
- Total economic benefits: ₹ 5.97 crores

Micronutrient foliar liquid formulation technology (Micronol)

- Total additional income: ₹ 21.23 crores. Cassava – ₹ 14.48 crores, Elephant foot yam – ₹ 2.46 crores, Sweet potato – ₹ 1.63 crores, Yams – ₹ 1.61 crores and Chinese potato – ₹ 1.06 crores.

Aggregate impact

- Total additional economic benefits (8 improved varieties + micronutrient technology): ₹ 759 crores.
- Benefited marginal farmers – 45.73%, small farmers – 31.05% and semi medium farmers – 18.09%.

3. Social impact

Cassava (Improved varieties adopters)

- Income increase: 17%
- Yield increase: 13% (3.29 t/ha)
- 56% reinvested in farming, 12% for education, 14% for health.
- Market price gain: 3.6%
- Environmental impact quotient (EIQ) reduced from 54.9 to 22.35

Chinese potato (Sree Dhara)

- Income increase: 87%
- 55% reinvested in farming
- 12% of income used for education, 10% for health
- Employment increased by 11.3% (521 vs 468 days/ha)
- Women participation increased in transplanting and post-harvest handling

4. Technology characteristics and farmers' preferences

Cassava

- Adoption of improved varieties mainly driven by yield and access to technical advice, socio-economic characteristics and irrigation availability.
- High yield, starch content, good cooking quality, pest resistance, short duration were the most preferred traits by the farmers.

Elephant foot yam

- High yield, good keeping quality and good shape and size of tubers significantly influenced adoption of Gajendra variety.
- High seed cost, price instability and inadequate market facilities were the major constraints.

Chinese potato

- Education, income, extension access and block dummies significantly influenced adoption of improved varieties.
- Lack of awareness and seed tuber access were the major constraints.

5. Contributions to SDGs

- SDG 1: Poverty eradication
- SDG 2: Zero hunger and improved nutrition
- SDG 8: Employment generation and inclusive economic growth
- SDG 12: Sustainable agricultural practices
- SDG 13: Climate resilience and reduced environmental impact

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Annexures

Annexure I: Percent of adoption of cassava varieties in India

Varieties	Kerala			Tamil Nadu			Andhra Pradesh			India		
	1985	2005	2023	1985	2005	2023	1985	2005	2023	1985	2005	2023
Local varieties	68.18	90.96	81.61	23.10	19.29	53.57	-	-	70.00	43.03	35.48	65.01
Improved varieties from SAUs*	25.01	7.32	4.20	4.41	0.30	7.74	-	-	-	12.77	3.81	5.30
High yielding and improved varieties from ICAR-CTCRI**	6.81	1.72	14.19	72.49	80.42	38.69	-	100	30.00	44.20	60.71	29.69

Source: Edison 2006; Srinivas 2006; Anantharaman and Ramanathan 2011; Primary surveys (2023)

* Mulluvadi, CO 4, YTP I, YTP II

**H-165, H-226, Sree Vijaya, Sree Jaya, Sree Pavithra, Sree Visakhram, Sree Athulya, Sree Reksha, Sree Kaveri

Annexure II: Percent of adoption of sweet potato varieties in India

Varieties	Odisha	Uttar Pradesh	West Bengal	India
Kanhangad	32.24	-	-	32.24
Pusa Safed	4.28	-	-	4.28
Samrat	1.75			1.75
Sree Nandini	0.95	-	-	0.95
Kishan	4.08	-	-	4.08
Sree Bhadra	0.23			0.23
Lalfarm	-	24.93	-	24.93
Dartho fora	-	0.99	-	0.99
Ranchi white/red	-	2.96	--	2.96
NDSP 9		0.69		0.69
NDSP 10	-	0.30	-	0.30
NDSP 65	-	0.86	-	0.86
Malati		0.09		0.09
Kalagarh	-	0.43	-	0.43
Other high yielding varieties			2.85	2.85
Local varieties	6.83	4.77	10.79	22.39
All high yielding varieties	43.51	31.24	2.85	77.61
All local varieties	6.83	4.77	10.79	22.39

Source: Srinivas and Nedunchezhiyan (2020)

Annexure III: Improved varieties of tuber crops released from ICAR-CTCRI

Crop	Varieties
Cassava (22)	H-97, H-165, H-226, Sree Sahya, Sree Visakham, Sree Prakash, Sree Harsha, Sree Jaya, Sree Vijaya, Sree Rekha, SreePrabha, Sree Padmanabha, Sree Athulya, Sree Apoorva, Sree Pavithra, Sree Swarna, Sree Reksha, Sree Sakthi, Sree Suvarna, Sree Kaveri, Sree Annam, Sree Manna
Sweet Potato (21)	H-41, H-42, Varsha, Sree Nandini, Sree Vardhini, Sree Rethna, Sree Bhadra, Gouri, Sankar, Sree Arun, Sree Varun, Sree Kanaka, Kalinga, Goutam, Kishan, Sourin, Bhu Sona, Bhu Kanti, Bhu Krishna, Bhu Ja, Bhu Swami
Greater Yam (10)	Sree Keerthi, Sree Roopa, Sree Shilpa, Sree Karthika, Orissa Elite, Sree Neelima, Sree Swathy, Bhu Swar, Sree Nidhi, Sree Hima
White Yam (6)	Sree Subhra, Sree Priya, Sree Haritha, Sree Dhanya (dwarf), Sree Swetha (dwarf), Sree Dhrona
Lesser Yam (2)	Sree Latha, Sree Kala
Elephant Foot Yam (2)	Sree Padma, Sree Athira
Taro (10)	Sree Rashmi, Sree Pallavi, Muktakeshi, Sree Kiran, Pani Saru-1, Pani Saru-2, Bhu Kripa, Bhu Sree, Sree Hira, Sree Telia
Chinese Potato (1)	Sree Dhara
Arrowroot (3)	Sree Aadya, Sree Nakshathra, Sree Karti

Annexure IV: Research cost and present value of research cost in cassava improvement and production technologies in India (1966 to 2022)

Year	Research cost (₹)	Present value of Research cost (₹)
1966	11320	273426
1967	6680	160964
1968	12752	284643
1969	75866	1649261
1970	81762	1666322
1971	81578	1574530
1972	88738	1555360
1973	86850	1266786
1974	119228	1389035
1975	128812	1517389
1976	130630	1507793
1977	143756	1577124
1978	149119	1635080
1979	154948	1451225
1980	230008	1822550
1981	242369	1755961
1982	266683	1841864
1983	269963	1733295
1984	276244	1666663
1985	363974	2102302

1986	371136	2026028
1987	373725	1886305
1988	413594	1942616
1989	449259	1964517
1990	643858	2553343
1991	706893	2464597
1992	717217	2272238
1993	777475	2273582
1994	897721	2331456
1995	893916	2149747
1996	1055696	2427034
1997	1289165	2838799
1998	1461915	3038450
1999	1631435	3283434
2000	2619302	4919502
2001	2681900	4862195
2002	3170500	5558477
2003	3296950	5481137
2004	4076200	6364171
2005	3820250	5709348
2006	3183200	4463341
2007	3812200	5103308
2008	5180050	6417721
2009	6884200	8216728
2010	6554300	7140126
2011	6554300	6554300
2012	9065000	8479888
2013	9346350	8307867
2014	9404150	8256497
2015	10130900	9235096
2016	10398800	9317921
2017	11244650	9786466
2018	13800650	11519741
2019	12836850	10539286
2020	12569150	10185697
2021	14080800	10101004
2022	14730400	9659279
Total	194045337	238064813

Source: Srinivas, 2009 and various reports of ICAR-CTCRI

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