CTCRI/QSF/RP/400

वार्षिक प्रतिवेदन
Annual Report
2014 - 2015

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
श्रीकारियम 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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ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE

An ISO 9001-2008 Certified Institute

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Cover Illustration
Front : Cassava (*Manihot esculenta*) canopy, Female flower of cassava (*Manihot esculenta*), Flowering taro plant (*Colocasia esculenta*), Sweet potato (*Ipomoea batatas*) vine
Back : *Dioscorea alata* (Greater yam), Farmer in Ranchi, Jharkhand with elephant foot yam harvest, Farmer in Joida Taluk, Uttar Kannada with dasheen type taro tubers

16 June 2015

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Preface

It is my pleasure to present the Annual Report of ICAR-Central Tuber Crops Research Institute for the year 2014-2015. The root and tuber crops like cassava, potato, sweet potato, yams and taro contribute about 6% of the world's dietary calories. They constitute the third important food crops of mankind, after cereals and legumes and are either a staple or subsidiary food for about one-fifth of the world population. Many of the poorest farmers and most undernourished households in India depend on R&T crops as a contributing, if not principal source of food and nutrition. These farm households value R&T crops because they produce large quantities of dietary energy and have stable yields under conditions in which other crops may fail. Ever since its establishment in the year 1963, ICAR-CTCRI is facilitating scientific production and utilization of those crops for food, nutrition and livelihood security.

During the year 2014-2015, two new varieties of cassava (Sree Swarna and Sree Pavithra) and two of greater yam (Sree Swathy and Sree Neelima) were released for cultivation in Kerala. Besides, promising elite genotypes of early maturing cassava and sweet potato, β-carotene and anthocyanin rich sweet potato and anthocyanin rich yams have been identified. Profitable production technologies, viz., drip fertigation for elephant foot yam, cropping system consisting of rice-black gram-short duration cassava, site specific nutrient management schedules based on nutrient zonation map, customized fertilizers, INM for yam bean have been developed. Similarly, bio-intensive management schedules for taro leaf blight and collar rot of elephant foot yam have been perfected. Full genome sequence of Dasheen Mosaic Virus was determined that facilitated development of robust detection protocol for the virus. Technologies for production of lacto-pickle from elephant foot yam, low-moist gelatinised dough for cassava *papad*, cassava-rice based extruded products, functional sago with high protein and calcium content, cereal grain type pasta including cassava-maida and cassava-rice blends were developed.

An electronic device (E-Crop) for giving real-time agro-advisory was developed. It collects real-time weather data at 15 minutes interval and generates agro-advisories that are delivered to the farmers as SMS. Farmers of NEH region preferred Sree Jaya and Sree Vijaya varieties of cassava, Muktakeshi of taro and Gajendra of elephant foot yam. The value chain analysis of cassava in Nagaland indicated that both the tubers as well as the leaves were used for human consumption and as pig feed. The Tribal Sub Plan programme was conducted in collaboration with Ramakrishna Mission, Narayanpur, Chhattisgarh; Ramakrishna Mission, Ranchi, Jharkhand; ORRISSA (NGO), Kandhamal and PRAGATI (NGO), Koraput of Odisha.

I am extremely grateful to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for his constant support and guidance. I would also place on record my thanks to Dr. N. K. Krishna Kumar, DDG (Horticultural Science), Dr. S. K. Malhotra, former ADG (HS II), Dr. T. Janakiram, ADG (HS I), Dr. B.K. Pandey, PS (HS), Dr. Manish Das, PS (HS), Dr. Vikramaditya Pandey, PS (HS) for their suggestions and encouragement. I appreciate sincere efforts made by Dr. G. Suja (Chairperson), Dr. A. Asha Devi, Dr. V. Ramesh, Dr. M. L. Jeeva, Dr. R. R. Korada, Dr. Sheela Immanuel, Mrs. Namrata Ankush Giri, Dr. M.S. Sajeev, Shri. Davis Joseph, Shri. R. Bharathan, Smt. T.K. Sudhalatha, Dr. S. Shanavas and Shri. A. S. Manikuttan Nair in compiling the report and publishing in time.

16 June 2015

S. K. Chakrabarti
Director

Executive Summary

Crop Improvement

A total of 5895 accessions of different tuber crops are being maintained in the National Repository for Tuber Crops at ICAR-Central Tuber Crops Research Institute (CTCRI), which comprises cassava 1383, sweet potato 1483, yams 1151, edible aroids 1350 and minor tuber crops 391 accessions along with 137 newly augmented accessions. Institute germplasm collection augmented with 137 accessions of various tuber crops from three targeted collection trips to Joida Taluk, Uttara Kannada, Karnataka, Arunachal Pradesh and Northern parts of Kerala apart from few collections from Meghalaya, Karnataka, Kerala and Maharashtra.

Genetic diversity analysis of cassava (12 landraces), sweet potato (15 accessions) and elephant foot yam (12 accessions) was done using six SSR markers (cassava) and six ISSR markers (sweet potato and elephant foot yam). The results demonstrated uniqueness of all the accessions in cassava and elephant foot yam with a similarity coefficient ranging from 0.35 to 0.88 and 0.50 to 0.93, respectively. In sweet potato, the ISSR markers could identify duplicates su ccessfully. Two sets of duplicates could be identified and the similarity coefficient ranged from 0.40 to 1.00. In white yam, few elite clones having desirable traits were identified viz., 17 accessions (Dr-2, 24, 69, 73, 121, 128, 132, 142, 144, 161, 175, 240, 251, 318, 332, 334 and 342) having excellent cooking quality; one accession (Dr-292) having high dry matter and starch content coupled with excellent cooking quality and eight accessions, Dr-2, 20, 40, 73, 140, 147, 287 and 292 with high dry matter content (>42%).

The genetic diversity study based on SSR markers as well as morphological traits of 40 landraces of greater yam collected from different parts of India showed that among the landraces, the ones from Kerala (Da-331), Assam (Da-145) and Odisha (Da-327) were highly divergent as compared to the other accessions. Maximum polymorphism was revealed by the marker, Dab2E07 originally identified from a related species viz., *D. abyssinica*. Da2F10, Dab2D11, Da3G04, Da3E10 and Dab2C12 also revealed high levels of polymorphism.

Morphological and molecular characterization of 25 taro accessions from NEH regions showed high levels of diversity as shown by Shannon Weaver's (H'=0.87) and Simpson's diversity index (D=1.00) computed according to percentage distribution of the various traits. Molecular characterization using 10 polymorphic SSR markers (Ce1 A06, Ce1 B03, Ce1 C03, Ce1 C06, Ce1 F04, Ce1 H12, uq73-164, uq84-207, uq97-256 and uq201-302) gave high polymorphism as explained by the high values of Shannon's index (1.59-2.37), average number of alleles (6.00-12.57) and polymorphic marker ratio (0.76-1.00). No duplicates were identified.

Preliminary yield evaluation was initiated in arrowroot collections for tuber traits. The fresh single tuber weight ranged from 69.90 g in the collection from Kerala to 100.50 g in the collection from Maharashtra and the dry matter percentage ranged from 31.90 in the Kerala collection to 33.80 in the Odisha collection. The per plant tuber yield ranged from 1.30 kg (Kerala) to 2.40 kg (Maharashtra), while the number of tubers per plant ranged from 17 in Odisha collection to 34 in the Maharashtra collection.

At the regional centre, preliminary yield evaluation was done in taro (5-18 t ha^{-1}), elephant foot yam (8-24 t ha^{-1}), yam (8-25 t ha^{-1}) and yam bean (13.55-29.94 t ha^{-1}).

Under IVAG, 88 pre-identified core collections of sweet potato; 100 accessions received from NBPGR; 48 cassava; 22 yams; 26 taro; 5 Chinese potato and 2 elephant foot yam varieties/pre-release varieties as well as elite lines are being maintained *in vitro*.

Four varieties, two in cassava and two in greater yams were released in the State Release Committee 2015.

Sree Swarna is a cassava variety having high yield (40.00 t ha^{-1}), early bulking (7 months), good culinary quality, yellow flesh colour and tolerance to cassava mosaic disease (CMD), whereas, Sree Pavithra is a cassava variety with high yield (35-45 t ha^{-1}) at low levels of potassium (K) with excellent cooking quality, low cyanogenic glucoside (25.80 ppm) and high K efficiency (243.65 kg tuber/kg K absorbed), suitable for cultivation in Kerala soils, which are inherently low to marginal in soil exchangeable K.

Sree Swathy is a greater yam variety released for its high yield (30.00 t ha^{-1}), good culinary and nutritive quality and moderate tolerance to anthracnose disease, whereas, Sree Neelima is a high yielder (35.00 t ha^{-1}) with good culinary and nutritive quality and light purple flesh colour.

Three early maturing cassava hybrids, 8S-501-2 (5.88 kg $plant^{-1}$), 11S-30 (4.25 kg $plant^{-1}$) and 8W-5 (3.82 kg $plant^{-1}$) were identified, which matured at seven months.

To address the national and international gaps of sweet potato breeding and to satisfy the consumer demands, 16 germplasm lines and 35 hybrids were identified having the targeted objectives of higher yield (more than 17 t ha^{-1}), starch (more than 18%), β-carotene (more than 14 mg $100g^{-1}$) and anthocyanin (more than 1g$100g^{-1}$) with reduced crop growth cycle (75-90 days) and weevil resistance (infestation less than 10%). Maturity of 75 days was recorded for 1 orange and 2 white-fleshed, whereas 90 days maturity for 15 white, 5 orange and 5 purple-fleshed sweet potatoes. Yield ranged from 17-22 t ha^{-1}, β-carotene 14-16 mg $100g^{-1}$ and anthocyanin more than 1g $100g^{-1}$. Comparison between improved breeding lines with parental source indicated higher yield with enhanced starch, β-carotene and anthocyanin.

A purple-fleshed high yielding greater yam variety, Da-340 was identified for anthocyanin extraction. The white yam hybrid, DRh-657 with compact tuber shape, high yield and cooking quality, for release in Kerala and a dwarf clone, Drd-1157 with high yield (25 t ha^{-1}) and good culinary properties were identified. Ten TLB tolerant taro accessions (C-84, C-203, C-370, C-388, C-565, C-679, C-690 (violet), C-717, C-723 and IC012470) and one high yielding flowering clone of elephant foot yam having good cooking quality and high multiplication rate (Puttur local) were identified.

Friable Embryogenic Callus (FEC) production from different cassava varieties viz., H-226, H-165, Sree Athulya and Sree Apoorva were initiated using different explants (unopened leaf lobes and embryogenic structures at different stages). Among these varieties, H-165 showed good response to FEC production. Parameters were standardized for developing transgenic elephant foot yam, which includes antibiotic concentration (Geneticin–20 mg l^{-1}; Hygromycin-5 mg l^{-1}; Ticarcillin–650 mg l^{-1}), acetosyringone (400 µM), number of days for co-cultivation (2-3 days) and co-cultivation temperature (28°C). Using GUS gene as marker, these parameters were validated and transgenic elephant foot yam having GUS gene was successfully developed.

In view of developing resistance to DsMV in *A. paeoniifolius*, a hairpin construct of DsMV (DsMV-hp) was designed containing the most conserved region in the CP gene of DsMV in the forward and inverted orientation separated by an intron, thereby resulting in a hairpin (hp) construct. The resistance against DsMV upon the hp construct expression was assessed in a model host, *N. benthamiana*. The construct was found to provide complete resistance towards the DsMV upon challenge inoculation of transgenic lines as evidenced from the symptom score and molecular analysis.

Bioinformatics approach was applied to identify potential cassava miRNA regulated genes in cassava mosaic virus genome. Fourteen miRNA families were found to have the potential to target cassava mosaic virus genome with nearly perfect complementarities.

Potential SNP markers were predicted in three classes of deletions, insertions and substitutions for cassava using the input sequences from Phytozome and EST sequences from NCBI. DNA polymorphism characterizations were carried out and Gene ontology classification of the identified SNPs were carried out.

Crop Production

In a study to identify the best weed management practice in cassava, tuber yield was maximum (28.26 t ha^{-1}) under ordinary black polythene mulching (32.06% greater than Package of Practices, POP),which was on par with the use of weed control ground cover (WCGC) till final harvest (26.62 t ha^{-1}) and transparent plastic mulch (26.47 t ha^{-1}). However, considering the constraints such as scarcity, timely availability and high cost of labour, the WCGC method that generated a net profit of Rs. 1,55,795 can be recommended for weed control in cassava. Fertigation studies in cassava indicated that the effect of different levels of N (75, 100 and 125 kg ha^{-1}) tried were on par with respect to tuber yield. However, K showed a positive response with increasing levels of drip fertigation up to 125 kg ha^{-1}.

The cropping system, rice (var. Aiswarya)-black gram (var. Co-6)-short-duration cassava (var. Sree Vijaya) was productive, profitable and energy efficient. There was a possibility to save half FYM and N and full P to short-duration cassava in this system. Continuous application of manures and fertilizers on the sustainability of cassava production and soil productivity for the 10^{th} consecutive season indicated that application of NPK@ 125:50:125 kg ha^{-1} produced the highest tuber yield (30.84 t ha^{-1}), which was on par with NPK @100:50:100 kg ha^{-1} (25.17 t ha^{-1}) and 50:50:100 kg ha^{-1} (25.13 t ha^{-1}). Soil test based application of NPK@78:0:48 kg ha^{-1}resulted in an yield of 22.57 t ha^{-1} on par with NPK @100:50:100 kg ha^{-1}(25.17 t ha^{-1}) and 50:50:100 kg ha^{-1} (25.13 t ha^{-1}). Continuous cassava cultivation for the 10^{th} season without any manures and fertilizers resulted in an yield of 17.93 t ha^{-1}. Different organic manures tried to substitute FYM viz., green manuring *insitu* with cowpea (27.29 t ha^{-1}), vermicompost (29.31 t ha^{-1}) and coir pith compost (28.31 t ha^{-1}) produced yield on par with FYM (25.17 t ha^{-1}).

Field demonstration trials conducted with six selected K efficient genotypes in three locations each during the two seasons indicated Aniyoor and 7III E3-5 as the best, yielding high (4-11 kg per plant) without K and K @ 50 kg ha^{-1} as well as having good cooking quality. Field experiments conducted for two seasons with three NPK efficient genotypes under four nutrient management practices showed that the genotypes, Acc. No. 905 and 906 as promising under low input management in terms of tuber yield (33.68 and 34.72 t ha^{-1} respectively) and B: C ratio (4.43 and 4.57 respectively). The low input management strategy could save P, K, Mg and Zn to the extent of 100.00, 11.50, 62.50 and 80.00% respectively and the decrease in the cost of inputs under the low input practice over the POP recommendation was up to 55%. Field experiments conducted for the first season with thippi compost indicated the possibility of substituting thippi compost with other organic manures like FYM, green manuring *in situ*, crop residue, coir pith compost, vermicompost and fertilizers to the full extent and secondary nutrient (Mg) and micronutrient (Zn).

A new experiment initiated to study the spatial and temporal variations of soil properties as influenced by tillage and mulching practices with respect to hydro-physical, nutrient use and rooting characteristics of cassava revealed that saturated hydraulic conductivity and sorptivity of soils under conventional tillage was 26% and 41% higher respectively as compared to minimum tillage. Significant variation in surface soil moisture content was observed between ground cover sheet (12.4%, v/v) and no mulch plots (6.1%).

The NPK use efficiency studies in rainfed cassava under complex risk prone and diverse zone at Pachamalai hills, Eastern Ghats of Tamil Nadu, has shown that the values were significantly higher in scientific practice (SP) (NPK use efficiency of 28, 42, 23% respectively) as compared to farmer's practice (FP) (23, 23, 10%) as well as in ground cover sheet applied soils (31, 13 and 20%) against no sheet (23, 12 and 17%) treatments. Better plant growth was also exhibited under scientific practice-ground cover treatment.

Site specific nutrient management (SSNM) zonation maps were developed using geoinformatics tools based on QUEFTS model outputs, potential yield,

indigenous nutrient supply, nutrient recovery fraction, benchmark soil series and/or agro-ecological units/ zones for different yield targets of cassava, elephant foot yam and sweet potato in major growing environments of India.

Customized fertilizers incorporating major, secondary and micronutrients were developed for cassava, elephant foot yam and sweet potato for all the major growing environments of India for different yield targets based on the SSNM zonation maps developed as well as the principles of fertilizer best management practices (FBMP).

The climate-based ecological niche model, ECOCROP, has been calibrated and methodology was developed using geoinformatics tools for studying climate change impact on cassava, sweet potato, elephant foot yam and yams and for developing suitable management strategy to minimize climate change impact.

Technology to develop site specific natural resource management at farm level (130 locations of ICAR-CTCRI farm) has been developed using geoinformatics tools. Based on the information generated, a decision support tool, Fertcalc_CTCRI was developed for nutrient management of the farm. The tool has been uploaded in www.ctcri.in.

Samrat and CIP-440127 were identified as promising genotypes of sweet potato for cultivation in natural saline soils under island ecosystem of Andaman.

In elephant foot yam, highest corm yield (35.20 t ha^{-1}) was obtained with drip fertigation at 3 days interval and 50 number of splits of recommended dose of fertilizer (RDF) (120:60:120 $N:P_2O_5:K_2O$ kg ha^{-1} water soluble fertilizer). The first dose of fertigation should start 10 days after planting. Fertigation up to 150 days after planting was essential for production of higher corm yield. Drip fertigation at 3 days interval with 50 number of splits of recommended dose of fertilizer realised fertilizer use efficiency of 61.70 kg kg^{-1},which was 33.40 kg kg^{-1} higher than RDF. In elephant foot yam, drip irrigation at 100% CPE during 13-24 weeks resulted in maximum yield (46.56 t ha^{-1}) followed by bed irrigation during the entire period of 1-24 weeks (40.41 t ha^{-1}). In elephant foot yam, water requirement was critical during 13-24 weeks, coinciding with tuber bulking phase compared to initial sprouting phase. Water requirement of elephant foot yam is worked out to be 4.30 mm per day for attaining a targeted yield of 46.50 t ha^{-1}.

On farm trials laid out to validate the on station developed organic farming technologies for yams and taro indicated that the yields under organic management were 8, 17, 21 and 29% higher over chemical based farming in greater yam, lesser yam, dwarf white yam and taro respectively. There was significant improvement in pH, organic C and available K status under organic management in the sites. Soil microbial population was also improved under organic practice in these sites.

Studies on INM in yam bean indicated highest tuber yield (23.36 t ha^{-1}) for integrated application of lime, FYM, NPK and $ZnSO_4$ with a yield response of 136% over control. The increase in tuber yields for applications of 50, 100 and 150% NPK based on soil test values were 40, 72 and 124% over control.

Soil samples collected from areas adjacent to chromium mining tract of Sukinda block in Jajpur district, iron mining areas of Joda and Banspal blocks of Keonjhar district and Thermal power plants and Aluminium factories of Talcher block of Angul district of Odisha showed that the mean available Zn and Cu was highest (4.96 and 0.71 mg kg^{-1}, respectively) in the iron mining areas of Keonjhar district. Highest Cr values were observed in the Cr mining areas of Jajpur district (135.23 - 178.25 mg kg^{-1}, with a mean of 152.75 mg kg^{-1}).

A total number of 108 micro plants of different cassava varieties and 72 micro plants of elephant foot yam (var. Gajendra) were indexed. Popular cassava varieties multiplied were Sree Visakham, Sree Vijaya, Sree Jaya, Sree Athulya, Sree Apoorva, Vellayani Hraswa, Sree Swarna and CMR-100. Virus free planting materials of ten cassava varieties that were obtained from ICAR-CTCRI, Regional Centre,

Bhubaneswar were multiplied through minisett technique.

Crop Protection

A field survey was conducted for borer pests in different states of Odisha, Assam, Meghalaya, Arunachal Pradesh, Uttar Pradesh and Jharkhand. In Odisha, the sweet potato weevil (SPW) *Cylas formicarius* was a major pest with 30 to 70% yield loss. Sweet potato weevil sex pheromone lures, distributed to farmers in 10 ha @ 10 traps per ha in Pamala, Shakarpur and Parvathiya villages of Dhenkanal (Odisha), convinced the farmers to adopt pheromone trap technology during *kharif* season of 2014 in 150 ha and increased the yield up to 25%. The cost:benefit ratio of this technology was 1:7.3. The technology was widely accepted because of availability of sex pheromone lures.

Gamma irradiation of male sweet potato weevil *Cylas formicarius* @ 200 Gy h^{-1} decreased the chance of emergence of weevils by five times *in vitro*. Females after mating with irradiated males produced less number of weevils in the 1st generation (7 weevils per kg tubers) compared to 35 weevils per kg from the tubers infested with normal males and females.

The sweet potato plots applied with Thiomethoxam 25 WG and Imidachloprid 17.80 SL had lowest incidence of *Cylas formicarius*, 0.33 and 0.83 per plant, when compared to the control plots (5.23 weevil). In another experiment, the topical application of quinalphos @ 0.001% could control 100% sweet potato weevil after one day treatment, whereas Malathion was least toxic. The bioformulation Nanma at 5% also managed sweet potato weevil .

CMD resistant transgenic line (TMS 60444) having resistance against ACMV available at ETH were imported to ICAR-CTCRI. CMD resistant clones (CR-43-7, CR-43-2, CR-24-4, 9S-127, 11S-33, 8S-501-2 and S-1284) were selected for multiplication for conducting on farm trials in Tamil Nadu. *In vitro* cultures of high starch CMD resistant clones were established (30 cultures) for micropropagation. Planting material of released varieties, Sree Athulya, Sree Apoorva and H-226 were planted in the field for large scale multiplication.

Among 135 isolates made from 70 soil samples collected from 10 states, 35 showed high inhibition of *Phytophthora colocasiae* and *Sclerotium rolfsii in vitro*. Based on consistent pathogen suppression, IAA production and growth promotion in cowpea, 13 bacterial isolates were selected and identified using 16s rRNA sequencing. Among them, *Bacillus subtilis, B. licheniformis* and *B. amyloliquefaciens* were selected for further field trials.

Bio-priming of taro cormels with *B. subtilis, B. licheniformis* and *B. amyloliquefaciens* @10^8 cfu ml^{-1} suspension reduced taro leaf blight incidence (from PDI of 30.50 to 11.80) and induced growth promotion. In a field trial on disease management in taro, the least TLB incidence (PDI of 14.80) was noted in metalaxyl 0.05% treated plots followed by vermicompost and vermiwash applied (18.20) ones. Addition of boron and silicon @ 100 (3 kg ha^{-1} and 50 kg ha^{-1} respectively) and 150% recommended dose (4.50 kg ha^{-1} and 75 kg ha^{-1}) significantly reduced taro leaf blight incidence in a pot culture study.

In another field trial on disease management in elephant foot yam, least collar rot incidence (8.00%) and highest yield (36.60 t ha^{-1}) was obtained with incorporation of vermicompost (750 g per pit at the time of planting and 400 g per plant at 90 and 120 DAP) and vermiwash (10%).

Corm treatment with *Trichoderma* @ 5 g kg^{-1} + soil application of neem cake 200 g per pit + two sprays with ICAR-CTCRI bioformulation at 60 and 90 DAP resulted in least collar rot incidence (0.20%) and leaf blight incidence (4.40%) and highest yield (34.20 t ha^{-1}) in elephant foot yam under field condition.

Twenty *P. colocasiae* isolates have been added to the existing collection from the farm of ICAR-CTCRI for studying yearly variation. All isolates were confirmed to the species level using species specific PCR. Genetic diversity analysis was performed using Random Amplified Microsatellites (RAMS) Markers. A reliable method for screening resistance in taro

accessions against leaf blight disease using real-time PCR has been standardized. Several genes expressed in *P. colocasiae* during a compatible interaction with taro variety Sree Kiran (leaf blight susceptible) was identified using Suppression Subtractive Hybridization (SSH) approach. Total genomic DNA was isolated from taro accessions with varying level of resistance to leaf blight. Resistant Gene Analogues (RGAs) are currently being amplified using available degenerate primers.

Colletotrichum gloeosporioides causing greater yam anthracnose could survive in the sterilized dry and 20% moistened field soil up to three and nine months respectively *in vitro*. It could survive in crop debris up to one year. The major source of inoculum was air followed by tuber and soil and the disease progress was significantly high through air borne infection. The progress of the disease started from the month of August (fourth month after planting) after rainfall and reached high during October when the rainfall and number of rainy days were more. Soil treatment with *Trichoderma* @ 50 g of 10^7 cfu g^{-1} and tuber treatment with 5 g in fresh cow dung slurry per kg of tuber and foliar spraying of Carbendazim (Bavistin) 0.05% three times after the initiation of symptoms at 15 days interval followed by monthly spray for another four months drastically reduced the anthracnose intensity (66%) and increased the yield (22%) in greater yam. The toxin produced by *C. gloeosporioides* was purified through column chromtography. The UV absorbance of the fractions was recorded and leaf bioassay has been done for further identification.

MS media with 2,4-D 3 mg l^{-1} supported good callus proliferation in greater yam var. Orissa Elite. The callus could be regenerated successfully in MS media with 1.5:1.5 mg l^{-1} NAA:BA. In the study on recovery phenomena of cassava mosaic disease, symptoms as well as virus titre of recovery types decreased over the growth period; while resistant line had low concentration of viral DNA even though there were no symptoms.

An effective RT-LAMP assay has been developed for the easy detection of DsMV in less than an hour and it was validated with field samples of elephant foot yam. For large scale indexing of samples, CP specific non-radioactive probe was developed and used in NASH with great reliability.

The complete nucleotide sequence of DsMV was deduced from the transcriptome data and validated using PCR amplification of various overlapping regions with 11 set of primers, which was designed based on the assembled sequence obtained from the transcriptome data and subsequent sequencing of PCR products. The sequence of the virus of 10024 bases showed 83% identity with DsMV infecting *Z. aethiopica* (China), the only available whole genome sequence of DsMV at NCBI.

Testing of different viruses in 22 taro leaf samples using PCR based method revealed the presence of DsMV (68%), TaBV (45%) and mixed infection (27%). The DsMV sequence showed maximum similiarity of 93% to D*asheen mosaic virus* isolate DsMV-Amp3 polyprotein gene, DsMV isolate T10 (Accession KJ786965) and DsMV partial CP gene for coat protein of NiNG1 (Accession AM910398) and NiNG4 isolate (Accession AM910400), whereas the TaBV sequence showed maximum sequence similiarity of 92% to TaBV isolates (NC1, SI2 and S17) polyprotein gene.

The PureLink RNA Mini kit and $LiCl_2$ method were the most appropriate for RNA isolation from greater yam leaf and tuber samples respectively.

A pair of species specific primers (YMacF1/R1) was designed to amplify the full CP gene of the *Yam Maclura virus in* greater yam. RT-PCR analysis with these primers provided an amplicon of ~1100 bp. The full CP gene was cloned into *E. coli* DH5α cells. BLAST analysis of the CP coding region revealed that the virus has maximum similarity to *Chinese yam necrotic mosaic virus* (ChYNMV) (70% nucleotide identity). Sequence and phylogenetic analyses revealed considerable variability; and the virus was in the same cluster as ChYNMV and *Yam chlorotic necrotic mosaic virus* (YCNMV). The virus coat protein gene exhibited only 65 to 70% nucleotide

sequence identity with other *Maclura viruses*. The full CP region of *Yam mild mosic virus* (YMMV) could be amplified using highly sensitive and species specific primers, YMMV F and YMMV R in greater yam. Mining of different viruses in lesser yam (*D. esculenta*) showed the presence of only *Yam mild mosaic virus*.

Crop Utilization

The tuber crop products such as gluten-free spaghetti from sweet potato, *nutriose* fortified sweet potato noodles, high protein starch noodles from sweet potato, functional sago with high protein content, functional sago with high calcium content, cassava starch noodles using resistant starch enhanced (annealed) cassava starch, cereal grain type pasta-cassava-maida and cassava-rice blends, sweet potato spaghetti enriched with bioactive pigments and purple yam flour based pasta rich in anthocyanins were developed. Elephant foot yam (var. Gajendra and Sree Padma, and a local variety) corms were pickled by lactic fermentation. Sensory evaluation rated the elephant foot yam lacto-pickle acceptable to consumers based on texture, taste, flavour and after taste.

Field trials with sweet potato genotypes, ST-13 (with purple anthocyanin rich tuber) and Acc. No. 1468 (with anthocyanin rich leaf) were conducted under different treatments for enhancement of anthocyanin in leaves and tuber. The treatments viz., foliar spray of BA and humic acid application significantly increased anthocyanin yield per plant in ST-13 as compared to control. In Acc. No. 1468, anthocyanin yield was maximum in the soil application of humic acid (5 g per plant) at 3rd week after planting. Anthocyanin yield per plant was greater in the leaves of Acc. No. 1468 than in tuber of ST-13. The dried sweet potato leaves subjected to super critical CO_2 fluid extraction trials showed distinct bands of anthocyanin along with chlorophyll.

A vibro sieving system developed at ICAR-CTCRI was installed at M/s T.A. Perumal Sago Industry, Salem and evaluated with cassava starch slurry. Motorised cassava chipping machines were fabricated and supplied to TNAU KVK Yethapur, Salem district. The evaluation of the machine showed that the average outturn of the machine was up to 1.50 tonnes per hour for 3.23 mm thick chips. A cassava prototype harvester developed at ICAR-CTCRI was evaluated in the field conditions and the field capacity and percentage of tuber breakage in operating the cassava prototype harvester ranged from 15.72-40.2 man h ha^{-1} and 2.14-8.61%, respectively.

Microwave drying experiments were conducted in a hot air assisted microwave dryer. The final moisture content of wet starch ranged from 11.09 to 12.82% (w.b) and the total drying time varied from 1.19-3.15 h. Ozonisation trials were conducted with wet cassava starch. The colour values of the treated samples ranged from L-76.3-83.61, a-1.45-1.69 and b-7.13-7.52. The water activity (a_w) ranged from 0.932-0.936.

Electrical properties of cassava tubers viz., capacitance, impedance, dissipation factor and phase angle values ranged from 1.14 X1$^{0-10}$ to 2.952 X1$^{0-7}$, 1.05-9.13, 0.052 kΩ - 4.09 kΩ and -43.51 to -6.6°, respectively. Microwave studies were conducted in four varieties of cassava viz., Sree Jaya, H-226, M-4, CMR-100 using Vector Network analyser in S-band frequency. The hardness of the peeled and unpeeled tubers varied from 1.1836-3.033N and 0.6714-2.481N, respectively. These properties are useful in designing an electronic starch measurement device.

Process variations in the production of high quality cassava flour were studied at different loading densities (3, 5 and 7 kg m^{-2}) of cassava chips and gratings and at different drying methods viz., open yard, poly carbonate solar yard and mechanical tray drying. The gratings of 3 kg m^{-2} loading density dried under solar dryer yielded brighter colour.

Studies were carried out to develop biodegradable films from modified starches viz., etherification using propylene oxide and esterification using octenyl succinic anhydride added with various waxes viz., microcrystalline wax, candelilla wax, carnauba wax and proteins viz., whey protein concentrate and casein. The concentration of starch in the filmogenic

solution varied from 3 to 5%, wax from 5 to 15%, protein from 5 to 15% and glycerol from 15 to 30%. The physico-mechanical properties of the films viz., thickness, moisture content, solubility, colour, tensile force, elongation at break, sorption isotherms and water permeability were studied. Biodegradable films were also prepared from native and modified starches with keratin and their properties were evaluated. Rheological properties viz., storage modulus, loss modulus, phase angle and viscosity under frequency sweep test was noted. Among all the composites, maximum tensile force (28.56 N), minimum elongation at break (5.60%) and minimum water vapour transmission rate (0.0096 g mm cm^{-2}) was obtained for carnauba esterified starch based films. By adding the whey protein concentrate with the esterified starch, maximum tensile force (26.45 N), minimum elongation at break (10.23%) and minimum water vapour transmission rate (0.017 g mm cm^{-2}) was obtained. The properties of the film made with native/modified starch with keratin showed that maximum tensile force (12.45 N), minimum elongation at break (30.45%) and minimum WVTR (0.017 g mm cm^{-2}) was obtained for native starch-keratin composites.

Drying characteristics of cassava stem under different methods was studied for the preparation of card boards from cassava stems. The drying studies showed that during tray drying, the maximum average drying rate of 30.26 g $h^{-1}100g^{-1}$ bone dry matter was obtained for 2" long stem at 70°C and minimum of 10.14 g $h^{-1}100g^{-1}$ bone dry matter for 6" long stem at 50°C. During oven drying, the maximum drying rate was only 11.36 g $h^{-1}100g^{-1}$ bone dry matter for 2" long stem at 70°C, whereas minimum was 7.2 g $h^{-1}100g^{-1}$bone dry matter for 6" long stem at 50°C.

Corrugating adhesives and binding pastes formulations were prepared from modified starches. The tack of the adhesive bond measured using a spring scale, varied from 0.6-0.75 kg for different formulations and the drying time of the adhesive on paper board was in the range of 45-56 sec. Broken sago, a by-product from sago industry has been utilized for developing a corrugating adhesive based on a pre-blended carrier component and native starch. The tack varied from 0.60-0.72 kg and the drying time was 72-106 sec. Adhesive pastes based on native as well as modified cassava starch has been developed as multipurpose binding paste especially for paper industries. The adhesive paste can be stored at ambient temperature for more than six months without significant alteration in binding properties. The drying time was 2-3 min and tack was 0.70-0.80 kg for the samples. Cassava starch based samples exhibited the same or higher tack in comparison to commercially available binding paste, some of which were not based on starch. A Ready-to-mix two-part moisture resistant adhesive with extended shelf life has been prepared and it exhibited a tack of 0.68±0.06 kg and the drying time of 2-4 min.

Extension and Social Sciences

Of the seven cassava accessions evaluated for consumption purpose at Kadegaon, Sangli district, Maharashtra under supplementary irrigation, Sree Athulya produced significantly higher yield (52.00 t ha^{-1}) and was on par with Ci-888 and 2-18. Based on cooking quality and taste, M4 and 9S-127 were most preferred by the farmers.

The survey on elephant foot yam production system conducted in the Nadia and 24-Parganas districts in West Bengal indicated that the varieties resembling Gajendra, from Bihar/Andhra Pradesh were popular among farmers and the recommended cultivation practices were well adopted by the farmers.

Food choice survey conducted in Kerala, Tamil Nadu and Haryana revealed that health consciousness, familiarity and naturalness as well as sensory quality were the major factors that determined food choice of consumer. Sensory evaluation of tapioca crisps indicated that aroma is the principal factor that determined the consumers acceptability

A SAS macro for generating letter displays in multiple comparison of means of interaction effects of factorial experiments has been developed. An Excel macro has

been developed for creation of horizontal minimum average maximum chart from summary statistics.

Electronic Crop (E-Crop) an electronic device for giving real-time agro-advisory was developed. The E-Crop collects real-time weather data at 15 minutes interval. Crop models generates agro advisory based on the weather data collected. Agro advisory is sent to the farmer as SMS. One device can generate agro advisory for many crops. This is simple to install, cheap and cost effective.

Sree Visakham Cassava Expert System (SVCES), a web based user friendly cassava expert system was developed and is available at the address http://www.ctcritools.in/cassavaexpert. Major components of the system are agro-techniques, varieties, cassava protector, nutrient management system, online market, machineries, agro-advisory, literatures and upload news.

The North-Eastern Hill Region (NEH) programme of the Institute aiming at ensuring food security through tuber crops technologies continued this year in the four implementing states of Manipur, Meghalaya, Nagaland and Tripura. Performance appraisal of the demonstrated technologies, particularly the high yielding varieties, introduction of simple post-harvest value addition technologies, laying out demonstration plots in more farmers' fields, study of value chain analysis of cassava and taro, capacity building activities etc. are the salient activities carried out during the period.

High yielding varieties, Sree Jaya and Sree Vijaya in cassava, Muktakeshi in taro and Gajendra in elephant foot yam were preferred by farmers. The value chain analysis of cassava in Nagaland indicated that both the tubers as well as the leaves were used for human consumption and as pig feed. As in case of cassava, in taro too, value addition enabled the farmers to get good price for their product, "Anishi" - a semi-processed food from fermented taro leaves in Nagaland.

In the area of post-harvest value addition, tiny interventions such as use of cassava slicer, chipping machine, grater etc. improved the efficiency of preparation of various value added products. In addition to the beneficiary farmers, additional number of farmers covering an approximate area of 30 ha was brought under demonstration programme in the implementing states. The necessary planting materials for this was mobilized from the beneficiary farmers and from the Institute, 4000 cassava stems, 3 tonnes of taro and 500 kg each of elephant foot yam and greater yam were supplied.

ICAR-CTCRI Tribal Sub Plan continued this year with Ramakrishna Mission, Narayanpur, Chattisgarh, Ramakrishna Mission, Ranchi, Jharkhand, ORRISSA (NGO), Kandhamal, PRAGATI (NGO), Koraput as the collaborating partners. A total of 254 beneficiaries from seven villages were chosen for intervention. Quality planting materials of elephant foot yam (var. Gajendra) 6800 kg, taro (var. Muktakeshi) 6000 kg, yam (var. Orissa Elite) 6000 kg, cassava stems 3500, yam bean 100 kg and sweet potato cuttings 1.1 lakhs were distributed to 260 tribal farmers of Jharkhand, Chhattisgarh and Odisha. Distribution of chicks, ducks, poultry birds, farm implements, training programmes on production and value addition of tuber crops, demonstration trials on improved cultivation of elephant foot yam and integrated disease management were the major highlights of the programme.

Introduction

ICAR-CTCRI (1963-2015)

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 in an area of 21.50 ha. Later, an area of 26.69 ha has been added. The Head quarters has completed it's golden jubilee during 2012-2013 and became the **ISO (ISO 9001:2008) certified Institute since 31 March, 2014.** ICAR-CTCRI has one Regional Centre (RC) at Bhubaneswar with a farm area of 20 ha. The All India Coordinated Research Project on Tuber Crops (AICRPTC) was started at ICAR-CTCRI in 1968 with three centres at Dholi in Bihar, Coimbatore in Tamil Nadu and Acharya N.G. Ranga Agricultural University, Hyderabad, Andhra Pradesh. The AICRP TC which was started for testing and popularizing the location specific tuber crop technologies in various parts of India has presently 18 centres including ICAR-CTCRI HQ and Regional Centre. The Institute is also one of the centres of All India Coordinated Research Project on Harvest and Post-Harvest Technology. The ICAR-CTCRI is conducting basic 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

- To undertake basic, strategic and applied research for generating technologies to enhance productivity, farm profitability and utilization potential of tuber crops (other than potato).

- To act as a national repository of scientific, social, and economic information on tuber crops.
- To coordinate network research with State Agricultural Universities and ICAR Institutes for generating location specific technologies.
- To act as a centre for human resource development for various clientele systems involved in research, development, cultivation and utilization of tuber crops.
- To undertake transfer of tuber crops technology through consultancy, outreach programmes and linkage with developmental agencies.

General Achievements

The ICAR-CTCRI is a premier research organisation in the world dedicated solely to the research on tropical tuber crops. The institute celebrated its golden jubilee last year and five decades of concerted research have led to the development of several production and processing technologies for tuber crops, besides release of 53 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 popularisation of the technologies. In addition, several industrial Hi-tech technologies were also developed in the recent past enabling resource generation through consultancies.

ICAR-CTCRI has a wealth of germplasm of tuber crops, totalling 5895. This has formed the basis of all the genetic improvement and variety development programme. Earlier the improvement work was exclusively based on conventional breeding programmes. Infact, the pioneering role of ICAR-CTCRI in the area of tropical tuber crops classical breeding attracted international collaboration in the breeding and genetic improvement of these crops in the past. Now, work on molecular based improvement has also been initiated.

ICAR-CTCRI has released 53 varieties in eight different tropical tuber crops. Each variety has its own unique traits and preferences. The cassava starch and sago production in the country is mostly dependent on two major industrial varieties of cassava released from ICAR-CTCRI, viz., H-165 and H-226. Two Triploid cassava varieties, viz., Sree Athulya and Sree Apoorva have been released recently, which are found to be promising and acceptable to farmers as well as industries. b carotene rich ST-14 sweet potato developed by ICAR-CTCRI was included in LANSA and FSN programme to alleviate malnutrition.

The domestic and international training received in the use of biotechnology in conservation, characterisation and genetic improvement of tuber crops has contributed to a great extent in development of facilities and formulation of programmes using this advanced technology for the improvement of tuber crops. The Institute presently has very strong 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 waxy starch.

A host of tuber crops production technologies are available for monocrop, intercrop and multiple cropping systems which help in enhancing the yield, soil fertility, employment opportunities for farm families and income levels. Integrated crop protection technologies developed for cassava mosaic disease, taro leaf blight, collar rot of elephant foot yam and sweet potato weevil would help the farming community in extreme eventualities. Management of banana pseudostem weevil through cassava based biopesticides, *viz., Nanma* and *Menma* was a grand success in the farmers' fields. Besides, technology has been perfected for organic production of elephant foot yam, taro and all species of yams; cropping system with rice-black gram-short duration cassava proved to be profitable with good return.

Efforts in crop utilization have paid rich dividends in terms of value addition and diversified technologies suitable for big, small and cottage industries. Many of these technologies are capable of ensuring food and nutritional security to the people of India.

Technologies for the industrial sector include the latest products like superabsorbent polymers; graft copolymerized starches, cold water miscible starch, solid adhesives, bioethanol, pasta products etc. Cassava starch composite based biodegradable films and adhesive formulations for corrugation and paper industries are successfully developed recently. Development of functional food products from cassava, yam and elephant foot yam and enhancement of anthocyanin recovery from anthocyanin sweet potato is in pipeline.

Aroids especially elephant foot yam is gradually gaining importance in different areas like Odisha, Bihar, Uttar Pradesh, Gujarat and north-eastern states. Supply of quality planting material is ensured to farmers of all regions though revolving fund scheme, mega seed project and tuber crops development scheme from state department. There exists a good research base in the country to sustain root and tuber crops research for development with ICAR-CTCRI giving the leadership and ICAR-AICRPTC to plan and coordinate region specific research and testing of technologies on these crops. Technology generation and transfer are being closely interlinked with the utilization by the clientele system.

ICAR-CTCRI bagged the Sardar Patel Outstanding Institution Award for the year 2005, instituted by the ICAR for outstanding contribution made in the improvement of tropical tuber crops and development of low cost production technologies.

The Institute also bagged many national and international recognitions in the past that include J. Chinoy Gold Medal (1970), three ICAR Team Research Awards (1985, 1996, 1998), D. L. Plucknett Award for Tropical Root Crops, 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) and Vasantharao Naik Memorial Gold Medal (2002). 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 to 15 November, 2006.

The best annual report award (1997-98) among the category of small institutes was conferred to ICAR-Central Tuber Crops Research Institute for succinctly presenting the research results. The Institute has conducted more than 15 national and international Symposia/Seminars/Workshops.

The infrastructural facilities of the Institute have been tremendously increased during the X and XI Plan periods. Additional laboratories like Food Extrusion Laboratory, Transgenic Glass House, Bioinformatics Laboratory, Biodiversity Sheds, Modernised Computer Cell, Seed Storage Laboratories, Net Houses etc. have been constructed. A new wing has been constructed for Division of Crop Improvement in the first floor. The Institute Headquarters has been renovated thoroughly, giving a totally new look to it, with modern laboratories, library, museum and millennium hall. Crop museum with the display of all mandatory crops is also being maintained for the visitors.

A number of new and sophisticated equipment have been added to the existing ones to raise the standard of research. These include several state-of-the-art equipments like the food extruder, texture analyzer, differential scanning calorimeter, FTIR, HPLC, HPTLC, atomic absorption spectrophotometer, auto analyser, gel documentation system, real time quantative PCR, nitrogen analyser, fibre analyser, genetic analyser etc. The infrastructural facilities of the Regional Centre have also been considerably improved through the creation of additional laboratory space, providing several new equipments.

Extramural support by way of research schemes from both international (like CIAT, CIP, CIRAD , European union, IFAD etc) and national agencies like DBT, DIT, DST, DRDO, DSIR, ICAR, JNU, KSCSTE, LSRB, MOEF, DoA, Kerala, KSPB, NABARD, PPIC, PVP & FRA, SHM, UGC etc., were a great boon to the Institute to upgrade the research infrastructure as well as to facilitate detailed studies on frontier areas of

Museum

Crop museum

research. The Network projects of ICAR have helped the Institute to focus research on priority areas.

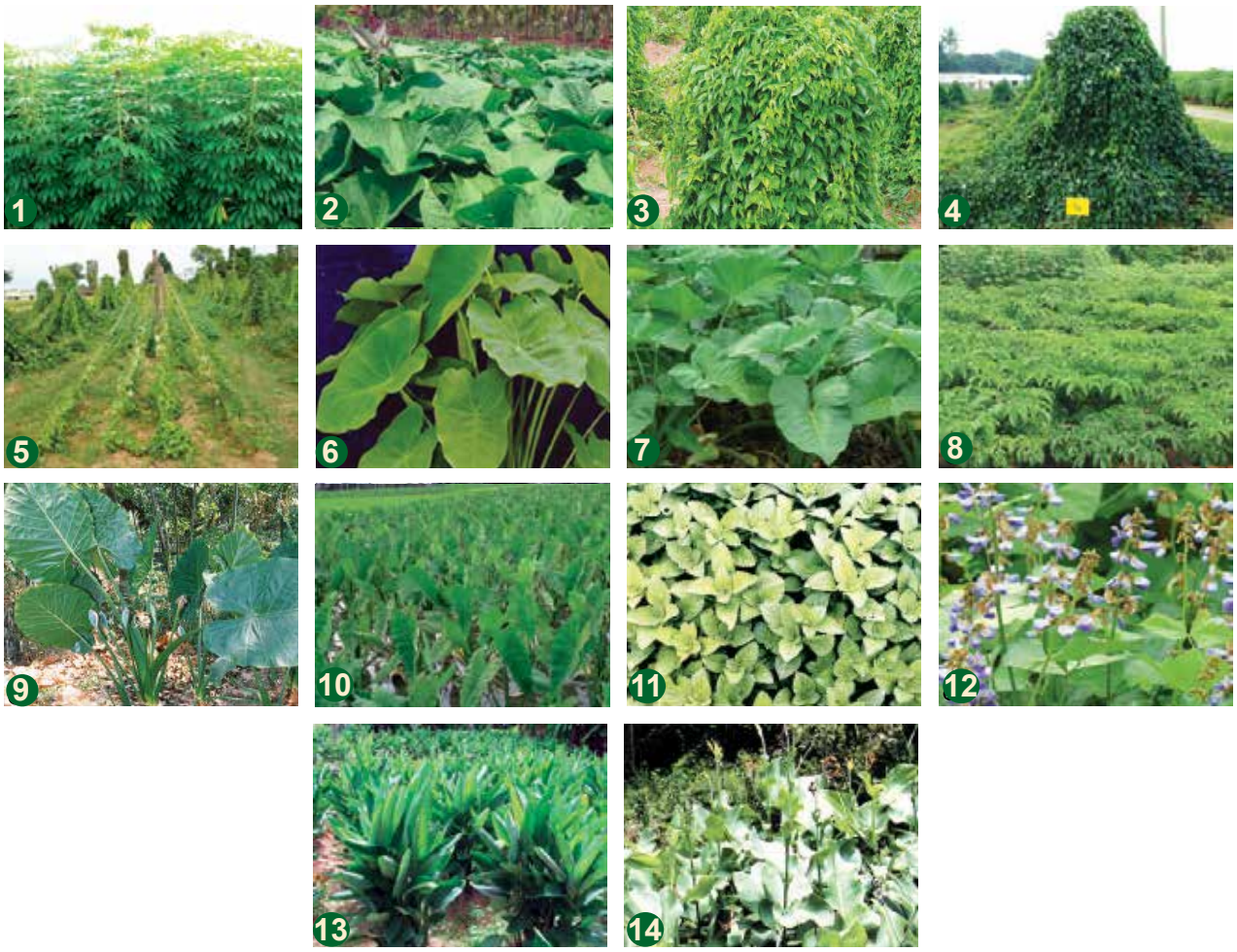
Institute Technology Management Unit (ITMU) of the Institute has been active in carrying out IP activities. The unit is engaged with public/private parties for the commercialization of technologies. The ITMU has taken initiative in filing patent applications.

Agriculture Knowledge Management Unit (AKMU) has 17 state of the art computers with centralised printing, high capacity file server with 8TB storage, 6 TB Storage server for Data Backup, proxy server with integrated Firewall, Anti Spam, IPS and Web Application Firewall, CISCO ASR 1002 Series Routers for high speed routing, connectivity with NKN, 1Gbps Powergrid fiber connectivity for Internet, 2mbps backup connectivity with BSNL for internet load balancer for peak internet traffic management, Unified Threat Management (UTM) appliance for Internet security, Internet content filtering with automatic internet access, Switchover to IPv6 in place of IPv4 being carried out step by step, Dual Layer protection against virus attack - antivirus on Internet gateway and centralized distribution on client nodes, automatic log generation, reporting and storage, Leased line video conferencing facility, VPN connectivity for global Access to the servers and touch screen information kiosk. A full fledged local area network connecting the various divisions and administration wing has also been established. The network consists of windows nt server, internet proxy server, intranet file server and email server, computers, laser printers, inkjet printers, scanners, dtp and multimedia work stations. Legal licensed versions of popular software packages like windows 98, windows, microsoft office 2000, Microsoft XP office, pagemaker 6.5, corel draw 6.0, ism multiscripts, visual studio etc. are installed for various type of applications. In addition to the supporting statistical softwares such as SAS, JMP Genetics, Genomics and R environment for statistical computing, WinBugs Visual Studio 2012, bioinformatics software DNASTAR and Laser Gene 11 Genomic Suite are installed to meet the computing requirements.

ICAR-CTCRI has set up a home page on the internet. This can be accessed at http://www.ctcri.org which provides a comprehensive picture about the various activities of the institute and various online facilities like sales counter, discussion forum etc.

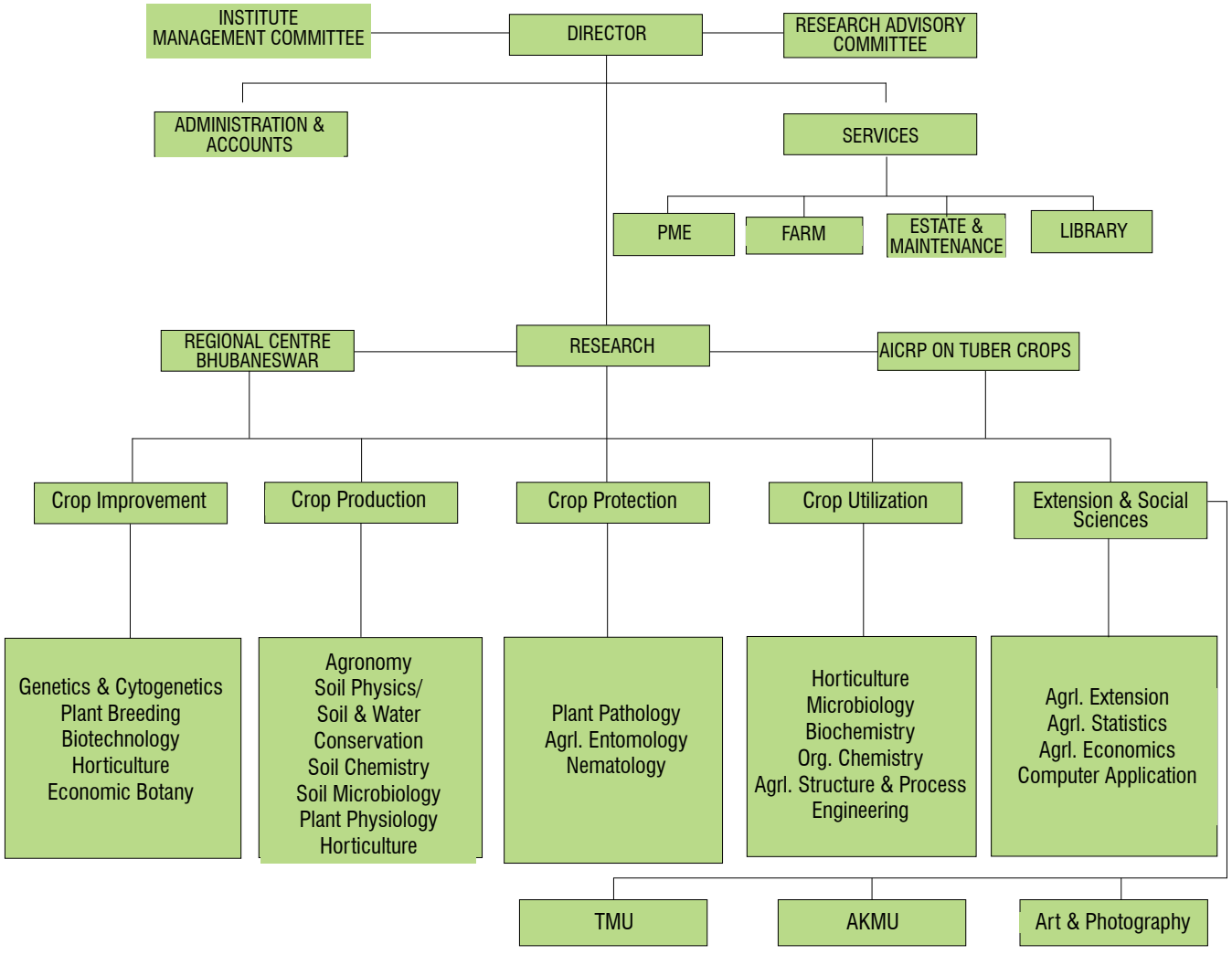
Regional Centre, ICAR-CTCRI, Bhubaneswar

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. Taro *Colocasia esculenta* (L.) Schott. Araceae; 7. Tannia *Xanthosoma sagittifolium* (L.) Schott. Araceae; 8. Elephant foot yam *Amorphophallus paeoniifolius* (Dennst.) Nicolson Araceae; 9. Giant taro *Alocasia macrorrhiza* (L.) Schott. Araceae; 10. Swamp taro *Cyrtosperma chamissonis* (Schott.) Merr. Araceae; 11. Chinese potato *Plectranthus rotundifolius* (Poir.) J.K. Morton Labiatae; 12. Yam bean *Pachyrrhizus erosus* (L.) Urban Leguminaceae; 13. Arrowroot *Maranta arundinacea* L. Marantaceae; 14. Queenland arrowroot *Canna edulis* (Ker-Gawler) Cannaceae.

Organisational Set up



Staff Position (2014-2015)

Category	Sanctioned	Filled	Vacant
RMP	1	1	0
Scientists	49	38	11
Technical	47	37	10
Administration	31	25	6
Skilled support staff	55	30	25
Total	183	131	52

Expenditure (2014-2015)

Plan

(Rupees in lakhs)

No.	Head of Accounts	RE 2014-15	Expenditure
1.	Works		
	A. Land		
	B. Building		
	i. Office building	28.43	28.43
	ii. Residential building		
	iii. Minor works		
2.	Equipments	17.57	17.57
3.	Information technology	10.00	10.24
4.	Library books & journals	10.00	9.73
5.	Vehicles & vessels		
6.	Livestock		
7.	Furniture & fixtures	4.00	4.03
8.	Establishment charges		
9.	Travelling allowances (Instt. + NEH)	32.74	32.74
10.	Research & operational expenses (Instt.+TSP + NEH)	139.16	139.15
11.	Administrative expenses	112.00	111.99
12.	Miscellaneous (Instt.+TSP+NEH)	6.10	6.10
	GRAND TOTAL (CAPITAL + REVENUE)	360.00	359.98
13.	AICRP on TC	300.00	300.00
14.	AICRP on PHT	5.70	5.69
15.	Plan Schemes	90.89	90.14

Non-plan

(Rupees in lakhs)

No.	Head of Accounts	RE 2014-15	Expenditure
1.	Works		
	A. Land		
	B. Building		
	i. Office building	5.36	5.43
	ii. Residential building		
	iii. Minor works		
2.	Equipments	6.67	6.60
3.	Information technology		
4.	Library books & journals		
5.	Vehicles & vessels	7.19	7.19
6.	Livestock		
7.	Furniture & fixtures	2.78	2.78
8.	A. Establishment charges	1160.00	1160.00
	B. Pension & other retirement benefits	192.00	191.96
	C. Loans & advances	10.00	7.86
9.	Travelling allowances	8.00	8.00
10.	Research & operational expenses	35.00	35.02
11.	Administrative expenses	92.00	91.99
12.	Miscellaneous	4.00	4.00
	TOTAL	**1523.00**	**1520.83**

Research Achievements

INSTITUTE PROJECTS

CROP IMPROVEMENT

COLLECTION, CONSERVATION, CHARACTERIZATION AND EVALUATION OF GERMPLASM OF TROPICAL ROOT AND TUBER CROPS

New collections

Institute germplasm collection was augmented with 137 accessions of various tuber crops from three targeted collection trips to Joida taluk, Uttara Kannada, Karnataka (Fig. 1) (36 accessions comprising 8 greater yam, 6 lesser yam, 4 sweet potato, 5 taro including 2 dasheen types and a salad type non-acrid accession, 1 elephant foot yam, 1 tannia, 2 Chinese potato, 2 potato yam, 1 canna, 4 wild yam, 1 wild elephant foot yam and 1 wild turmeric); Arunachal Pradesh (42 accessions comprising 3 cassava, 9 sweet potato, 11 taro, 5 greater yam, 3 tannia, 1 *Alocasia* sp., 1 *Ipomoea* wild sp., 2 wild taro, 2 wild elephant foot yam, 1 wild yam, 1 wild arrowroot and 3 wild related species) (Fig. 2) and northern parts of Kerala (27 accessions comprising 9 greater yam, 6 taro, 2 sweet potato, 1 elephant foot yam, 1 tannia, 1 Chinese potato, 1 arrowroot, 1 canna, 1 potato yam, 3 wild turmeric and 1 *Ipomoea* wild sp.) (Fig. 3). Apart from these, 32 collections were made from the other States, which comprised 7 cassava (Meghalaya-3, Kerala-4); 1 sweet potato (Belgaum); 9 taro (Meghalaya-3, Kerala-6); 2 greater yam (Kerala); 5 lesser yam (Kerala); 4 tannia (Kerala) and one each of arrowroot (Kerala), wild yam (Kerala), turmeric (Kerala) and *Arisaema* sp. (Maharashtra).

Fig. 1. Tuber variability collected from Joida taluk, Uttar Kannada, Karnataka

Fig. 2. The exploration team to Arunachal Pradesh and a view of wild *Amorphophallus* spp. collected

Fig. 3. Tuber variability collected from North Kerala

Field gene bank

A total of 5895 accessions of different tuber crops are being maintained in the National Repository for Tuber Crops at ICAR-Central Tuber Crops Research Institute (CTCRI), which comprises cassava 1383, sweet potato 1483, yams 1151, edible aroids 1350 and minor tuber crops 391 accessions along with 137 newly augmented accessions.

Cassava

At ICAR-CTCRI HQ, a total of 1270 accessions of cassava, comprising the indigenous, exotic, landraces and breeding lines were planted in the field for maintenance, characterization and preliminary evaluation (Fig. 4). Two hundred and seventy eight accessions of cassava germplasm were characterized and evaluated for seven qualitative (two plant and five tuber characteristics) and six quantitative (tuber) traits. Genetic diversity analysis of 12 landraces of cassava was done using six SSR markers, which demonstrated uniqueness of all the accessions with a similarity coefficient ranging from 0.35 to 0.88. Dendrogram generated using UPGMA separated the 12 cassava accessions into two major clusters with 9 and 3 accessions respectively, showing 50% similarity.

Fig. 4. A view of the field gene bank of cassava maintained at ICAR-CTCRI

Sweet potato

A total of 1110 sweet potato accessions including 707 indigenous collections and 403 exotic collections were maintained under the field gene bank (Fig. 5). Fifty sweet potato accessions were screened morphologically for 17 vegetative characters and seven tuber characters (IPGRI descriptors). Of these, six were orange-fleshed and the remaining were either white-fleshed or yellow-fleshed. Cooking quality of 50 sweet potato accessions was evaluated, including Sree Arun and Kishan. These included nine orange-fleshed, seven purple-fleshed and rest white/ cream/yellow-fleshed ones. Consistency of cooked tubers, texture and sweetness were assessed as per IPGRI descriptor. Taste was assessed by a team of three members. Fifteen were identified as high starch lines. Eleven lines were very sweet and four were not at all sweet. Five were assessed as having very good taste, which was comparable with the released varieties, Sree Arun and Kishan. Apart from this, 15 sweet potato accessions were subjected to molecular characterization using six ISSR markers and two sets of duplicates could be identified and the similarity coefficient ranged from 0.40 to 1.00 (Fig. 6).

Yams

Nine hundred and twelve accessions of yams comprising *Dioscorea alata* (591), *D. rotundata* (158), *D. esculenta* (220), *D. bulbifera* (6) and wild yams (135) are being maintained in the field gene bank (Figs. 7, 8).

Fig. 5. Field view of sweet potato field gene bank

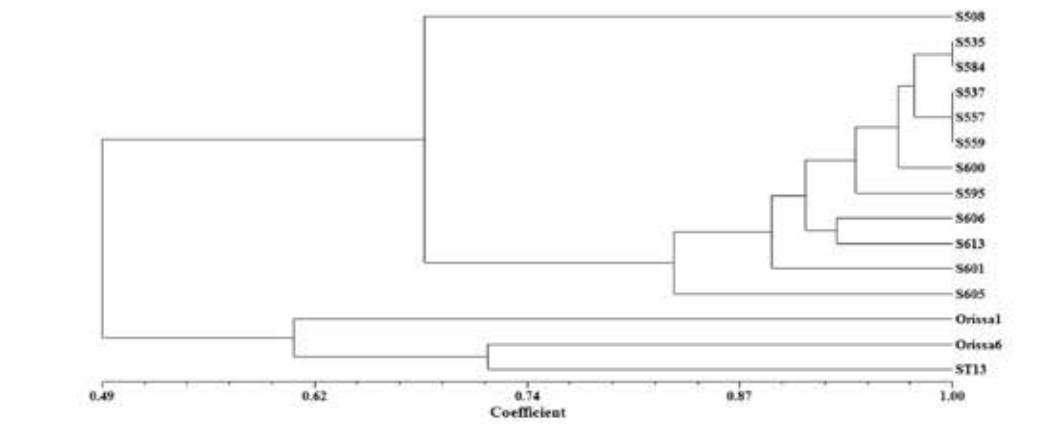


Fig. 6. Dendrogram showing the clustering pattern in sweet potato using ISSR markers

Fig. 7. Field view of *D. alata* germplasm

Fig. 8. *D. rotundata* germplasm maintained at ICAR-CTCRI HQ

Field screening for anthracnose resistance was done in *Dioscorea alata* germplasm, where a total of 319 accessions were screened. Amongst them, 17 showed no infection. The rest 109, 78, 57, 37 and 21 accessions showed 0-5%, 5-25%, 25-50%, 50-75% and >75% disease intensity.

In white yam, 111 accessions were evaluated for cooking quality, of which 17 had excellent cooking quality (Dr-2, 24, 69, 73, 121, 128, 132, 142, 144, 161, 175, 240, 251, 318, 332, 334 and 342). Among the accessions, Dr-292, had high dry matter and starch content coupled with excellent cooking quality. Dry matter content of 37 white yam accessions was recorded and it ranged from 29.60% (Dr-267) to 48.90% (Dr-287). High dry matter content (>42%) was recorded in the accessions Dr-2, 20, 40, 73, 140, 147, 287 and 292.

Among the greater yam accessions evaluated, Da-28, produced the highest tuber yield/plant (8.25 kg) followed by Da-177 (5.25 kg), Da-205 (5.00 kg), Da-251 (5.00 kg) and Da-242 (4.75 kg). Genetic diversity was studied based on microsatellite markers as well as morphological traits of 40 landraces of greater yam collected from different parts of India. Based on molecular data, the accessions formed nine clusters with four clusters having one accession each (Da-327, Da-145, Da-107 and Da-331) and four clusters with two accessions each (Fig. 9). The cluster nine with 32 accessions formed five sub clusters. Among the landraces, Da-331, a landrace from Kerala and Da-145, a landrace collected from Assam and Da-327 collected from Odisha were highly divergent as compared to the other accessions. Maximum polymorphism was revealed by the marker, Dab2E07 originally identified from a related species viz., *D. abyssinica*. Da2F10, Dab2D11, Da3G04, Da3E10 and Dab2C12 also revealed high levels of polymorphism.

Screening of the tuber sample of *Dioscorea floribunda* using Thin Layer Chromatography (TLC) revealed the presence of diosgenin in this species.

Edible aroids

Six hundred and seventy one edible aroid germplasm comprising 429 taro, 203 elephant foot yam and 39 tannia are being maintained in the field gene bank (Fig. 10). Morphological characterization in taro was done for 25 accessions from NEH regions for 39 above and below ground characters as per a combination of NBPGR/IPGRI descriptors. The Shannon Weaver's and Simpson's diversity index computed according to percentage distribution of the various traits, gave high mean values (H'=0.87; D=1.00). The first four PCs accounted for 76.59% of

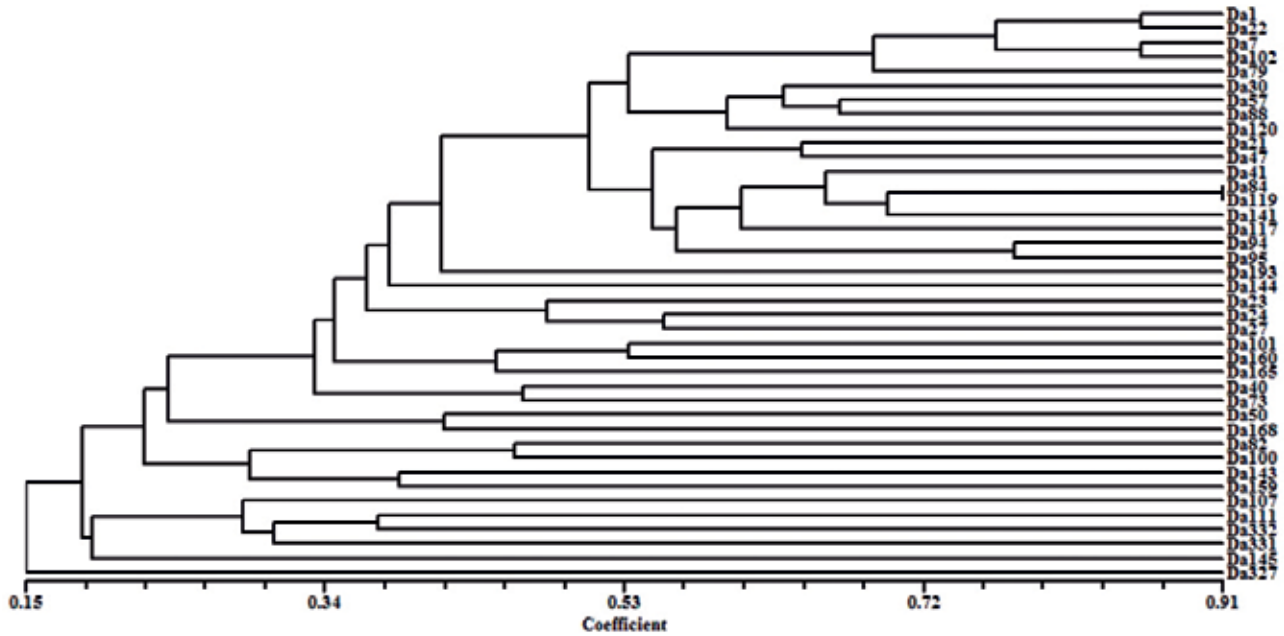


Fig. 9. Dendrogram of greater yam accessions based on molecular markers

Fig. 10. Field view of the taro gene bank

the total variatio. Molecular characterization of these 25 accessions was done using 10 polymorphic SSR markers (Ce1 A06, Ce1 B03, Ce1 C03, Ce1 C06, Ce1 F04, Ce1 H12, uq73-164, uq84-207, uq97-256 and uq201-302) (Fig. 11). All the selected primers gave high polymorphism as explained by the high values of Shannon's index (1.59-2.37), average number of alleles (6.00-12.57) and polymorphic marker ratio (0.76-1.00). No duplicates were identified from either morphological or molecular characterization.

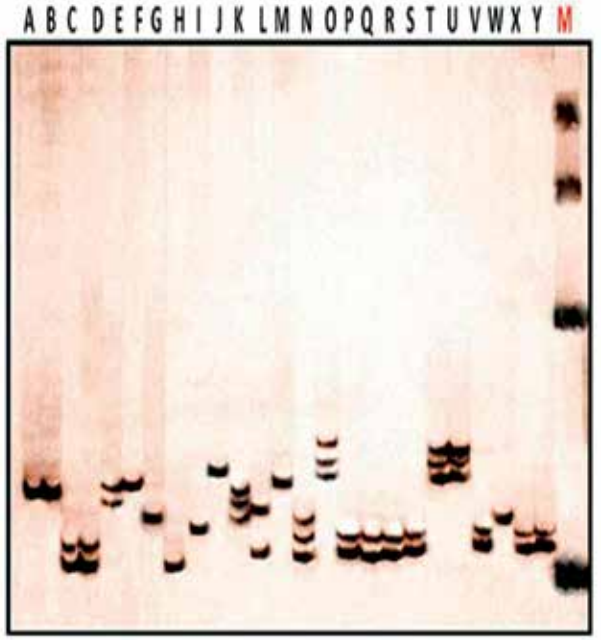


Fig. 11. Six per cent denaturing PAGE profile of 25 taro accessions using SSR marker Ce1 F04

Morphological characterization of underground tuber characters was recorded from 12 wild elephant foot yam accessions using 12 traits as per NBPGR descriptor. Genetic diversity analysis of 12 accessions of elephant foot yam was done using six ISSR markers. The results demonstrated uniqueness of all the accessions in elephant foot yam with a similarity coefficient ranging from 0.50 to 0.93. Cooking quality of five taro accessions was done and it was noted that all five had good cooking quality. Virus indexing of nine aroids (taro, tannia, elephant foot yam and karunakizhangu) collected from Nagercoil during 2014 was done. The results showed that only two tannia lines were free from potyvirus. Taro, *Amorphophallus* and karunakizhangu were all infected with this virus. However, the taro collection, though it was infected with potyvirus (screened with MJ1 and MJ2 primers), was free from DSMV as it showed negative result with DSMV specific primer DsMV3F/3R.

Minor tuber crops

A total of 220 accessions of minor tuber crops comprising 127 Chinese potato, 75 yam bean, 9 *Curcuma* spp., 7 arrowroot, 1 each of *Coleus aromaticus* and *Vigna* sp. were planted in the field for maintenance, characterization and preliminary evaluation. Seven arrowroot collections from different states like Odisha, Assam, Tamil Nadu, Bihar, Maharashtra, Madhya Pradesh and Kerala were evaluated for tuber traits, which showed a range of fresh weight of single rhizome from 69.90 g in the collection from Kerala to 100.50 g in the collection from Maharashtra and the dry matter percentage ranged from 31.90 in the Kerala collection to 33.80 in the Odisha collection. The per plant rhizome yield ranged from 1.30 kg (Kerala) to 2.40 kg (Maharashtra), while the number of rhizomes per plant ranged from 17 in Odisha collection to 34 in the Maharashtra collection.

Germplasm exchange

Germplasm of different tuber crops were supplied to farmers/researchers. Ten accessions (11S-33, CI-800, 9S-127, CI-888, CR-24-4, 11S-4, 9S-128, CTCRI-4, 4-2 and 8W-5) of cassava, four varieties (Kanaka, Gouri, Kanjangad local and Sree Bhadra) of sweet potato, seven accessions (Da-801G, Da-298,

Da-811G, Da-340, Da-331, Da-11 and Da-153) of *Dioscorea alata*, three accessions of white yam (DR -1047, DR-657 and Sree Shubra) and the dwarf white yam variety, Sree Dhanya, lesser yam, *D. bulbifera* and two accessions of yam bean were supplied to farmers/researchers. Taro varieties, Sree Rashmi and Sree Kiran as well as trypsin rich taro accessions (C-110, C-384 and C-464) were given to researchers.

Regional Centre

At the Regional Centre, ICAR-CTCRI, Bhubaneswar, different tuber crops viz., taro (506), sweet potato (373, including 76 wild lines), yams (51), elephant foot yam (41), yam bean (146), Chinese potato (5), arrowroot (2), tannia (1) and *Alocasia* (3) are being maintained under field gene bank. Yield evaluation was done in taro (5-18 t ha^{-1}), elephant foot yam (8-24 t ha^{-1}), yam (8-25 t ha^{-1}) and yam bean (13.55-29.94 t ha^{-1}).

In vitro conservation of tuber crops germplasm

Fifty accessions from the pre-identified core collections of sweet potato and hundred accessions received from NBPGR are being maintained under *in vitro* conditions (Fig. 12). Apart from these, released varieties of all tuber crops; cassava (2 breeding lines, 13 varieties, 3 landraces and 18 accessions); yams (7 accessions and 10 breeding lines) and taro (5 accessions) are also being maintained *in vitro*. At the Regional Centre, 38 sweet potato, 21 taro, 12 cassava, 5 yam, 5 Chinese potato and 2 elephant foot yam varieties, pre-release varieties as well as elite lines are being maintained under *in vitro* conditions.

Fig. 12. *In vitro* cultures of various tuber crops maintained under slow growth conditions

VARIETAL IMPROVEMENT IN TROPICAL TUBER CROPS

Cassava

Since cassava is an important food crop in Kerala, culinary attributes play an important role in variety development. Two new improved varieties were released from the Institute, recommended by the Kerala State Varietal Release Committee 2015 viz., Sree Swarna and Sree Pavithra. Sree Swarna is a cassava variety having high yield (40.00 t ha^{-1}), early bulking nature (7 months), good culinary quality, yellow flesh colour and tolerance to cassava mosaic disease (CMD) (Fig. 13). Sree Pavithra is a cassava variety with high yield (35-45 t ha^{-1}), excellent cooking quality, low cyanogenic glucoside content (25.80 ppm) and high K efficiency (243.65 kg tuber/kg K absorbed), suitable for cultivation in Kerala soils, which are inherently low to marginal in exchangeable K (Fig. 14).

Fig. 13. Sree Swarna

Fig. 14. Sree Pavithra

Introgression of CMD resistance

Introgression of CMD resistant genes into susceptible popular varieties was done to develop CMD resistant

varieties with high yield, earliness, starch content and cooking quality. Two thousand four hundred and fifty F_1 seedlings of cassava were planted for evaluation. It included 572 F_1 seedlings produced by crossing early bulking clones, Vellayani Hraswa and CI-889 with the resistant clones, 9S-127, 9S-132 and CR-54 A-3. The seedlings were screened for CMD resistance and 889 seedlings showed field resistance. Twenty promising symptom free clones were screened for the presence of virus using multiplex PCR with SLCMV and ICMV specific primers and all were free from virus. Among the CMD resistant hybrids evaluated, 8S-532, 9S-125, 9S-736, 11S-4 and 11S-33 had good culinary quality coupled with CMD resistance. The CMD resistant hybrids viz., 9S-127, 11S-33, CR-43-2, CR-24-1 and CR-43-7 were evaluated under on-farm trials and were also planted in demonstration plot at Krishi Vigyan Kendra (KVK), Kottarakkara, Kollam.

In the preliminary evaluation of cassava hybrids for early maturity, 8S-501-2 produced the highest tuber yield of 5.88 kg plant^{-1} at seven months after planting followed by 11S-30 (4.25 kg plant^{-1}) and 8W-5 (3.82 kg plant^{-1}) as compared to 3.30 kg plant^{-1} in Vellayani Hraswa, the check variety. The CMD resistant hybrid (F_1C_6), 8S-501-2 also had the highest harvest index (0.62). A replicated evaluation trial of cassava lines was undertaken and 8S-1284 produced the highest yield of 75.30 t ha^{-1}.

Sweet potato

The objectives of sweet potato breeding are higher yield (more than 17.00 t ha^{-1}), starch (more than 18%), β-carotene (more than 14 mg 100g^{-1}) and anthocyanin (more than 1g 100g^{-1}) with reduced crop growth cycle (75-90 days) and weevil resistance (infestation less than 10%). To achieve that, 265 germplasm lines as well as the breeding lines developed from high starch (ST-10), high β-carotene (ST-14) and high anthocyanin (ST-13) were evaluated.

Out of 265 accessions evaluated, 16 accessions showed yields higher than 16.00 t ha^{-1}. The accessions viz., S30/16, S30/15 and Baster-45 had early maturity of 75 days. Rest matured by 90 to 110 days. Four of them were found to be nutrient efficient and responded to half doses of N and K. Progressive evaluation of breeding lines generated from high starch white-fleshed, β-carotene rich orange and anthocyanin rich purple-fleshed lines showed yield ranging from 12-24 t ha^{-1} at the Institutional Farm. Of the 55 breeding lines, 35 lines produced more than 16 t ha^{-1} tuber yield. Clonal generation of such 29 high yielding lines with high starch, β-carotene and anthocyanin were tested on-farm in coastal Kendrapada having 6-8 dSm^{1} salt stress. Of the 11 orange-fleshed breeding lines, yield ranged between 19.60 to 21.57 t ha^{-1}. Of the 10 purple-fleshed lines, VABP-19 produced the highest yield of 22.45 t ha^{-1} and lowest was by VAP-9 with an yield of 18.24 t ha^{-1}. Among the white-fleshed lines, yield ranged between 23.30 to 24.75 t ha^{-1}. The highest yield was obtained from VAW-9. Besides yield, the targeted valued traits like starch, β-carotene and anthocyanin were observed to be higher in all those lines.

Overall assessment for valued traits of sweet potato germplasm and other breeding lines identified three

Orange-fleshed sweet potato (A-C) with β-carotene 14-16 mg 100g^{-1}

White-fleshed sweet potato (D and E) with high starch 16.00-20.80%

Purple-fleshed sweet potato (F and G) with anthocyanin 90 mg-1.2 g 100g^{-1}

Fig. 15. Sweet potato accessions with notable traits

germplasm lines with 75 days maturity of which, one was orange and two were white-fleshed. Among the breeding lines, 90 days maturity was recorded for 15 white, 5 orange and 5 purple-fleshed sweet potato. Starch content was observed to be 16.00-20.80% among the improved lines. β-carotene content in the orange-fleshed lines was recorded as 12-16 mg $100g^{-1}$ and anthocyanin content was observed to be 90 mg to 1.2 g $100g^{-1}$ (Fig. 15 A-G). All these lines showed weevil infestation between 2-10%.

Diallel crosses were conducted with 20 selected parents for genetic enhancement for higher starch, β-carotene and anthocyanin content coupled with higher yield and weevil tolerance. Hybridization resulted in 266 combinations. F_1 seeds were collected in the range of 10-45 per combinations.

Yams

Dioscorea alata (greater yam) is mainly used as a vegetable, cultivated either as an inter crop or as a sole crop. ICAR-CTCRI has released two new greater yam varieties during the recently held Kerala State Varietal Release Committee, 2015. Sree Swathy is a greater yam variety, released for its high yield (30.00 t ha^{-1}), good culinary and nutritive quality and tolerance to anthracnose disease (Fig. 16). Sree Neelima is a high yielder (35.00 t ha^{-1}) with good culinary and nutritive quality and light purple flesh colour (Fig. 17).

Preliminary evaluation trial of greater yam hybrids (F_1C_7) was conducted and the hybrids, Dah-139, Dah-10-11, Dah-10-1-36 and Dah-12-4-11 with high yield (>40.00 t ha^{-1}), compact tuber shape, good texture and

Fig. 16. Sree Swathy

Fig. 17. Sree Neelima

cooking quality were selected for further evaluation. A purple-fleshed high yielding greater yam variety, Da-340, was identified for anthocyanin extraction, which could be useful for the industries (Fig. 18).

Fig. 18. Da-340, a dark purple anthocyanin rich greater yam

Among the white yam dwarf hybrids (F_1C_8) evaluated for cooking quality, Drd-1038, Drd-1110, Drd-1835, Drd-920, Drd-1089 and Drd-1078 had excellent cooking quality and were found to be superior to the released dwarf variety, Sree Dhanya. Among the semi-dwarf varieties of white yam, SD-15 produced high yield coupled with excellent culinary quality. The dry matter content of the dwarf hybrids ranged from 24.94% (Drd-1157) to 37.92% (Drd-93).

Twenty five tall white yam hybrids (F_1C_8) were evaluated for dry matter content and it ranged from 24.56% (Drh-1150) to 45.78% (Drh-39). Among the eighth clonal white yam hybrids evaluated, Drh-1125

produced the highest tuber yield (59.30 t ha^{-1}) and produced tubers with good tuber shape and maximum tuber girth (40.67 cm). A new white yam hybrid, Drh-657, was identified with compact tuber shape, high yield and cooking quality for release in Kerala (Fig. 19).

Fig. 19. Drh-657, a white yam hybrid with compact tuber shape, high yield and cooking quality

Taro

To identify promising parental lines, field screening for taro leaf blight (TLB) was done in 192 taro accessions. Of these, 110 were scored as moderately resistant, 27 as resistant and 55 as susceptible. Artificial screening was done in 23 taro accessions for TLB resistance. Of these, 10 accessions (C-84, C-203, C-370, C-388, C-565, C-679, C-690 (violet), C-717, C-723 and IC012470) were found to be tolerant.

A preliminary evaluation trial was initiated in taro using eight selected high yielders in RBD replicated thrice with Sree Rashmi as check variety. The average corm yield was highest in IC310104 (10.00 t ha^{-1}), whereas average cormel yield was highest in IC003046 (29.60 t ha^{-1}), closely followed by IC211587 (28.70 t ha^{-1}) and IC310104 (28.30 t ha^{-1}). Sree Rashmi produced an average corm yield of 7.10 t ha^{-1} and cormel yield of 22.70 t ha^{-1}. Four of the eight accessions, IC003046, IC416980, IC410320 and IC310104 were scored as either resistant or moderately resistant to taro leaf blight. Acridity was also analyzed biochemically and it ranged between 0.13% (Sree Rashmi) to 0.33% (IC087153).

Elephant foot yam

To identify promising parental lines, artificial screening was done in 16 elephant foot yam accessions for collar rot resistance. However, none was found resistant.

In elephant foot yam breeding, 202 F_1 seeds obtained from the cross between Puttur local II x Puttur local I, were sown, of which, 168 seeds germinated. Morphological observations like number of emerging leaves, length of stem and general vigour were recorded three months after sowing. The tubers were harvested when the pseudostems dried at maturity at the ninth month. One hundred and twenty two plants produced corms with a weight ranging from 0.16 g-54.10 g. The healthy corms will be carried forward to the second year. Another cross was attempted between two local cultivars. A total of 520 F_1 seeds were obtained. The seeds were washed and dried and will be sown to get the F_1 progeny.

Artificial induction of flowering using different concentrations of GA_3 at different intervals showed that initial spraying with 500 ppm GA_3 produced inflorescences, but the inflorescences were abnormal.

Tannia

As part of clonal selection, an initial evaluation trial has been initiated for tannia with seven accessions.

Yam bean

Seeds of ten yam bean genotypes were planted in August 2014. Inter-varietal hybridization was undertaken among selected yam bean parental lines in a diallel fashion. About 2250 flowers were crossed to produce F_1 hybrid seeds and 1547 hybrids seeds were collected. Forty five single cross F_1 hybrids were made. Among 45 F_1 hybrids, maximum number of seeds were obtained from cross 4 x 8 (86) and minimum number of seeds were obtained from cross 5 x 7 (20).

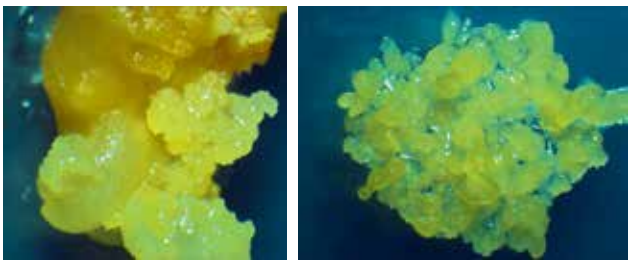
BIOTECHNOLOGICAL APPROACHES FOR IMPROVEMENT OF TROPICAL TUBER CROPS

Gene for pyramiding for cassava mosaic disease (CMD) resistance

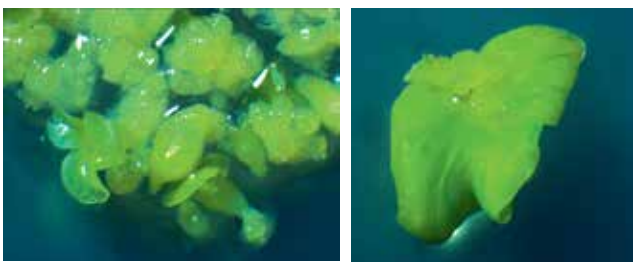
A crossing block was planted in the ICAR-CTCRI farm with five TMS lines viz., TMS-30001, TMS-30572, TMS-96/1089A, TMS-96/0304, TMS-96/0160 and three TME lines viz., TME-3, TME-4, CR-43-11. A total of 325 hybrid seeds from TMS-96/1089A x CR-43-11, TMS-30572 x CR-43-11 and reciprocal crosses were made and the seeds will be evaluated for the presence of both *cmd-1* and *cmd-2* genes in the progenies. To understand flowering behaviour of the TME-3 and TME-4 lines, these lines were planted along with other TMS lines in Tapioca and Castor Research Station (TCRS), Yethapur (TNAU) and different blocks (I, II and III) of ICAR-CTCRI farm. In all the blocks of ICAR-CTCRI and TCRS, Yethapur, TME-3 and TME-4 did not flower.

Development of mosaic resistant transgenic cassava

For the production of FEC from different cassava varieties viz., H-226, H-165, Sree Athulya and Sree Apoorva was initiated using different explants (unopened leaf lobes and embryogenic structures at different stages). Among these, H-165 showed good response to FEC production (Fig. 20).



FEC initiation in H-165 | 14th Day



21st Day | Emerging shoots separated in regeneration action media

Fig. 20. FEC production in H-165

Genetic modifications for quality improvement in cassava

The *gbssI* gene fragments amplified from the cDNA of cassava clone, H-226 using designed primers were digested with respective enzymes flanking each of the fragments. Standardized the blunt end ligation of the two *gbssI* gene fragments. The ligated fragment of approximately 1200 base pairs were eluted and cloned to pBluescript vector and the construct was transformed to *E. coli* DH5ὰ. Standardization of transformation of cassava TMS60444 Friable Embryogenic Callus (FEC) with *Agrobacterium* having *glgC* gene was done and the transformed cultures are in maturation media. Regeneration potential of cassava TMS60444 FEC was confirmed using the method of Bull et al. (2009) (Fig. 21).

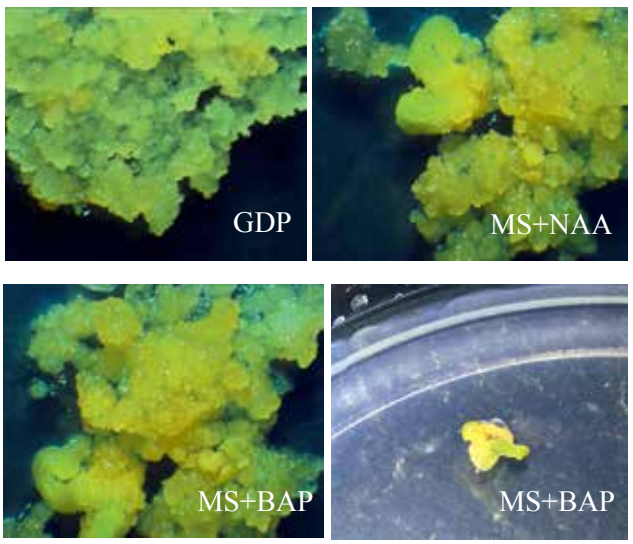


Fig. 21. Regeneration of FEC of TMS60444

DNA fingerprinting of cassava varieties

For quick identification, SSR fingerprinting was done for all the released cassava varieties along with Vellayani Hraswa (variety from KAU) using Genetic Analyzer (ABI-3500) (Table 1). Four fluorescent labelled cassava specific SSR primers were used for PCR amplification and fingerprinting viz., SSRY32-

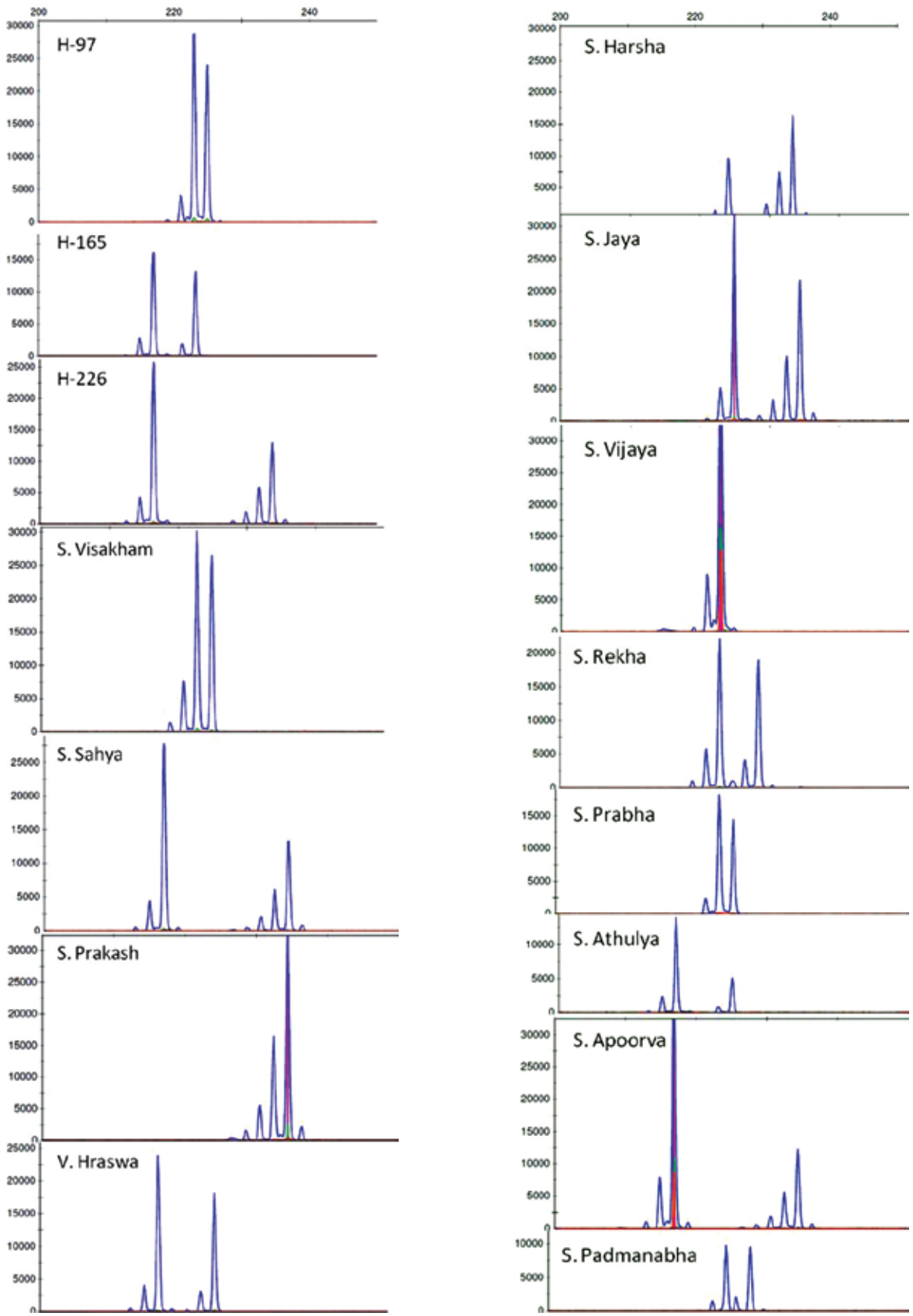


Fig. 22. SSRY40 primer fingerprinting pattern for 15 cassava varieties

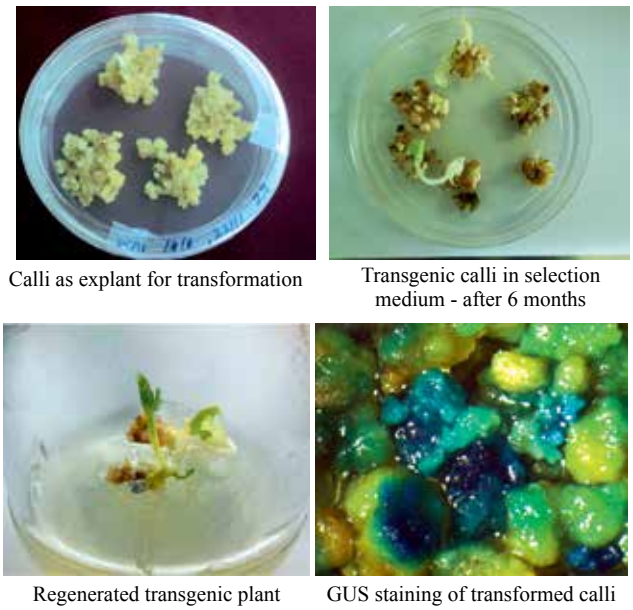
Table 1. DNA fingerprinting pattern of released varieties of cassava

No.	Variety/primers	SSRY-32	SSRY-40	SSRY-34	SSRY-39
1.	H-97	298/302	224	277/281	293
2.	H-165	298/302	216/224	275/281	293/298
3.	H-226	298/302	216/234	267/281	293/298
4.	Sree Visakham	295/298	224	281	293
5.	Sree Sahya	298/302	216/234	281	293/298
6.	Sree Prakash	295/298	234	281	293/304
7.	Sree Harsha	298/302	224/234	276/281	293/298
8.	Sree Jaya	298/302	224/234	275/281	293/298
9.	Sree Vijaya	284/302	222	275/281	293
10.	Sree Rekha	298	222/228	277/281	293
11.	Sree Prabha	298/302	224	277/281	293
12.	Sree Athulya	298	216/224	267/277	293/298
13.	Sree Apoorva	298	216/234	277/281	293/298
14.	Sree Padmanabha	298	224/228	277	293/298
15.	Vellayani Hraswa	284/302	216/224	277	293/304
	Alleles	Four	Five	Five	Three

FAM, SSRY34-VIC, SSRY39-PET, SSRY40-FAM. The amplified product was run in genetic analyzer along with LIZ600 size standard for fingerprinting. The primers SSRY34, SSRY40 (Fig. 22) produced five alleles followed by SSRY32-four and SSRY39-three alleles among the released cassava varieties.

RNAi mediated resistance against dasheen mosaic virus (DsMV) in elephant foot yam

Parameters were standardized for developing transgenic elephant foot yam, which included antibiotic concentration (Geneticin–20 mg l^{-1}; Hygromycin-5 mg l^{-1}; Ticarcillin–650 mg l^{-1}), acetosyringone (400 µM), number of days for co-cultivation (2-3 days) and co-cultivation temperature (28°C). Using GUS gene as marker, these parameters were validated and transgenic elephant foot yam having GUS gene was successfully developed (Fig. 23).



Calli as explant for transformation | Transgenic calli in selection medium - after 6 months

Regenerated transgenic plant | GUS staining of transformed calli

Fig. 23. Transgenic elephant foot yam having GUS gene

In view of developing resistance to DsMV in *A. paeoniifolius*, a hairpin construct of DsMV (DsMV-hp) was designed containing the most conserved region in the CP gene of DsMV in the forward and inverted orientation separated by an intron, thereby resulting in a hairpin (hp) construct. The resistance against DsMV upon the hp construct expression was assessed in a model host, *N. benthamiana*. The construct was found to provide complete resistance towards the DsMV upon challenge inoculation of

transgenic lines as evidenced from the symptom score and molecular analysis (Fig. 24).

Fig. 24. Symptoms observed on challenge inoculation with DsMV in control and transgenic *N. benthamiana*

Development and application of bioinformatics tools for tuber crops research

Bioinformatics approach is applied to identify potential cassava miRNA regulated genes in cassava mosaic virus genome. Potential regulatory targets, having five or fewer mismatches and with no gaps in full length nucleotide sequences were identified. Fourteen miRNA families, namely mes-miR159, mes-miR164, mes-miR167, mes-miR168, mes-miR171, mes-miR319, mes-miR394, mes-miR395, mes-miR397, mes-miR408, mes-miR477, mes-miR482, mes-miR1446 and mes-miR2275 were found to have the potential to target cassava mosaic virus genome with nearly perfect complementarities. Potential SNP markers were predicted in three classes of deletions, insertions and substitutions for cassava using the input sequences from Phytozome and EST sequences from NCBI. DNA polymorphism characterizations were carried out and Gene ontology classification of the identified SNPs were carried out.

CROP PRODUCTION

CROP AND WATER MANAGEMENT IN TROPICAL TUBER CROPS

Cropping systems involving short-duration cassava and legumes

Second season field experiment confirmed that rice-pulse-short-duration cassava is a viable sequential cropping system (Fig. 25). Both the short-duration varieties, Sree Vijaya (25.06 t ha^{-1}) and Vellayani Hraswa (21.77 t ha^{-1}) were suitable for crop intensification (Fig. 26). During the second year, green gram proved superior and had a significant impact on cassava tuber yield (26.22 t ha^{-1}). Energy equivalent (234.07 x 10^3 MJ ha^{-1}), tuber equivalent yield (47.39 t ha^{-1}), production efficiency (131.63 kg ha^{-1} day^{-1}) and system profitability (added profit of Rs. 95,758 ha^{-1} over sole cassava) worked out based on average yield data (of two years) of the component crops indicated that rice (var. Aiswarya)-black gram (var. Co-6)-short-duration cassava (var. Sree Vijaya) was productive, profitable and energy efficient. There was a possibility to save half FYM and N and full P to short-duration cassava (23-24 t ha^{-1}). The pH, organic C, available N, P and K remained unaffected, but K status was higher under cropping systems involving pulses.

Fig. 25. Third crop of short-duration cassava in rice-black gram-short-duration cassava sequence

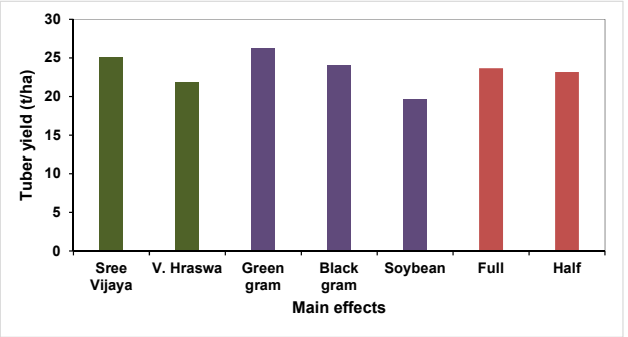


Fig. 26. Effect of cassava varieties, pulses and fertility levels on tuber yield of short-duration cassava in rice based system

Weed management in cassava

Field experiment to identify the best weed management practice in cassava (var. Sree Vijaya) conducted for the second season with eight treatments in randomized block design (RBD) under rainfed conditions indicated that tuber yield was maximum (28.26 t ha^{-1}) under ordinary black plastic (BP) mulching (32.06% higher compared to Package of Practices Recommendations, POP), which was on par with weed control ground cover (WCGC) (26.62 t ha^{-1}) and transparent plastic mulching (26.47 t ha^{-1}). Dry weight of weed biomass at final harvest was maximum (60.00 g m^2) in control plots, without weeding and interculturing. Averaging over the years, maximum tuber yield was obtained under ordinary black plastic mulching (25.57 t ha^{-1}), which was on par with WCGC (24.58 t ha^{-1}). Nevertheless, maximum net profit was obtained under the treatment, one weeding with interculturing (Rs. 1,85,390; average net profit of two years was Rs. 1,72,295). This was because of the low expenditure incurred compared to the cost of ordinary black plastic mulching or transparent plastic mulching. However, considering the constraints such as scarcity, timely availability and high cost of labour, the WCGC method that generated a net profit of Rs. 1,55,795 can be recommended for weed control in cassava.

Water management in elephant foot yam

Field experiment on elephant foot yam to assess the water requirement and scheduling of irrigation was conducted for the second season in split plot design.

Two methods of irrigation viz., drip irrigation and bed irrigation were included in the main plots (Figs. 27 and 28). Subplots comprised two levels of irrigation applied at different frequencies viz., irrigation at 75% CPE for 1-12 weeks after planting, irrigation at 75% CPE for 13-24 weeks, irrigation at 75% CPE for 1-24 weeks, irrigation at 100% CPE for 1-12 weeks, irrigation at 100% CPE for 13-24 weeks, irrigation at 100% CPE for 1-24 weeks, irrigation at 75% CPE for 1-12 weeks and 100% CPE for 13-24 weeks and irrigation at 100% CPE for 1-12 weeks and 75% CPE for 13-24 weeks. A rainfed crop was also included as control. Drip irrigation was given daily and bed irrigation was given at weekly intervals. Quantity of water was calculated based on the daily evaporation rate and the crop factor.

Fig. 27. Elephant foot yam under drip irrigation

Fig. 28. Elephant foot yam under bed irrigation

Under drip irrigation, the crop took 22 days for initiating sprouting, whereas it was 36 days under bed irrigation. Fifty percent sprouting was achieved within 36-46 days and 100% sprouting within 52-55 days under drip irrigation. The corresponding values for bed irrigation were 42-52 days and 68 days respectively. Wherever irrigation was not given during the initial periods, the crop took 68-90 days for 50% sprouting and 105-110 days for 100% sprouting. Morphological characters monitored at monthly intervals were more or less similar, once the canopy established. However, during grand growth stage of the crop after five months, maximum girth, canopy spread, number of leaves and leaf area were observed under drip irrigation at 100% level.

Soil samples were collected from two depths, 0-15 cm and 15-30 cm at monthly intervals and the moisture content was assessed over a period of six months from planting. Drip irrigation maintained 20-40% moisture content in the top soil compared to 20-30% soil moisture under bed irrigation and less than 20% moisture under no irrigation.

Drip irrigation resulted in corm yield on par with bed method. Among the levels of irrigation, irrigation at 100% CPE during the whole period of 1-24 weeks resulted in maximum yield (41.14 t ha^{-1}). However, it was on par with 100% CPE during 13-24 weeks (38.52 t ha^{-1}), irrigation at 75% CPE during 1-24 weeks, 75% CPE during 1-12 weeks and 100% CPE during 13-24 weeks and irrigation at 100% CPE for 1-12 weeks and 75% CPE for 13-24 weeks. Considering the interaction effects, drip irrigation at 100% CPE during 13-24 weeks resulted in maximum yield (46.56 t ha^{-1}) followed by bed irrigation during the entire period of 1-24 weeks (40.41 t ha^{-1}). The yield under drip irrigation at 100% CPE was also on par with drip irrigation at 75% CPE during 1-24 weeks and 75% CPE during 1-12 weeks and 100% CPE during 13-24 weeks and irrigation at 100% CPE for 1-12 weeks and 75% CPE for 13-24 weeks. Water requirement was found to be critical during 13-24 weeks, ie, tuber bulking phase compared to the initial sprouting phase. Drip irrigation enhanced the corm yield by 13% and water use efficiency by 38% over bed irrigation. Rainfed crop (as control) produced 24.70 t ha^{-1} during the season. Water requirement of

elephant foot yam was computed as 4.30 mm per day for attaining a targeted yield of 46.50 t ha^{-1}.

Precision approach for fertigation management in cassava

A new field experiment was initiated in cassava to arrive at the optimum dose of N and K fertilizers through fertigation and also to develop package of practices through precision approaches in cassava cultivation. The experiment was laid out in 3^2 factorial design with three levels each of N and K nutrients. The levels included were 75, 100 and 125 kg ha^{-1} each of N and K and full dose of P was applied as basal soil application. Standard NPK recommendation of 100:50:100 kg ha^{-1} was kept as control.

Planting materials of cassava variety Sree Vijaya prepared through minisett technique was planted during summer season and the fertigation treatments were imposed. During the first year of the study, different levels of K and interaction of N and K levels imparted significant effect on tuber yield, whereas N levels were at par. Increasing levels of K had a positive response. Among the interaction effects, 125 kg each of N and K per ha resulted in maximum tuber yield (53.25 t ha^{-1}). However, it was on par with 75 kg of N and 125 kg of K (51. 08 t ha^{-1}) and 100 kg each of N and K (51.91 t ha^{-1}). Under control, the crop yielded 11.40 t ha^{-1} during the summer season.

Management of fertigation in elephant foot yam

A field experiment was conducted at the Regional Centre of ICAR-CTCRI, Bhubaneswar, to study the effect of frequency, dose and duration of fertigation on the growth and yield of elephant foot yam. The experiment was laid out in split plot design with fertigation intervals (2, 3 and 4 days) in main plots. In sub plots, the recommended fertilizer (soluble fertilizer N-P_2O_5-K_2O 120-60-120 kg ha^{-1}) was split into 30 (N-P_2O_5-K_2O 4-2-4 kg ha^{-1}dose^{-1}), 40 (N-P_2O_5-K_2O 3-1.5-3 kg ha^{-1}dose^{-1}) and 50 (N-P_2O_5-K_2O 2.4-1.2-2.4 kg ha^{-1}dose^{-1}) doses and applied through drip irrigation. A check (IW/CPE: 1.0; P_2O_5 @ 60 kg ha^{-1} basal application; N-K_2O 120-120 kg ha^{-1} soil application at 1 (40%), 2 (30%) and 3 (30%) months after planting (MAP)) and a control (no fertilizer application) were also included separately for comparison. The treatments were replicated thrice. The treatments were imposed 10 days after planting. Farmyard manure @ 10 t ha^{-1} was incorporated at the time of last ploughing in all the treatments. The crop was drip irrigated at 80% CPE. The irrigation was withheld 10 days before harvesting. The crop was harvested at 8 MAP.

Maximum plant height and canopy spread at 3 and 5 MAP was observed under higher fertigation. Fertigation at 2-3 days interval with 30-40 split doses produced taller plants with greater plant spread at 3 MAP, whereas fertigation at 3 days interval with 50 split doses resulted in taller and wider plants at 5 MAP. Corm yield increased with increasing fertigation intervals from 2 to 3 days. The maximum corm yield was observed under fertigation at 3 days interval (32.30 t ha^{-1}). The recommended fertilizers applied in more number of splits produced higher corm yield. However, higher corm yield was noticed with 40 numbers of split of recommended fertilizer. The interaction effect between fertigation interval and number of splits of recommended fertilizer dose was significant. Maximum corm yield of 35.20 t ha^{-1} was observed with fertigation at 3 days interval and 50 numbers of split of recommended dose of fertilizer. Fertigation at 4 days interval with 50 numbers of split of recommended dose of fertilizer produced lesser corm yield (30.90 t ha^{-1}). The crop responded to fertigation up to 150 days. Plants were unable to utilize nutrients applied after 150 days. Maximum fertilizer use efficiency of 61.70 kg kg^{-1} was obtained with fertigation at 3 days interval and 50 numbers of split of the recommended dose of fertilizers, which was higher than that of the recommended dose of fertilizer in soil by 33.40 kg kg^{-1} (nutrient use efficiency of soil application was 28.30 kg kg^{-1}).

Hydro-physical properties on soil water-nutrient use, root characteristics and cassava productivity

A new experiment was initiated at ICAR-CTCRI, Thiruvananthapuram (latitude 8°32'46.5''N; longitude 76°54'50.1''E; 73 m above msl), to study the

spatial and temporal variations of soil properties as influenced by tillage and mulching practices with respect to hydro-physical, nutrient use and rooting characteristics of cassava (Fig. 29). Initial soils (texture- sandy clay loam) was highly acidic (pH 4.20) with organic C content of 0.82%, low in available N (165.50 kg ha^{-1}), high in available P (50.90 kg ha^{-1}) and low in available K (109.60 kg ha^{-1}). Field experiment in cassava (var. Sree Vijaya) with three tillage (conventional (T_1), deep (T_2) and minimum (T_3)) and three mulch types (porous weed control ground cover (WCGC) (M_1), live crop (M_2) and no mulch (M_3)) was laid out in split plot design. The crop was planted on 22 December 2014. Soil hydraulic properties were studied using Guelph permeameter. It is a constant-head device, which operates on the Mariotte siphon principle and provides a simple method for simultaneously determining the field saturated hydraulic conductivity, matric flux potential and soil sorptivity in the field.

Initial soils had a field saturated hydraulic conductivity of 0.043-0.067 cm min^{-1}, matric potential of 0.0060-0.0094 cm^2 min^{-1} and a sorptivity of 0.046-0.056 cm $min^{-1/2}$ when estimated at an initial soil moisture content of 3.60-5.00 %, v/v at different sites. Among the treatments, saturated hydraulic conductivity and sorptivity of soils under conventional tillage was 26% and 41% higher than minimum tillage. Significant variation in surface soil moisture content was observed between ground cover sheet (12.40%, v/v) and no mulch plots (6.10%), whereas among different tillage treatments, it was non-significant, when readings were taken one day after a rainfall event with an intensity of 4.70 mm. Biometric characters, including root parameters, were studied at 2 MAP. The number of absorbing roots ranged from 13 (T_3M_2) to 24 (T_2M_2). Like-wise, number of tuberous roots ranged from 0 under T_3M_2 to 4 in T_1M_2. In general, growth parameters viz., plant height, number of green leaves and leaf area index were better in WCGC applied plots under conventional tillage (Fig. 30).

Fig. 29. Field view of the experiment

Fig. 30. Performance of cassava under WCGC and crop mulch in conventional tillage

SOIL HEALTH AND PLANT NUTRITION IN TROPICAL TUBER CROPS

Fertilizer best management practices by SSNM

Three field experiments on site specific nutrient management (SSNM) of sweet potato (crops 1 and 2), elephant foot yam (EFY) (crop 4) and cassava (crop 7) were conducted in the farm of ICAR-CTCRI with six treatments (N-omission, P-omission, K-omission, NPK-omission, present recommendation (PR) and SSNM) and four replications in a randomized block design (RBD). The QUEFTS model was calibrated for SSNM of sweet potato based on published literature and was validated in the field trials. The results of the field experiment on elephant foot yam showed very good agreement between the predicted and measured yields, which indicated that the calibrated QUEFTS model can be used to improve NPK fertilizer recommendations for elephant foot yam in India. The yield in SSNM plot was 33.50 t ha^{-1}, whereas in PR plot it was 27.00 t ha^{-1}. A significant increase

in different nutrient use efficiency parameters was observed in SSNM plot compared to PR plot.

The field experiment on SSNM of cassava over the past seven seasons showed the superiority of the SSNM treatment over present recommendation (Fig. 31). The yield in SSNM treatment (37.60 t ha^{-1}) was significantly higher compared to present recommendation (32.30 t ha^{-1}). The long term sustainability of SSNM on soil quality was assessed by studying the profile distribution of 20 different parameters at 0-10, 10-20, 20-30, 30-40, 40-50 and 50-60 cm depths. The results of the study showed significant improvement in soil quality in SSNM plot compared to PR plot.

Fig. 31. Field experiment on SSNM of cassava

The QUEFTS model was used to develop region specific NPK recommendations and based on potential yield, indigenous nutrient supply, nutrient recovery fraction, benchmark soil series and/or agro-ecological units/zones, SSNM zonation maps were developed using geoinformatics tools for different yield targets of cassava, elephant foot yam and sweet potato in major growing environments of India. Figs. 32 and 33 show some of the SSNM zonation maps developed. Secondary and micronutrient fortified customized fertilizers were developed for cassava, elephant foot yam and sweet potato for all the major growing environments of India for different yield targets based on the above SSNM zonation maps as well as the principles of fertilizer best management practices (FBMP). Fig. 34 shows, as an example, the six different nutrient management zones and the customised fertilizers developed for those zones for cassava in Kerala for an yield target of 30.00 t ha^{-1}. On-farm validation experiments to validate the customised fertilizers developed for elephant foot yam were laid out in five farmers' fields in Chenkal Panchayat, Thiruvananthapuram district, Kerala.

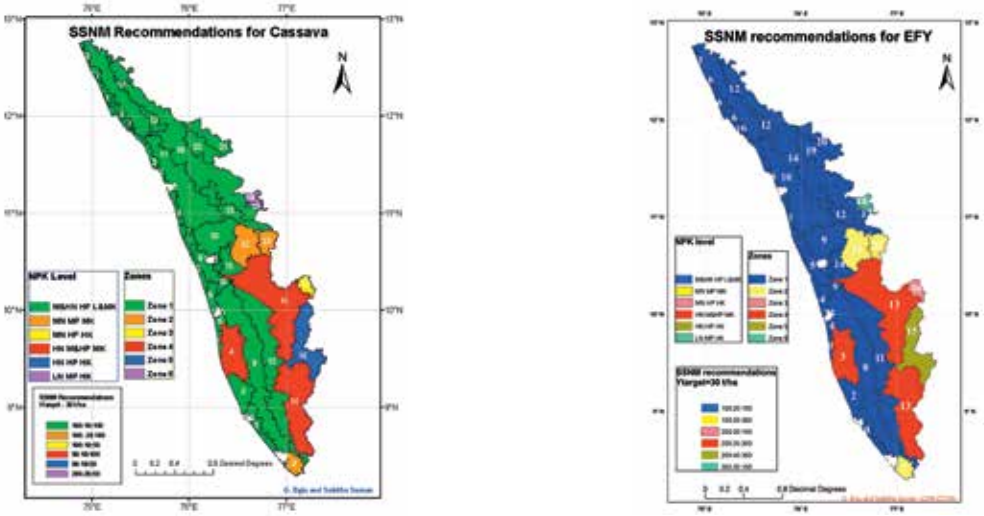


Fig. 32. The SSNM zonation maps for cassava and elephant foot yam in Kerala state for Y_{target} = 30 t ha^{-1}

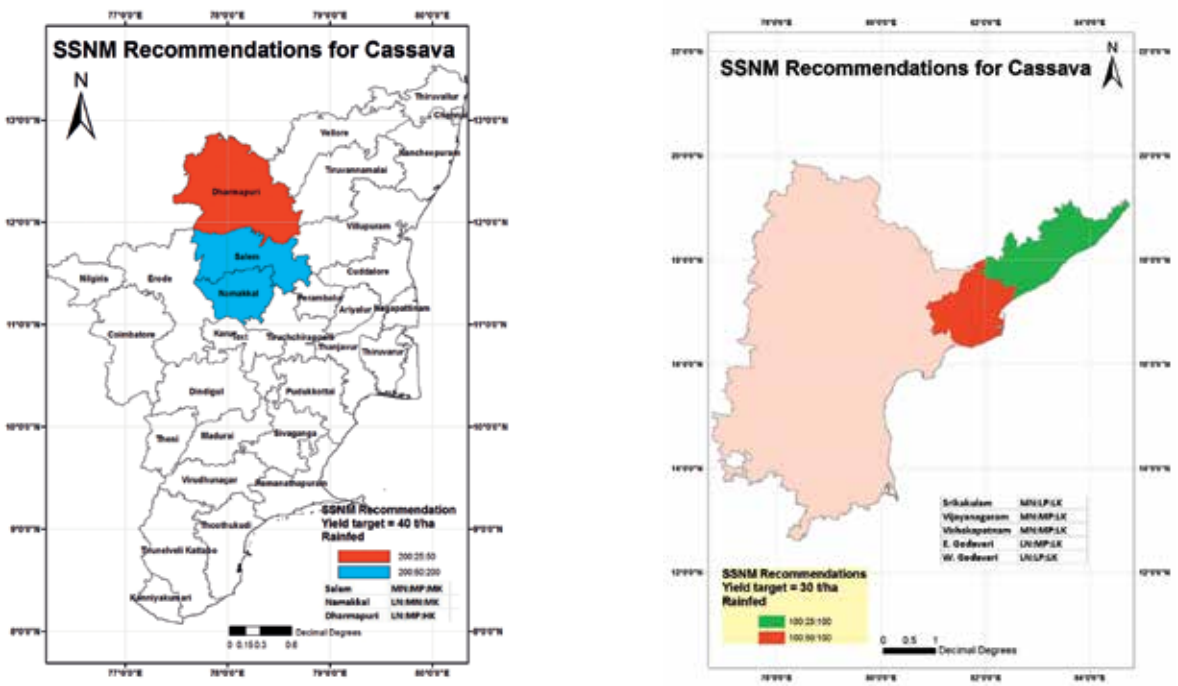


Fig. 33. The SSNM zonation maps for cassava in Tamil Nadu and Andhra Pradesh for Y_{target} of 40 and 30 t ha^{-1} respectively

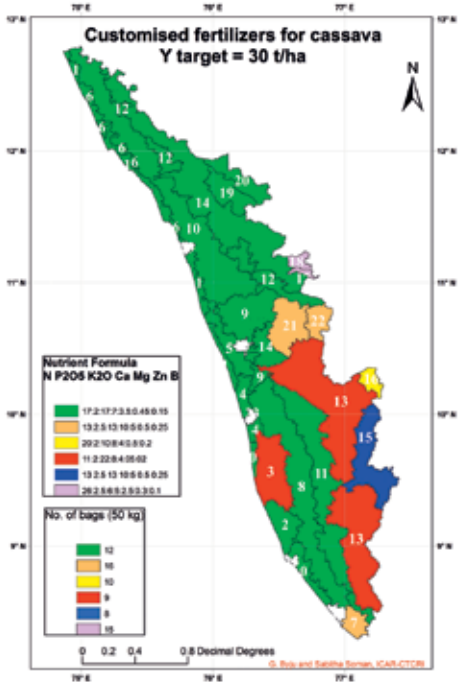


Fig. 34. Customised fertilizers developed for six different zones of cassava in Kerala for Y_{target} = 30 t ha^{-1}

Climate suitability studies

The current and future climate suitability of elephant foot yam and sweet potato in India was studied using geoinformatics tools. The results of the study showed that elephant foot yam is positively impacted in many areas of Andhra Pradesh, Bihar, Karnataka, West Bengal and Jharkhand with -1.30 to +9.20 % changes in climate suitability (average % change in all pixels).

The predicted increase in temperature by 2030 is between 0.91 and 1.16°C. The predicted changes in rainfall by 2030 ranges between +15.60 to +46.40 mm. (Fig. 35).

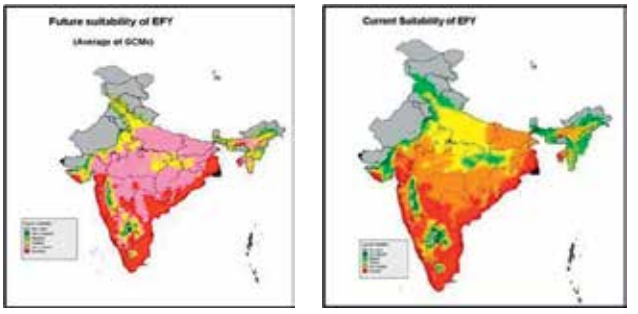


Fig. 35. Current and future (2030, average of 22 GCMs) suitability of elephant foot yam using the calibrated ECOCROP model

Acreage estimation using remote sensing

Kernel based possibilistic c-means (PCM) classification approach has been used to develop algorithm for acreage estimation of cassava in Salem district. The study, being done in collaboration with Indian Institute of Remote Sensing (IIRS),

Dehradun, uses temporal Landsat – 8 OLI images for the period from December 2013 to January 2015. Atmospherically corrected temporal images were developed (using ATCOR) that greatly reduces the influence of atmosphere and solar illumination. The NDVI Images were also generated to reduce the spectral dimensionality of the data. Other advantages of using vegetation indices include enhancement of vegetation signal, while normalizing the sun angle, minimizing solar irradiance, shadow and soil background effect. The temporal vegetation indices are being used to identify and discriminate cassava from rest of the crops/vegetation type present on ground.

Long term fertilizer-cum-manurial experiment in cassava

The influence of continuous application of manures and fertilizers on the sustainability of cassava production and soil productivity of the 10th season crop was investigated in detail. Application of NPK @ 125:50:125 kg ha^{-1} produced the highest tuber yield (30.84 t ha^{-1}) and was on par with NPK @ 100:50:100 kg ha^{-1} (25.17 t ha^{-1}) and 50:50:100 kg ha^{-1} (25.13 t ha^{-1}). Soil test based application of NPK @78:0:48 kg ha^{-1} resulted in a yield of 22.57 t ha^{-1} on par with NPK @ 100:50:100 kg ha^{-1} (25.17 t ha^{-1}) and 50:50:100 kg ha^{-1} (25.13 t ha^{-1}). Continuous cassava cultivation for the 10th season (without any manures and fertilizers) resulted in an yield of 17.93 t ha^{-1}. Different organic manures tried as a substitute to FYM viz., green manuring *in situ* with cowpea (27.29 t ha^{-1}), vermicompost (29.31 t ha^{-1}) and coir pith compost (28.31 t ha^{-1}) produced yield on par with FYM (25.17 t ha^{-1}). Application of secondary and micronutrients viz., Mg, Zn and B as single nutrient, two nutrients and three nutrient combinations did not produce any significant effect on tuber yield over POP. However, comparatively higher yield was obtained with soil test based application of Mg as $MgSO_4$ @10 kg ha^{-1} (28. 64 t ha^{-1})

Soil samples were collected during 2014, before planting the 10th season crop, from six selected treatments that received continuous organic manure applications as well as from absolute control plots and analyzed for basic physical parameters. Surface soil moisture and temperature observations were taken in the field, twelve times during the period, August-November 2014, following rainfall events with varying intensities. Soil water depletion over a period during August was calculated for the above treatments. The soil is of sandy clay loam in texture (sand-66%; silt-6% and clay-28% w/w) and no significant differences in sand, silt and clay content were observed among the six treatments. The bulk density was highest (1.61 Mg m^{-3}) in absolute control, whereas lowest values were observed in NPK + vermi compost and NPK + coir pith compost treated soils (1.43-1.45 Mg m^{-3}). Similarly, high porosity values were observed with NPK + VC, NPK + FYM and combination of organic manures viz., vermicompost, coir pith compost, ash and crop residue treatments (44.20-45.60 %). The mean volumetric soil moisture content varied from 4.30 to 11.80%, whereas the soil temperature ranged from 29.00 to 33.10^{o}C. Soil moisture depletion calculated during August over four days indicated that, coir pith compost treatment had low per cent of soil moisture depletion (36%) as against 49% in absolute control. Soil hydraulic measurements viz., saturated hydraulic conductivity, matric potential and sorptivity were carried out in the field for the six treatments using Guelph permeameter. The lowest saturated hydraulic conductivity value of 1.57 cm h^{-1} was in absolute control, whereas highest value of 3.93 cm h^{-1} was observed under integrated application of all the four organic manures. This treatment also had the maximum matric potential and sorptivity values of 0.545 cm^2 h^{-1} and 0.1150 cm min$^{-1/2}$ when compared to the corresponding values of 0.217 cm^2 h^{-1} and 0.0202 cm min$^{-1/2}$ respectively in the absolute control. Results indicated that saturated hydraulic conductivity, matric potential and sorptivity calculated at 5 and 10 cm section head have shown that, under integrated applications of organic manures it was higher as compared to absolute control. Relationship among soil variables has shown that, bulk density was significantly and negatively correlated with maximum water holding capacity (r= -0.583*).

Levels of fertilizers significantly increased the status of soil P, Zn and Fe. High P build up (80 kg ha^{-1}) was noticed with P @ 50 kg ha^{-1} and omission of P in the soil test based fertilizer recommendation (STBF) treatment resulted in substantial reduction of soil P status (50 kg ha^{-1}). The various organic manures tested significantly influenced the pH and the status of soil P and Fe. Application of ash resulted in a significantly higher pH of 6.95 over the other treatments. Soil P, Fe and Zn status were significantly affected by treatments having either secondary or micronutrients alone, in two nutrients or three nutrients combinations. Presence of Zn in the treatment significantly increased its status in the soil (3.69-4.15 ppm). Levels of fertilizers significantly influenced the tuber P and stem Zn contents. STBF without P resulted in tuber P content of 0.134% on par with the application of P @ 50 kg ha^{-1} (0.127-0.144%). Organic manures also significantly affected the tuber P and stem Zn contents. Application of organic manures alone (0.137%) resulted in tuber P content on par with FYM treatment (0.127%). Green manuring *in situ* with cowpea resulted in significantly highest stem Zn content (0.00543%). However, nutrient uptake by plants remained unaffected by the treatments.

Levels of fertilizers significantly influenced the population of bacteria, fungi and actinomycetes at 3 MAP with significantly higher population of bacteria and fungi under NPK @ 125:50:125 kg ha^{-1} and actinomycetes under soil test based fertilizer and manure application. The population of fungi at 3 MAP was significantly affected by different sources of organic manures, with coir pith compost indicating the maximum. Secondary and micronutrients did not have any significant effect on soil bacterial, fungal and actinomycetes population, except the population of actinomycetes at 3 MAP, where combined application of B and Zn resulted in the highest count.

The cyanogenic glucoside content of cassava tubers were significantly influenced by levels of fertilizers, different organic manures and different combinations of secondary and micronutrients. STBF and absolute control showed the least HCN content of 29.25 and 10.19 ppm respectively, whereas application of NPK @ 125:50:125 kg ha^{-1} had the maximum tuber HCN content (76.83 ppm). Green manuring *in situ* with cowpea resulted in a significantly higher cyanogenic glucoside content (53.04 ppm). Application of Zn along with Mg caused the significantly highest tuber HCN content of 112.83 ppm. The starch content of cassava tubers were not significantly influenced by the different treatments.

Testing the N efficiency potential of K efficient genotypes

The field experiment to test the N efficiency potential of K efficient genotypes was done for the second season. Tuber yield was significantly influenced by the independent effect of genotypes and N levels. The genotype, CR-43-8 produced the highest yield (41.24 t ha^{-1}) on par with 7 III E3-5 (36.13 t ha^{-1}) and W-19 (38.59 t ha^{-1}). Tuber yield without N (32.43 t ha^{-1}) and N @ 50 kg ha^{-1} (33.60 t ha^{-1}) were significantly lower than N @ 100 kg ha^{-1} (37.26 t ha^{-1}) and 150 kg ha^{-1} (39.19 t ha^{-1}), which in turn were on par. HCN content of cassava tubers significantly varied with the genotypes; Aniyoor had minimum (35.00 ppm) and 6-6 the maximum (255.10 ppm) HCN contents. The genotype, 7 III E3-5 had the significantly highest nutrient use efficiency parameters viz., agro-physiological efficiency (72), nutrient uptake ratio (0.73), physiological efficiency (106.40) and harvest index (0.73). Nutrient use efficiency parameters viz., agronomic efficiency (629), apparent recovery efficiency (0.46), utilization efficiency (4.28), agro physiological efficiency (58.90), nutrient efficiency ratio (172.80), nutrient utilization for tuber (0.75) and biomass (1.09) were significantly influenced by N levels and these were maximum at N @ 50 kg ha^{-1}. Among the physiological parameters, crop growth rate (CGR) and tuber bulking rate (TBR) were significantly influenced by the genotypes. N levels significantly affected the CGR also. CR 43-8 had significantly the maximum CGR (27.93 g m^{-2} day^{-1}) on par with W-19 (24.05 g m^{-2} day^{-1}). TBR was maximum for W-19 (4.26 g day^{-1}) and was on par for all NUE genotypes. CGR was maximum at N @ 100 kg ha^{-1}, which in turn was on par at N @ 50 and 150 kg ha^{-1}. Leaf (4.07%), stem (1.21%) and tuber (0.64%) N were significantly highest for Aniyoor. Stem (1.14%)

and tuber (0.84%) N were significantly influenced by N levels with maximum values at N @ 100 kg ha^{-1}, which was on par with N @ 150 kg ha^{-1}.

Field demonstration trials of K efficient genotypes

Field demonstration trials conducted with seven selected K efficient genotypes in three locations (Krishi Vigyan Kendra (KVK), CARD, Pathanamthitta, KVK, Mitranikethan, Thiruvananthapuram, KVK, Sadanandapuram, Kollam, Farmers' fields at Anchal, Kalayapuram, Sadanandapuram and Chullimanoor) each during the two seasons (2013-2014, 2014-2015) indicated that Aniyoor (Fig. 36) and 7III E3-5 were the best yielders (4-11 kg $plant^{-1}$) even without K and with K @ 50 kg ha^{-1} having good cooking quality.

Fig. 36. A view of harvest of genotype Aniyoor at Kottarakkara

Low input management strategy with selected nutrient use efficient genotypes

Field experiments conducted for two seasons with three NPK efficient genotypes under four nutrient management practices indicated that the genotypes viz., Acc. No. 905 (G_2) and 906 (G_3) as promising ones over Acc. No. 766 (G_1) and H-1687 (G_4) under low input management in terms of tuber yield (33.68 and 34.72 t ha^{-1} respectively) and B: C ratio (4.43 and 4.57 respectively) (Fig. 37). The low input management strategy (green manuring *in situ* with cowpea as a source of organic manure along with soil test based application of N, P, K, $MgSO_4$ and $ZnSO_4$ @ 106:0:88.5:7.5:2.5 kg ha^{-1} and a mixture of biofertilizers (containing N fixer, P and K solubilizers @ 10 g $plant^{-1}$ each) could save P, K, Mg and Zn by 100.00, 11.50, 62.50 and 80.00% respectively. The percentage decrease in the cost of inputs under the low input practice over the POP recommendation was up to 55%.

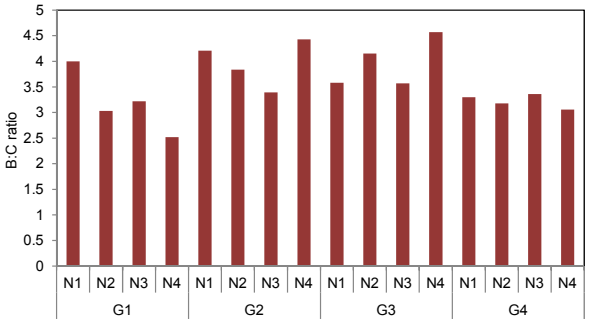


Fig. 37. B:C ratio under different nutrient management practices with different nutrient use efficient genotypes

Integrated soil and water conservation strategies for rainfed hill cassava production systems

Cassava cultivation in major hills of Eastern Ghats of Tamil Nadu, which falls under complex risk prone and diverse zone, increasingly face the risks of soil erosion and degradation, water and environmental security due to changes in land use, rainfed cultivation with faulty agricultural practices, decline in soil organic matter and productivity of crops as well as live stock. Hence the effect of suitable strategies using porous ground cover sheets for enhancing soil water storage and nutrient use efficiency was evaluated on soil quality and productivity of rainfed cassava in Pachamalai Hills.

First season crop of cassava was harvested at Vengamudi village, Pachamalai hills, Eastern Ghats of Tamil Nadu (latitude 11°19.476'N; longitude 78°34.363'E; 806 m above msl) on 2 September 2014. Field experiment was laid out at a different location in same village in a sloping hill bottom field to study the

interaction of soil moisture and nutrients, P and K in rainfed cassava with seven treatments (Fig. 38). The treatments consisted of black porous ground cover (GC), intercropping cassava with black gram (IC) and control (C) treatments each under farmer's (FP) and scientific (SP) practices along with an absolute control (AC) in factorial design. Initial soil samples were low in available N, (123.00 kg ha^{-1}), medium in available P (16.20 kg ha^{-1}) and high in available K (436.40 kg ha^{-1}). The quantity of nutrients applied in FP and SP was 204-204-161 and 108-20-98 N-P-K kg ha^{-1}. Cassava was planted on 04 September 2014. Volumetric surface soil moisture and soil temperature were measured in the above treatments (using theta probe and soil temperature probe) after four varying rainfall events/stages on 2 and 11 December 2014, 8 January and 12 February 2015. The grand mean soil moisture content during the above periods was estimated to be 12.40, 16.70, 14.60 and 7.70% v/v respectively. Estimations of available P and K were made at air dry and field moisture conditions for treatments at two stages of crop viz., 2 December and 8 January 2015. Biometric observations were taken up for selected treatments in the fourth month old cassava plants. Tuber yield of first year experiment varied from 7.51 t ha^{-1} in AC to 14.99 t ha^{-1} in SP treatments. GC treatment resulted in an yield of 13.87 t ha^{-1} as against no sheet (control) with a yield of 12.11 t ha^{-1} and the difference in yield was found to be significant. Starch content varied from 18.30% in AC to 23.90% in SP treatments with tubers under GC treatments having maximum content (24.00%). The N, P and K use efficiency was calculated from the tuber yield and quantity of nutrients applied. The NPK use efficiency was significantly higher in SP (28, 42, 23%) as compared to FP (23, 23, 10%), GC (31, 13 and 20%) and no sheet (23, 12 and 17%) treatments. The soil moisture under AC varied from 6.90 to 16.70%

Fig. 38. The layout and location of field experiment at Pachamalai Hills (top) and tubers obtained from AC (bottom left) and GC treatments (bottom right) due to better soil moisture conservation and nutrient use

(v/v) during the study period, whereas ground cover (GC) was beneficial over control with a soil moisture content of 8.60% when the estimations were taken after a rain-free period of 38 days on 12 February 2015. The soil moisture under GC was found to be high and significant (8-45%) over control during the first three stages of observation. No significant soil moisture differences were observed among intercrop and control treatments, whereas SP had the highest and significant soil moisture over FP to the extent of 13.70-14.30% during 02 December 2014 and 08 January 2015. The soil temperature varied from 23.80 to 31.00°C in the different treatments and it was significantly lowest in GC treatments over control only on 2 December 2014. Soil available P and K contents estimated at air dry (AD) and field moisture (FM) levels showed that at a mean field soil moisture content of 16.70%,v/v at 54 DAP, the available P at AD was 38% higher than FM, whereas at a mean soil moisture content of 14.60% at 91 DAP, it was only 16%, showing that the availability of soil available P at low moisture content was less than that at high soil moisture. However, the differences in available K content at high soil moisture levels was minimum (27 mg kg^{-1}) as against low soil moisture levels (51 mg kg^{-1}). There was better plant growth with a total biomass of 169.50 g $plant^{-1}$(on dry weight basis) under SP-GC treatment as against 78.20 g $plant^{-1}$ for AC.

Organic farming of yams and aroids

The secondary and micronutrient status estimated after three years of cropping in dwarf white yam indicated that organic management enhanced the exchangeable Ca by 16%, available Fe and Cu status of the soil by 8% over conventional practice, though there was no significant difference among production systems. Exchangeable Ca was significantly higher under organic management in taro after five years of continuous cropping. There was improvement in the status of exchangeable Mg, Fe, Zn and Cu status by 26, 17, 22 and 14% respectively under organic management over conventional practice in taro (Fig. 39). On farm trials (OFT) were laid out in seven sites with three practices, conventional, traditional and organic, in Thiruvananthapuram and Kollam districts to validate the on station developed organic farming technologies in yams (greater yam, lesser yam and dwarf white yam) and taro (Fig. 40). In all the sites, tuber yield under organic management was on par with conventional practice in these crops (Figs. 41 and 42). However, the yields under organic management were 8, 17, 21 and 29% higher over chemical based farming in greater yam, lesser yam, dwarf white yam and taro respectively. In general, there was significant improvement in pH, organic C and available K status under organic management in the sites. Soil microbial population was also improved under organic practice in these sites.

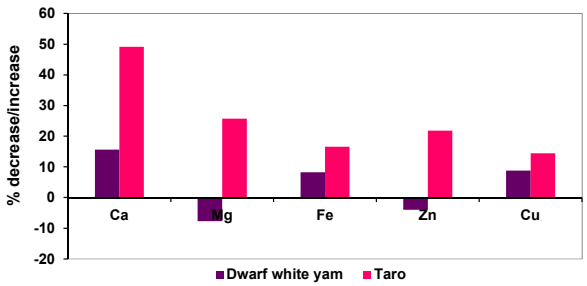


Fig. 39. Per cent increase or decrease in secondary and micro nutrient status of soil under organic management in dwarf white yam and taro

Fig. 40. Glimpses of OFTs to validate organic farming technologies for yams and taro

Fig. 40 (Contd). Glimpses of OFTs to validate organic farming technologies for yams and taro

Greater Yam

Lesser yam

Dwarf white yam

Fig. 41. View of tuber yield in the various practices (From left to right: Organic, Traditional, Conventional) at OFT sites

Fig. 41 (Contd). View of tuber yield in the various practices

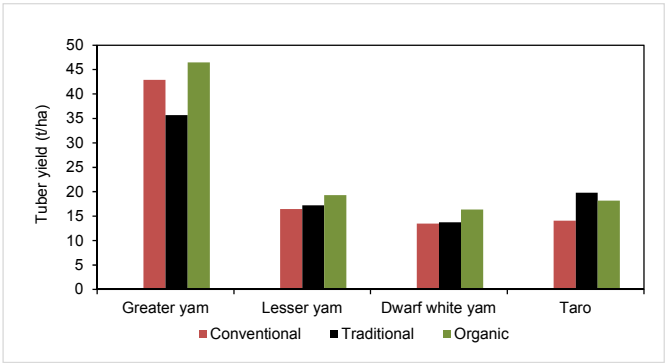


Fig. 42. Tuber yield under various practices in OFT in yams and taro

INM in yam bean

A field experiment was conducted for the second consecutive *kharif* season during 2014-2015 at Regional Centre of ICAR-CTCRI, Bhubaneswar, to study the effect of integrated use of lime, mycorrhiza, inorganic and organic manures on soil quality, yield and biochemical constituents of yam bean (Fig. 43). The soil of the experimental site is sandy loam in texture. It was acidic (pH 4.67), non saline (0.24 dS m^{-1}), with 0.26% organic C, and 22.60, 24.64, and 189.00 kg of N, P_2O_5, and K_2O ha^{-1}. The experiment was laid out with 16 treatments replicated thrice in a randomized block design. Yam bean (cv. RM-1) seeds were dibbled at a spacing of 50 x 30 cm. All the cultural practices were followed as per schedule and the crop was harvested at 5 months after sowing, yield parameters were recorded and plant samples were analyzed for proximate composition and nutrient contents. Significantly highest tuber yield (23.36 t ha^{-1}) was obtained due to integrated application of lime + FYM + NPK + $ZnSO_4$ with highest yield response of 136% over that of control, followed by 150% NPK (22.19 t ha^{-1}). The increase in tuber yields was 40, 72 and 124% due to application of 50, 100 and 150% NPK over control.

Fig. 43. Field view of the experiment on INM in yam bean

Among the organic sources, incorporation of FYM resulted in higher tuber yield (16.01 t ha^{-1}) on par with *in situ* incorporation of green manure (15.87 t ha^{-1}). Integrated use of FYM + NPK + VAM produced a tuber yield of 18.40 t ha^{-1}, whereas lime addition further enhanced the tuber yields by 8% over that of FYM + NPK + VAM (19.90 t ha^{-1}). The harvest index was highest (0.73) due to incorporation of vermicompost followed by FYM (0.71) and green manure (0.70). Highest starch content (10.91%) was obtained due to application of 150% NPK. However, the total sugars varied from 3.20-3.97% with the highest being due to integrated use of lime + FYM + NPK + B.

The soil pH improved due to integrated application of lime, inorganic fertilizers and organic manures. Addition of lime in combination with NPK enhanced the soil pH by 0.60 unit over the initial level. Highest increase of organic C was observed due to

the combined use of lime + FYM + NPK + $MgSO_4$ (0.64%) from the initial levels followed by lime + FYM + NPK + $ZnSO_4$ (0.58%). Total N content in the soils increased in all the treatments. Significantly highest available N (284.00 kg ha^{-1}) and P_2O_5 (103.30 kg ha^{-1}) was observed due to application of super optimal doses of NPK, however highest available K (296.20 kg ha^{-1}) was noticed due to integrated use of VAM along with lime + FYM + NPK. Significantly highest exchangeable Ca and Mg (2.96 and 1.82 cmol (p^+) kg^{-1} soil, respectively) was obtained due to combined application of lime, $MgSO_4$, optimum doses of NPK and FYM. In conclusion, integrated use of balanced dose of fertilizers along with organic manures, lime and $ZnSO_4$ not only improves the soil quality, but also enhances the yields of yam bean with good quality tubers.

ABIOTIC STRESS MANAGEMENT IN TROPICAL TUBER CROPS

Salt tolerance in sweet potato

Field experiments were laid out for the second consecutive rabi season during 2014-2015 in a participatory mode in the natural saline soils in the farmers' fields of Shri. Biswanath Majumdar from Lalpahar village (Location-1 (L-1)) and Shri. D. Madhu of Chouldari village (Location-2 (L-2)), Chouldari Gram Panchayat of South Andaman district, Andaman & Nicobar Islands in collaboration with Central Island Agricultural Research Institute, Port Blair, Andaman (Fig. 44). The trials were laid out with four white-fleshed genotypes (Samrat, Kishan, Sree Bhadra and Pusa Safed) and two orange-fleshed genotypes (ST-14 and CIP-440127) of sweet potato in RBD. Among the sweet potato genotypes, Samrat was superior with a tuber yield of 18.32 and 12.05 t ha^{-1} during the two years followed by CIP-440127 (16.23 and 10.66 t ha^{-1}) at L-1, while it was highest with Samrat (19.04 and 13.20 t ha^{-1}) at L-2 followed by CIP-440127 (16.46 and 12.41 t ha^{-1}). Among the genotypes, Kishan contained the highest biochemical constituents in both the seasons. Total uptake of N, P and K was the highest in Samrat at L-2, whereas uptake of N and P was highest in Samrat and highest K uptake was observed in CIP-440127 at L-1. In conclusion, Samrat and CIP-440127 were suitable genotypes of sweet potato for cultivation in natural saline soils under island ecosystem of Andaman.

Fig. 44. Field view of sweet potato genotypes in natural saline soils

Micro nutrients and heavy metal contamination in tuber crops based cropping systems adjacent to mines and industrial areas of Odisha

Soil and plant samples were collected during 2014 adjacent to chromium mining areas of Sukinda block in Jajpur district, iron mining areas of Joda and Banspal blocks of Keonjhar district and thermal power plants and aluminium factories of Talcher block of Angul district of Odisha (Fig. 45). The soils of Jajpur district contained the highest available Fe (114.70 mg kg^{-1}) and Mn (43.48-129.16 mg kg^{-1}, mean of 94.10 mg kg^{-1}). The available Zn and Cu in the polluted soils of the study ranged from 0.73 - 1.51 and 0.21 - 1.51 mg kg^{-1}, respectively. The mean available Zn and Cu was the highest (4.96 and 0.71 mg kg^{-1}, respectively) in the iron mining areas of Keonjhar district.

Fig. 45. Heavy metal contaminated areas adjacent to mines and industrial areas of Odisha

The DTPA extractable Cr in the polluted soils ranged from 1.85 to 178.25 mg kg^{-1}. Highest Cr values were observed in the Cr mining areas of Jajpur district (135.23 - 178.25 mg kg^{-1}, with a mean of 152.75 mg kg^{-1}). However, the arable soil had optimum levels of micro nutrients. Dehydrogenase activity (1.97 µg TPF $h^{-1}g^{-1}$) and fluorescein diacetate activity (2.15 µg $g^{-1}h^{-1}$) were observed in the soils of Keonjhar district. Acid phosphatase activity was the highest in the iron mining areas of Banspal block of Keonjhar (67.70 µg PNP g^{-1} h^{-1}) followed by Sukinda block (67.09 µg PNP g^{-1} h^{-1}). Acid phosphatase activities were relatively higher than alkaline phosphatase activities. The soil microflora had non-significant relationship with all the micronutrients, except Zn, which had significant relationship with actinomycetes.

The soils from bauxite mining areas of Koraput, industrial areas of Rayagada and Jagatsinghpur districts were collected during 2015 and analyzed for physico-chemical properties. The soils were strongly acidic to alkaline in reaction (pH 4.47-8.81), slightly saline (EC 0.12-1.68 dS m^{-1}) and had 0.15–1.59% organic C, 110-280 kg ha^{-1} of available N, 5.69 - 148.90 kg ha^{-1} of available P and 80-635 kg ha^{-1} of available K.

PRODUCTION OF DISEASE FREE PLANTING MATERIALS IN TROPICAL TUBER CROPS

The project aims at production of virus free planting materials through procedures involving indexing, micropropagation, hardening and minisett multiplication under protected environment, large scale multiplication of disease free planting materials in selected areas of Kerala, Tamil Nadu, Odisha and the North East India in farmer's participatory mode together with farmer's training programmes for mass multiplication and popularization of disease free planting materials. During the period a total number of 108 micro plants of different cassava varieties were indexed for cassava mosaic virus. Accordingly 45 numbers of H-226, 23 numbers of H-165, 11 numbers of Sree Prakash, 14 numbers of Sree Vijaya and 15 numbers of Sree Jaya were indexed. Total micro plants of cassava produced during the year was 1823, 1421, 582, 613 and 682 in H-226, H-165, Sree Prakash, Sree Vijaya and Sree Jaya respectively. Those micro plants were hardened and further multiplied initially in the net house and later in the field (Fig. 46). Further, a total number of 72 micro plants of elephant foot yam (var. Gajendra) were indexed. Apparently virus free planting materials were identified and selected from the standing crop and those selected stems were planted in Block III as per the minimum seed certification standards and adoption of prophylactic measures.

Fig. 46. Multiplication of micro plants of cassava in the net house (left) and field (right)

Under this programme, popular cassava varieties multiplied were Sree Visakham, Sree Vijaya, Sree Jaya, Sree Athulya, Sree Apoorva, Vellayani Hraswa, Sree Swarna and CMR -100. A total of 2.5 acres of area was covered. Virus free planting materials of cassava varieties such as Sree Prakash, Sree Rekha, Sree Jaya, Sree Vijaya, Sree Visakham, Vellayani Hraswa, H-226, H-165, H-97 and M-4 that were obtained from ICAR-CTCRI-Regional Centre, Bhubaneswar, were multiplied through minisett technique. The quantity of planting material of various tuber crops produced during the period is given in Table 2.

Table 2. Planting material production during 2014-2015

Crop	Quantity of planting material produced
Cassava stems (nos)	95,000
Elephant foot yam (Gajendra) (kg)	30,000
Yams (Sree Keerthi, Sree Roopa and Sree Shilpa) (kg)	11,000
Sweet potato vines (nos)	5,08,231
Arrowroot (kg)	100
Tannia (kg)	215
Taro (kg)	2307
Chinese potato cuttings (nos)	3307
Yam bean seeds (kg)	300

ECOFRIENDLY STRATEGY FOR MANAGEMENT OF INSECT PESTS IN TUBER CROPS

Survey of sweet potato weevil (SPW) incidence

A field survey was conducted in Odisha, Assam, Meghalaya, Arunachal Pradesh, Uttar Pradesh and Jharkhand. In Odisha, the sweet potato weevil, *Cylas formicarius*, was a major pest causing yield loss ranging from 30 to 70%. The crop was cultivated thrice a year in Dhenkanal district; hence, more number of generations of sweet potato weevil and sufficient weevil population were available to inflict significant yield reduction (Fig. 47). The number of weevils caught in a sex pheromone trap on the first day of installation was 1500 per day, whereas weevil catches in other states were 40 in Assam, 2 in Arunachal Pradesh, 60 in Meghalaya, 27 in Jharkhand and 2 in Uttar Pradesh. This trend shows that the SPW was present in minimum numbers in these states, indicating less area under cultivation.

Fig. 47. Scientists surveying sweet potato field in Dhenkanal for verifying the SPW pheromone efficacy (left) and interaction with farmers at Jajpur on the use of weevil sex pheromone trap (right)

Synthetic insecticides *vis-a-vis* biopesticides for SPW management

The efficacy of synthetic insecticides, viz., chlorpyrifos, quinalphos, dimethoate and malathion at concentrations of 0.001, 0.01 and 0.05% and ICAR-CTCRI developed biopesticides were screened against SPW by topical application on the pest and feeding the pest with leaves and tubers treated with insecticides. Mortality of the weevil was recorded at 0, 1, 2 and 3 days after treatment (DAT). Quinalphos was most toxic to weevil; the mortality of weevil on the same day was 100% even at a concentration of 0.001%. Chlorpyrifos at 0.01% resulted in 100% mortality. Among the selected insecticides, malathion and dimethoate were least toxic to SPW as no mortality was noticed at 0.001% concentration. Whereas the mortality was 60% and 40% with dimethoate and malathion one DAT.

When the insects were fed with leaves treated with different concentrations of quinalphos, the mortality was cent percent at 0.01 and 0.05% at two DAT, but at lower concentration (0.001%) mortality was relatively low. In the case of chlorpyrifos treatment, 100% mortality was observed at 0.05% on 3 DAT, but 73.3 and 40% at 0.01 and 0.001% respectively. Of the four insecticides used, malathion was least toxic to SPW; the mortality was 56.70% even at the higher concentration of 0.05%. Dimethoate was less toxic to weevil, which took nine days to achieve 100% mortality at 0.001% concentration and until 3 DAT only 60.00% mortality was noticed in 0.05% treated batches.

When the weevils were fed with tubers treated with 0.01% quinalphos, their mortality was 80% on 1 DAT, but it enhanced to 100% on 3 DAT. In the case of chlorpyrifos, cent percent mortality was achieved on 1 DAT at a concentration of 0.05%. Toxicity of malathion was relatively less, and the mortality was 26.70% at 0.05% concentration on 1 DAT, whereas it was 80 and 100% due to quinalphos and chlorpyrifos treatments respectively. Mortality of weevils fed with tubers treated with 0.01% dimethoate was 33.30%, which increased to 73.30% at 0.05% concentration.

When sweet potato leaves were treated with the bioformulation, *Nanma* at 1% concentration and fed to SPW, the mortality was 13, 70 and 73% on 0, 1 and 3 DAT respectively; however at 5% it was 43.30, 90.00 and 96.70%. The mortality of SPW fed with *Menma* treated leaves did not vary significantly from the untreated batches.

Broad-spectrum and safer pesticides for SPW management

In the first season, eight new insecticides including combination products, Flubendiamide 39.35 SC, Cartap Hydrochloride 50 SP, Acephate 75 WP, Thiomethoxam 25 WG, Imidachloprid 17.80 SL, Bifenthrin 10 EC, Chlorpyriphos 50 EC + Cypermethrin 5 EC, Triazophos 35 EC + Deltamethrin 1 EC were applied twice, first at 30 days after planting and second at 50 days after planting of sweet potato. Thiomethoxam 25WG and Imidachloprid 17.80 SL resulted in lowest number of *C. formicarius*, (Average < 1 per plant) when compared to the control plots (5.23 weevils per plant).

Sex pheromone for SPW management

Sweet potato weevil sex pheromone lures were given to farmers in 10 ha in Pamala and Shakarpur and Parvathiya villages of Dhenkanal. This intervention motivated farmers to adopt pheromone trap technology during *kharif* 2014 in 150 ha (Fig. 48) . The traps were installed at a distance of 30 m and the farmers were trained in the collection of weevils once in a week. The number of traps used were 10 per ha. The technology helped to avoid the ultimate yield loss of 25%. The cost : benefit ratio of this technology was 1:7.3. The technology was widely accepted because of availability of sex pheromone lures.

Male sterile technique for SPW management

The male insects were irradiated with gamma irradiations using two irradiators viz., 5000 GC producing 9.329 KGy h^{-1} and 2000 GC producing 0.6 KGy h^{-1}. Highest mortality of weevils was observed when they were irradiated at 250 Gy @ 0.6 KGy h^{-1} (41.80%) on the first day itself and within one week 82% of the irradiated males were dead. The irradiated males were allowed to mate with wild females. The mated females were allowed for egg laying on tubers. The weevils emerging from the first generation was counted after one month. The females that mated with irradiated males produced less number of first

Fig. 48. Farmers use their own pheromone traps at Dhenkanal (left) and a sweet potato farmer harvesting the produce, where pheromone traps were used (right)

generation (7 weevils per kg tubers) compared to 35 weevils per kg with normal males and females. Hence, gamma irradiation of male *C. formicarius* @ 200 Gy h^{-1} decreased the chance of emergence of weevils by five times in laboratory studies.

Effect of sweet potato volatiles on sweet potato weevil

Electrophysiological and behavioral studies coupled with field experiments were conducted to analyze the olfactory response of sweet potato weevil (SPW) to six varieties of sweet potato and to understand how the weevil's olfactory system distinguished between the volatiles from the susceptible and resistant varieties. Y-tube olfactometer bioassays indicated that the female SPW had significantly higher attraction towards volatiles ($P<0.01$) of var. Kishan, whereas it was lowest in the case of var. Gouri. A greater electrophysiological response was observed in the case of male SPW antenna to the flower volatiles and by females to the leaf volatiles. The highest average amplitude was observed in the responses of both the sexes to the highly susceptible and resistant varieties.

INTEGRATED MANAGEMENT OF FUNGAL DISEASES

Aroids

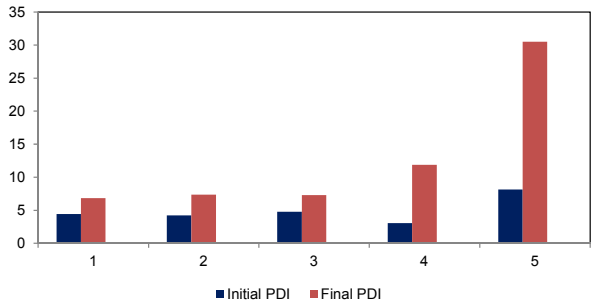
Collection, isolation and characterization of bioagents against *Phytophthora colocasiae* and *Sclerotium rolfsii*

Soil samples were collected from the rhizosphere region of tuber crops from the states of Odisha, Kerala, Mizoram, Manipur, Jharkhand, Meghalaya, Nagaland, Karnataka, Maharashtra and Arunachal Pradesh. A total of 125 bacterial and 10 fungal isolates were obtained and all these isolates were screened against *Phytophthora colocasiae* and *Sclerotium rolfsii***.** Among them 35 isolates showed high inhibition potential.

Altogether 600 bacterial isolates were screened thrice by adopting direct confrontation, production of diffusible metabolites and volatiles methods. Thirty seven isolates showed consistent inhibition potential against the target pathogens. These isolates were tested for their ability to produce Indole Acetic Acid and growth promotion in cowpea seedlings. Based on pathogen suppression, IAA production and growth promotion potential, 13 isolates were selected for identification. The identification was based on 16s r RNA gene sequencing and isolates were identified as *Bacillus amyloliquefaciens* (4 isolates), *B. cereus* (2), *B. licheniformis* (1), *B. subtilis* (1), *Pseudomonas aeruginosa* (5). Due to the human pathogenic nature, *Pseudomonas aeruginosa* and *B. cereus* were excluded from future study.

Effect of cormel priming with bioagents

Cormels of taro were primed with four bacterial isolates, *B. subtilis, B. licheniformis* and *B. amyloliquefaciens* (2 isolates) @ 10^8cfu ml^{-1}. The treated cormels were maintained under hydrated condition for 12 h and planted in pots. All the four isolates could significantly increase plant height, leaf production, leaf length and leaf breadth. The final PDI (per cent disease index) was very low in all PGPR treated plants compared to control plants (Fig. 49). Higher yield was also obtained with these isolates (up to 500 g per plant) compared to control plants (342.80 g per plant).



1. *B. amyloliquefaciens I* 2. *B. amyloliquefaciens II* 3. *B. subtilis* 4. *B.licheniformis* 5. Control

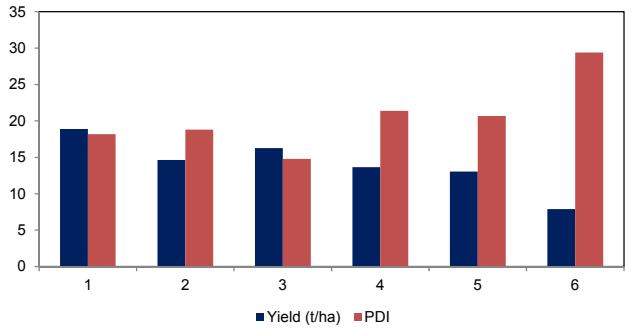
Fig. 49 . Disease incidence (%) in PGPR treated taro plants

Field trial on management of taro leaf blight incidence

Six treatments involving application of vermicompost, bacteria and fungicides were evaluated under field condition to find out their comparative efficacy in controlling taro leaf blight incidence. None of the agronomic parameters or microbial population showed significant variation due to various treatments. The least PDI was noted with application of metalaxyl followed by seed treatment with vermiwash (10%)

+ soil application of vermicompost (400 g per pit) + drenching and spraying with vermiwash (10%) at 60 and 90 days after planting (DAP) (Fig.50). However, highest yield was obtained due to application of vermicompost. Field performance of these treatments was evaluated twice and the same trend was obtained.

Field trial on integrated management of fungal diseases of taro



1. Application of vermicompost
2. Potassium phosphite 0.3%
3. Metalaxyl 0.05%
4. *Bacillus subtilis*
5. POP recommendation
6. Control

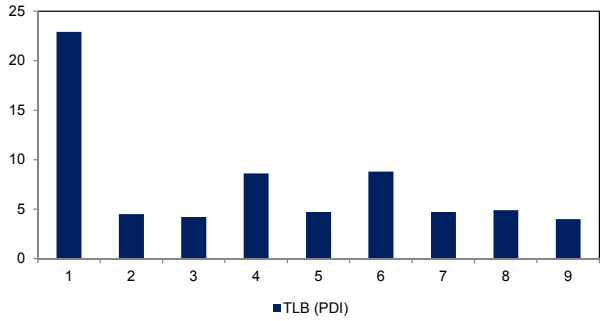
Fig. 50. Effect of management practices on PDI and yield in taro

A field trial was conducted at Regional Centre, ICAR-CTCRI, Bhubaneswar (Fig. 51), on the management of fungal diseases of taro. There were six treatments, viz., 1. Seed treatment with *Trichoderma* @ 5g kg^{-1} (T_1); 2. T_1 + two foliar sprays with Ridomil-MZ at 45 and 75 DAP; 3. T_1 + two foliar sprays with ICAR-CTCRI bioformulation at 45 and 75 DAP; 4. T_1 + two foliar sprays with Dithane M-45 at 45 and 75 DAP; 5. Control var. Muktakeshi; 6. Control var. Telia. Seed treatment with *Trichoderma* + two foliar sprays with ICAR-CTCRI bioformulation at 45 and 75 DAP produced highest yield (26.60 t ha^{-1}) and least blight incidence (4%).

Fig. 51. Field trial on the management of fungal diseases of taro at Regional Centre, ICAR- CTCRI

Effect of boron and silicon on taro leaf blight incidence

A pot experiment was conducted to evaluate the effect of the micronutrients, boron (B) and silicon (Si) in the form of borax and potassium silicate at 100% of the recommended dose (3 kg ha^{-1} and 50 kg ha^{-1} respectively) and 150% of the recommended dose (4.5 kg ha^{-1} and 75 kg ha^{-1}) (single nutrient and in combination) along with the recommended dose of NPK to study their effect on taro leaf blight incidence. Apart from this a control (NPK alone) was also included for comparison. All the treatments where B and Si were included (either alone or in combination) resulted in significant reduction in TLB over NPK alone (Fig.52).



1. NPK; 2. NPK+ B (100%); 3. NPK+ Si (100%); 4. NPK+ B (150%)
5. NPK+ Si (150%); 6. NPK + B (100%) + Si (100%)
7. NPK+ B (100%) + Si (150%); 8. NPK+ B (150%) + Si (100%);
9. NPK+ B (150%) + Si (150%)

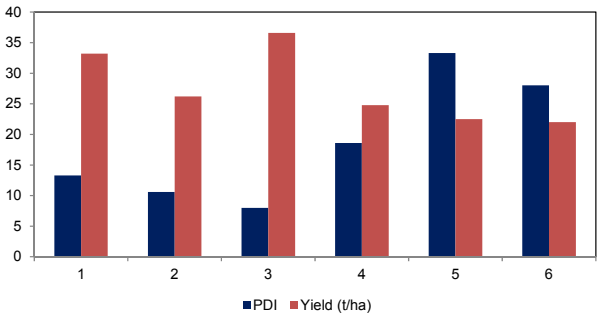
Fig. 52. Taro leaf blight incidence with boron and silicon application

Field trial on management of collar rot incidence in elephant foot yam

Six treatments involving application of vermicompost, *Trichoderma* spp, *Bacillus subtilis* and application of black plastic mulch were evaluated under field condition to find out their comparative efficacy in controlling collar rot incidence in elephant foot yam (Fig. 53). Soil application of vermicompost (750 g per pit) + seed treatment with vermiwash (10%) + drenching with vermiwash (10%) and soil application of vermicompost at 90 and 120 DAP (400 g per pit) showed least collar rot incidence followed by *Trichoderma asperellum* (Fig. 54). The highest disease incidence was in plots, where black polythene mulch was used. Even though, black polythene mulch reduced weed growth and promoted growth,

it increased the disease incidence. The highest yield was obtained due to application of vermicompost/ vermiwash.

Fig. 53. Elephant foot yam collar rot incidence in field trial



1. *Trichoderma harzianum*
2. *T. asperellum*
3. Vermicompost
4. *Bacillus subtilis*
5. Black plastic mulch
6. Control

Fig.54. Collar rot incidence and yield in elephant foot yam as affected by various treatments

Field trial on integrated management of fungal diseases of elephant foot yam

A field trial was conducted at Regional Centre, ICAR-CTCRI, Bhubaneswar on the management of fungal diseases of elephant foot yam. There were six treatments, viz., 1. Tuber treatment with cow-dung slurry mixed with *Trichoderma* @ 5 g kg^{-1} (T_1); 2. T_1 + two sprays (0.2%) with mancozeb (T_2); 3. T_2 + mulching with black polythene; 4. T_2 + soil application of neem cake (200 g per pit); 5. T_1 + soil application of neem cake + two sprays with ICAR-CTCRI bioformulation (12%) at 60 and 90 DAP; 6. Control. Tuber treatment with *Trichoderma* + soil application of neem cake + two sprays with ICAR-CTCRI bioformulation at 60 and 90 DAP resulted in highest yield in elephant foot yam and least collar rot and leaf blight incidence (Fig. 55).

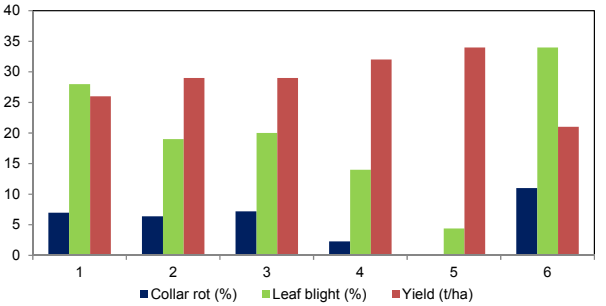


Fig. 55. Disease incidence and yield under different management options in elephant foot yam

Post-harvest rotting of aroids

The organisms causing 8-10% post-harvest loss in taro were identified as *Lasiodiplodia (syn. Botryodiplodia) theobromae*, *Phytophthora colocasiae*, *Sclerotium rolfsii*, *Fusarium* sp., *Rhizopus* sp., *Aspergillus* sp. and *Penicillium* sp. In addition to these organisms, the nematodes, viz., *Meloidogyne incognita, Pratylenchus* sp. and a soft rot causing bacteria also cause 4-5% loss in elephant foot yam (Fig. 56).

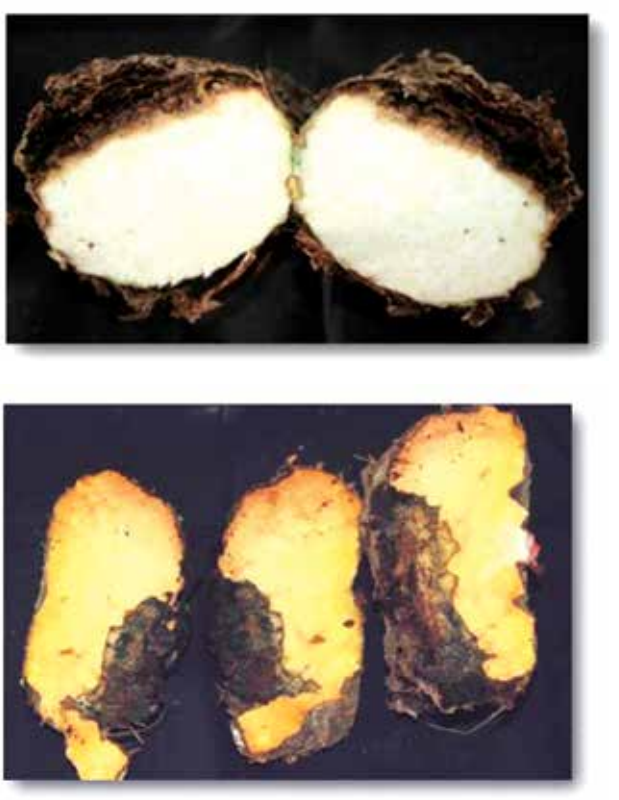


Fig. 56. Post-harvest rot in taro and elephant foot yam tubers

Greater yam

Epidemiology of yam anthracnose

Colletotrichum gloeosporioides, the causal organism of yam anthracnose, could survive in the sterilised dry and 20% moistened field soil up to three and nine months respectively *in vitro*. It could survive in crop debris up to one year. The pot trial showed that the major source of inoculum was air followed by tuber and soil. The disease progress was significantly high through air borne infection. About 21 isolates were collected from different greater yam growing areas of Kerala, Karnataka and Odisha and the pathogenicity of the cultures were tested on tissue cultured whole plants of greater yam var. Orissa Elite.

Disease intensity observed at 10 days interval in two varieties of greater yam viz., Orissa Elite (highly susceptible) and Sree Karthika (highly tolerant) under field condition showed that the disease progressed from the month of August (fourth month after planting) after rainfall and reached high during October when the rainfall and number of rainy days were more.

Characterization of toxic metabolite produced by *C. gloeosporioides*

The effective aqueous phase of the cell free culture filtrate of the pathogen, separated with diethyl ether (crude toxin) was extracted with hexane for further purification. Then the volume of the organic phase was reduced and fractionated through column (Silica gel). The UV spectrum of the fractions which produced lesion in bioassay showed the presence of more than five peaks between 200 to 240 nm (Fig. 57). The fraction was further purified through TLC and the eluted band was UV scanned. The effective fractions were stored for further identification. The crude toxin was used to screen about 150 accessions of greater yam germplasm lines *in vitro* (Fig. 58). Besides, the callus of greater yam var. Orissa Elite was produced to select toxin resistant clones further. The MS media with 1.5: 1.5 mg l^{-1} NAA:BA and 2,4-D 3 mg l^{-1} supported good callus proliferation among different combinations tried. The callus could be regenerated successfully in MS media with 1.5: 1.5 mg l^{-1} NAA:BA and further multiplied in half MS liquid media.

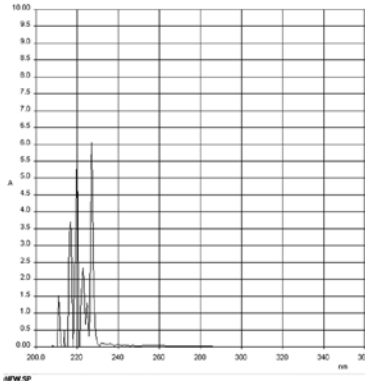


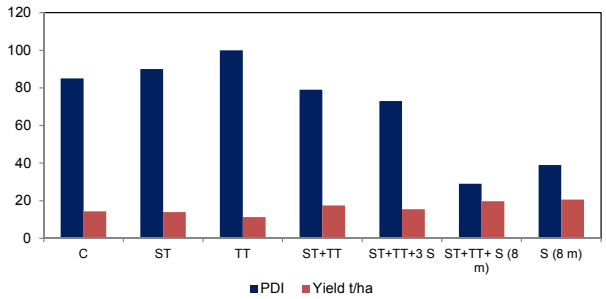
Fig. 57. UV absorbance of a column fraction of toxin

Fig. 58. Symptom development in germplasm lines by crude toxin

Management of anthracnose

A field experiment was carried out for the second season for confirmatory results with seven different treatments including soil and tuber treatment with biocontrol agent (BCA), *Trichoderma asperellum*, CTCRI-Tr 15 and fungicidal spray to manage anthracnose disease in greater yam var. Orissa Elite. The first spray was done when the symptom initiated. Soil treatment with *Trichoderma* @ 50 g of 10^7 cfu g^{-1} and tuber treatment with *Trichoderma* @ 5 g in fresh

cow dung slurry per kg of tuber along with foliar spraying of carbendazim (Bavistin) 0.05% three times after the initiation of symptoms at 15 days interval followed by monthly spraying with carbendazim for another four months till eight months after planting drastically reduced the disease intensity (66%) and increased the yield (22%), which was on par with spraying alone (without soil and tuber treatment) till eight months (Fig. 59).



C: Control; ST: Soil treatment with BCA; TT: Tuber treatment with BCA; 3S: Three sprays; S (8 m): Seven sprays up to eight months

Fig. 59. Effect of biocontrol agent and carbendazim on the intensity of anthracnose disease and yield in greater yam

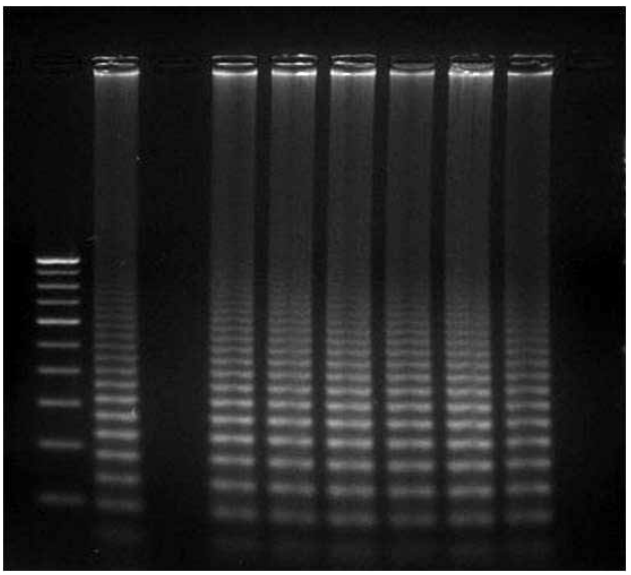


Fig. 60. RT-LAMP assay for detecting *DsMV*

CHARACTERIZATION, DIAGNOSIS AND MANAGEMENT OF VIRUSES OF TUBER CROPS

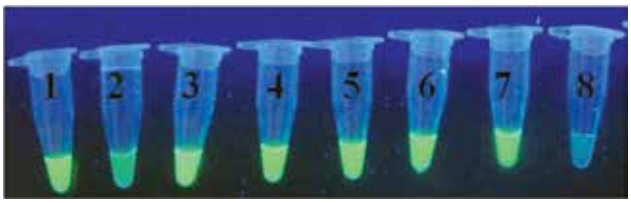
Diagnosis of viruses infecting tuber crops

Elephant foot yam

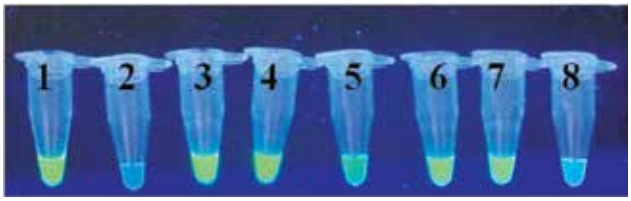
An effective RT-LAMP assay was developed for the rapid detection of DsMV in less than an hour (Fig. 60). The sensitivity of the assay was 100 times that of RT-PCR. *In tube* detection of the DsMV was carried out using fluorescence detection reagents (Loopamp fluorescent detection reagent and calcein/$MnCl_2$) and ethidium bromide staining (Fig. 61). The assay was validated with field samples collected from various regions of Kerala. For large scale indexing of samples, CP specific non-radioactive probe was developed and used in NASH with great reliability.

Taro

Taro leaf samples were screened for *Dasheen mosaic virus* (DsMV), *Taro bacilliform virus* (TaBV), *Taro vein chlorosis virus (*TaVCV*)* and *Colocasia bobone disease virus* (CBDV) using both genus and species specific primers. Out of 22, 15 samples showed DsMV infection in PCR and 10 samples showed TaBV infection. While mixed infection by DsMV and TaBV was found in six samples; there was a lone case of positive for TaBV-like sequence in one sample (N28). Both TaVCV and CBDV screening through PCR gave negative results.



Loopamp fluorescent



Calcein/$MnCl_2$

Fig. 61. In tube detection of DsMV (Loopamp fluorescent detection and calcein/$MnCl_2$

Yams

The total RNA was isolated from both leaf and tuber samples. Among different methods tried the PureLink RNA Mini kit (Ambion) (Fig. 62) and $LiCl_2$ method were the most appropriate for RNA isolation from greater yam leaf and tuber samples respectively. Serological (DAS-ELISA and DIBA) and nucleic acid based (RT-PCR and IC-RT-PCR) techniques were used to detect the presence of *Macluravirus* infection in greater yam. *Yam Macluravirus* (YMacV) specific antibodies were used for serological methods of detection. For nucleic acid based detection, two pairs of *Yam Macluravirus* specific primers (YMac1s/1c and YMacs/c) were used which produced amplicons of ~200 and 800 bp (partial NIb- partial CP gene) respectively in virus infected samples. Presence of virus infection was detected only in the samples collected from Thiruvananthapuram district. A pair of species specific primers (YMacF1/R1) was designed to amplify the full CP gene of the virus. RT-PCR analysis with these primers provided an amplicon of ~1100 bp (Fig. 63). The positive samples were gel eluted and sequenced to obtain the full CP gene of *Yam Macluravirus*. The full CP region of *Yam mild mosaic virus* (YMMV) was amplified using highly sensitive and species specific designed primers, YMMV F and YMMV R.

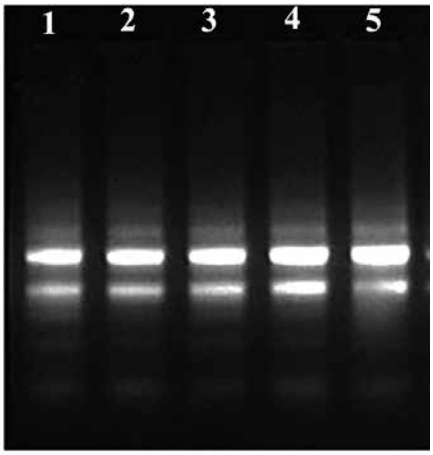


Fig. 62. RNA isolated by Ambion Purlink mini kit

Characterization of viruses

Dasheen mosaic virus in elephant foot yam

The complete nucleotide sequence of DsMV infecting elephant foot yam was deduced from the transcriptome data and the same was validated using PCR amplification of various overlapping regions with 11 set of primers (designed based on the assembled sequence obtained from the transcriptome data) and subsequent sequencing of PCR products. The genome (10024 bp) consisted of one long uninterrupted ORF from 167 to 9754 bases starting with AUG codon at nucleotides 167–169 and terminating with UAA at nucleotides 9752–9754. The bases 1-166 and 9755-10024 constituted the 5' and 3'UTRs. The nucleotides located at 167-1303 (P1), 1304-2680 (HC-Pro), 26813727 (P3), 3728-3883 (6K1), 3884-5806 (CI), 5807-5932 (6K2), 5933-6520 (NIaVPg), 6521-7252 (NIa-Pro), 7253-8890 (NIb) and 8891-9751 (CP) constituted the genes. The annotated nucleotide sequence for complete genome of DsMV infecting *A. paeoniifolius* (India) named as isolate T10 was deposited in Genbank, NCBI with accession number KJ786965. Phylogenetic analysis with selected fully-sequenced species in the genus *Potyvirus* placed DsMV (India) within the subgroup that included DsMV infecting *Z. aethiopica* (China), SMV, ZYMV, BCMNV and others. The sequence of the virus of 10024 bases showed 83% identity with DsMV infecting *Z. aethiopica* (China), the only available whole genome sequence of DsMV at NCBI.

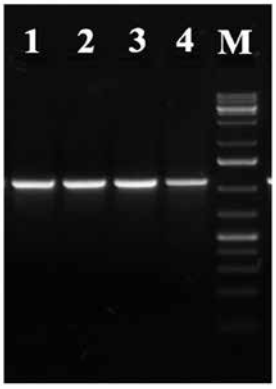


Fig. 63. RT PCR products amplified using designed Ymac F1 and Ymac R1 primers. Lane 1 to 4: PCR products, lane M: 1kb plus DNA ladder

Viruses of taro

One sample each for DsMV and TaBV, were cloned and sequenced (Fig. 64). The sequence data was analysed through BLAST and sequence similiarity was studied. The DsMV sequence obtained is 410 nt, which showed maximum similarity of 93% to *Dasheen mosaic virus* isolate *DsMV-Amp3 polyprotein gene*, DsMV isolate T10 (Accession KJ786965) and *DsMV* partial CP gene for coat protein of NiNG1 (Accession AM910398) and NiNG4 isolate (Accession AM910400). Whereas the 334 nt TaBV sequence showed maximum sequence similarity of 92% to TaBV isolates (NC1, SI2 and S17) polyprotein gene.

Fig. 64. Symptoms of DsMV (left) and TaBV (right) in taro

Yam Macluravirus

The full CP gene of YMacV was amplified from RNA isolated from infected leaf samples (Fig. 65) using designed primers. The product was purified and cloned into *E.coli* DH5α cells. The presence of gene insert in the transformed colonies was confirmed by colony PCR. The recombinant plasmids were isolated and RT-PCR was performed, which yielded amplicons expected band size (~1100 bp). The BLAST analysis revealed that the virus has maximum similarity to *Chinese yam necrotic mosaic virus* (ChYNMV) (70% nucleotide identity). Sequence and phylogenetic analyses revealed considerable variability; and the virus was found to be in the same cluster as ChYNMV and *Yam chlorotic necrotic mosaic virus* (YCNMV). The virus coat protein gene exhibited only 65 to 70% nucleotide sequence identity with other macluraviruses.

Fig. 65. Symptom of YMacV

RFLP studies were conducted with two restriction enzymes (Taq1 and Mse1). RFLP analysis with Taq1 enzyme produced three fragments, but none of the samples digested showed intraspecific variation. Restriction digestion with Mse1 enzyme produced seven bands and one sample showed presence of polymorphism.

Relation of symptom recovery of CMD with virus concentration

Fifteen selected cassava varieties of susceptible, resistant and recovery types were planted in field and observations were taken at monthly intervals based on different grades of symptoms. Symptom development was scored and the concentration of *Sri Lankan cassava mosaic virus* (SLCMV) was measured through Sybr Green qPCR assays and analysed in relation to incidence and severity of mosaic disease symptoms during the first six months of growth period. Cassava mosaic disease symptoms in susceptible lines were severe and were expressed throughout the six months of monitoring. Symptoms as well as virus titre of recovery types decreased over the growth period; while resistant genotypes had low concentration of viral DNA even though there were no symptoms. These findings were in conformity with that of previous years.

DEVELOPMENT OF FUNCTIONAL FOODS FROM TUBER CROPS

Functional and specialty food products from tuber crops

The products developed under this project are gluten-free spaghetti from sweet potato, n*utriose* fortified sweet potato noodles, high protein starch noodles from sweet potato, functional sago with high protein content, functional sago with high calcium content, cassava starch noodles using resistant starch enhanced (annealed) cassava starch, cereal grain type pasta including cassava-maida and cassava-rice blends, sweet potato spaghetti enriched with bioactive pigments and purple yam flour based pasta rich in anthocyanins.

Gluten-free spaghetti was developed from blends of sweet potato flour with native and pretreated rice flour (Fig. 66). Hydrothermal pretreatment of moist rice flour (50% moisture content) for 45 min. at 100°C followed by low temperature conditioning (-4°C) for 48 h could structurally alter rice starch and its incorporation at 30% level to sweet potato flour-whey protein concentrate-guar gum blend resulted in spaghetti with a low glycaemic index (GI) of 55.7 (Fig. 67)

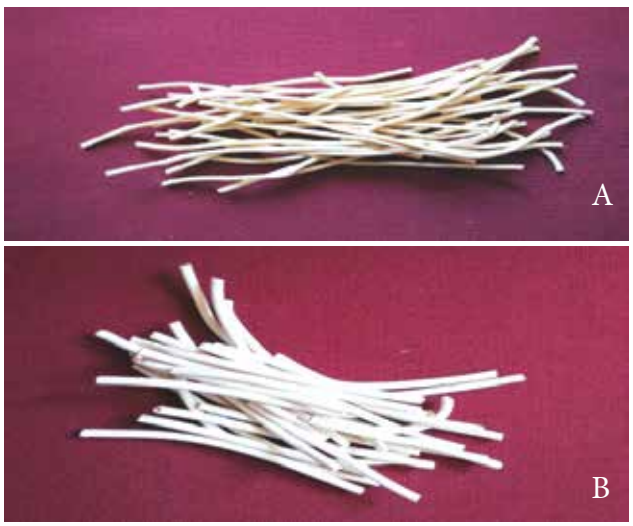
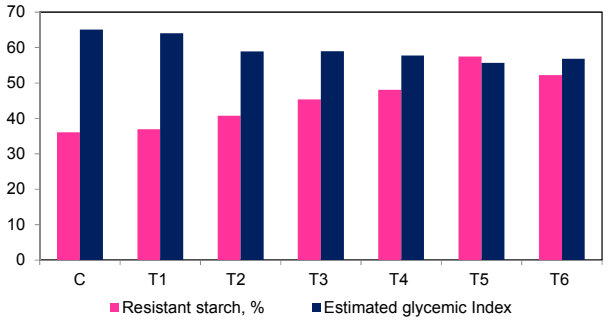


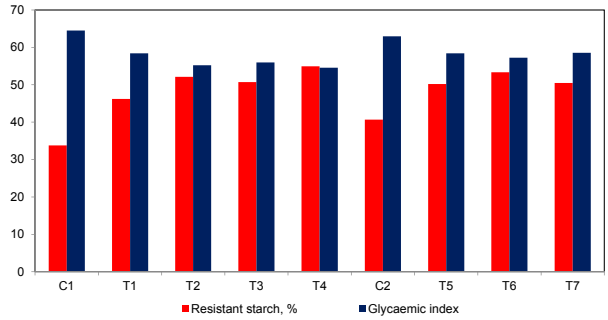
Fig. 66. A. Rice flour-sweet potato flour based gluten free spaghetti: Native gluten free spaghetti
B. Hydrothermally pretreated and low temperature conditioned spaghetti



C-Control (72% sweet potato flour+ 23% maida)
T1-65% SPF+ 30% rice flour
T2-54.5 SPF+ 30 rice flour+ 10% WPC+ 0.5% guar gum
T3-54.5 SPF+ 30 pretreated rice flour+ 10% WPC+ 0.5% guar gum; 0 h
T4-Pretreated rice flour at – 4 °C for 24 h and then mixed as in T3
T5-Pretreated rice flour at – 4 °C for 48 h and then mixed as in T3
T6-Pretreated rice flour at – 4 °C for 72 h and then mixed as in T3

Fig. 67. Effect of resistant starch content and glycaemic index of gluten-free spaghetti from sweet potato

NUTRIOSE® FB06 was used as a fibre rich additive to develop noodles with low starch digestibility. Estimated glycaemic index (EGI) could be brought down to 54.58 in 15% NUTRIOSE + 1% guar gum fortified flour noodles from 64.53 in control sweet potato flour noodles, while the EGI in starch noodles was 57.22 for 5% NUTRIOSE+ 0.5% guar gum fortified set (Fig. 68.).



C1-75% Sweet potato flour; T1-10% Nutriose; T3-15%; Nutriose + 05% guar gum
T4-15% Nutriose + 1% guar gum; C2-75% Sweet potato flour;T5-5% Nutriose
T6-5% Nutriose + 0.5% guar gum; T7-%% Nutriose + 1% guar gum

Fig. 68. Effect of different treatments on resistant starch and glycaemic index of NUTRIOSE fortified sweet potato noodles

Technology was perfected for the first time for developing good quality starch noodles from sweet potato starch, which also combined high protein content. Besides, the resistant starch content in sweet potato starch noodles could be enhanced through fortification with either banana starch (40%) or resistant starch enhanced (annealed) cassava starch (50%), which also had low *in vitro* starch digestibility and medium glycaemic index (Figs. 69, 70).

Banana starch fortified noodles Annealed cassava starch fortified noodles

Fig. 69. Sweet potato noodles

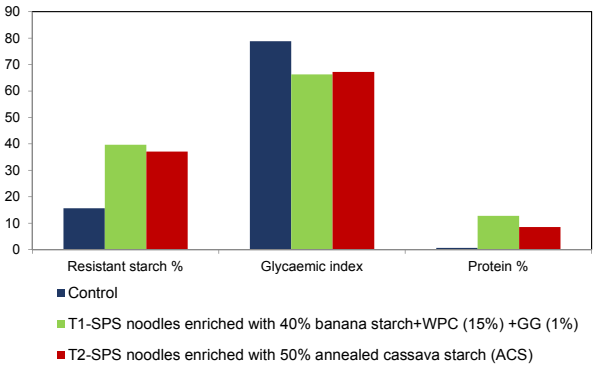
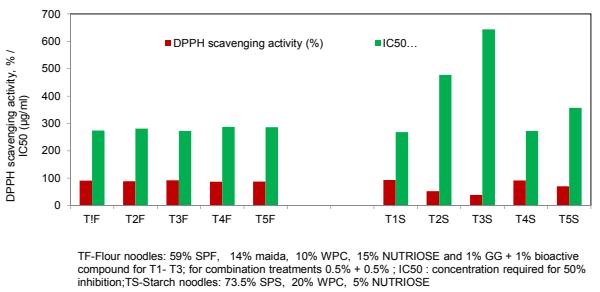


Fig. 70. Characteristics of high protein starch noodles from sweet potato

Bioactive compound fortified sweet potato flour and starch noodles with high antioxidant activity were developed using betanin, anthocyanin, carotene, curcumin or their combinations. In the case of flour noodles, betanin (1%) fortification alone was the best, when both high antioxidant activity and sensory quality were considered. However, in the case of starch noodles, very high antioxidant activity was exhibited by the betanin + anthocyanin (0.5% each) combination (Fig. 71)



TF-Flour noodles: 59% SPF, 14% maida, 10% WPC, 15% NUTRIOSE and 1% GG + 1% bioactive compound for T1- T3; for combination treatments 0.5% + 0.5% ; IC50 : concentration required for 50% inhibition;TS-Starch noodles: 73.5% SPS, 20% WPC, 5% NUTRIOSE

Fig. 71. Anti-oxidant activity in sweet potato noodles fortified with bioactive compounds

Anthocyanin from sweet potato

Sweet potato genotypes ST-13 (with purple anthocyanin rich tuber) and Acc. No. 1468 (with anthocyanin rich leaf) were planted and cultured under seven treatments viz., (i) T_1: Control (NPK @ 25:12.5:25 kg ha^{-1}); (ii) T_2: Foliar spray of benzyl adenine (250 ppm) 6 times at weekly intervals during 3 to 8 weeks after planting; (iii) T_3: Foliar spray of silver nitrate (250 ppm) 6 times at weekly intervals during 3 to 8 weeks after planting; (iv) T_4: Foliar spray of humic acid (2%) 6 times at weekly intervals during 3 to 8 weeks after planting; (v) T_5: Soil application of humic acid (5 g per plant) at 3rd week after planting; (vi) T_6: NPK@ 50:25:50 kg ha^{-1} through chemical fertilizers and (vii) T_7: NPK @ 62.5:25:62.5 kg ha^{-1} through chemical fertilizers.

In ST-13 tubers, the anthocyanin yield was maximum when the crop was fertilized with NPK @ 62.5:25:62.5 kg ha^{-1} (Fig. 72). This was due to higher anthocyanin content in tuber (118 mg 100g^{-1} fresh tuber) as well as maximum tuber yield per plant (359 g per plant). Other treatments viz., foliar spray of BA and humic acid application significantly increased anthocyanin yield per plant in ST-13 as compared to control. In the leaves of Acc. No. 1468, anthocyanin yield was maximum when the crop was treated with humic acid @ 5 g per plant at 3rd week after planting (Fig. 73). This was because of maximum anthocyanin content in leaf (222 mg 100g^{-1}). Per plant anthocyanin yield was greater in the leaves of Acc.No. 1468 than in the tuber of ST-13.

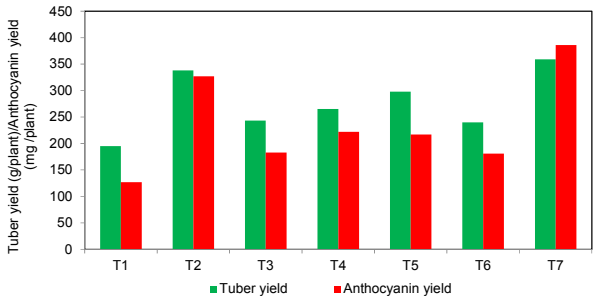


Fig. 72. Effect of different treatments on anthocyanin yield per plant in tubers of sweet potato (var. ST-13)

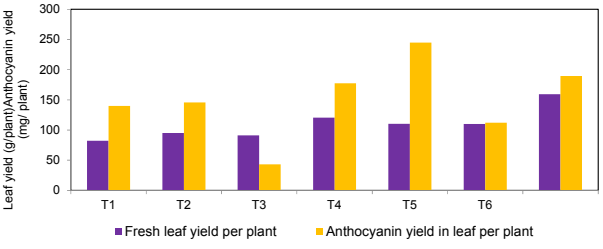


Fig. 73 . Effect of different treatments on anthocyanin yield per plant in leaves of sweet potato (Acc. No. 1468)

Supercritical CO_2 extraction of anthocyanin from sweet potato leaves

Freshly harvested sweet potato leaves were cleaned, sundried and powdered for the trials in super critical CO_2 fluid extractor (model: M/s Thermo). The co-solvents used were methanol, acidified methanol and ethanol. The process parameters such as, flow rate of both solvent and co-solvent and temperature were varied. After extraction, the extracts were collected, measured and taken to the qualitative estimations like thin layer chromatography.The extracts were analyzed for the presence of anthocyanin by column purification and TLC. Distinct bands of anthocyanin along with chlorophyll was observed confirming the presence of anthocyanins in the extract. A pre-treatment has to be standardised to remove the chlorophyll before the supercritical extraction process and increase the efficiency of extraction.

Probiotic enriched food products from elephant foot yams, yam beans and yams

Elephant foot yam (var. Gajendra, Sree Padma and a local variety) tuber matrices (in the form of cubes 1.5 x 1.5 x 1.5 cm^3) were pickled by lactic fermentation by brining the cut and blanched de-skinned tubers in brine (NaCl, 2-10%). Preliminary sensory studies had shown that the lacto-pickles prepared with 2-6% brine were not palatable; hence further studies were taken up with only 8-10% brine. The matrices were inoculated with a mixed culture of *Lactobacillus plantarum*, *L. acidophilus* and *Biofidobacterium bifidum*, and incubated for 21 days. The lacto-pickle with 8-10% brine had a pH of 2.44-2.89, titratable acidity of 1.80-3.00 g kg^{-1}, starch of 5.50-6.00 g kg^{-1}, total sugar of 0.80-1.20 g kg^{-1}, lactic acid of 2.80-4.20 g $kg^{-1}$and ascorbic acid of 41-66 mg kg^{-1} on fresh weight basis. The shelf life of the pickle without any preservative was 20 days; however, with addition of mustard or olive oil, there was no spoilage up to 45-60 days. Sensory evaluation rated the elephant foot yam lacto-pickle acceptable to consumers based on texture, taste, flavour and after taste.

PRE AND POST-HARVEST MACHINERY FOR COST EFFECTIVE CULTIVATION AND PROCESSING OF TUBER CROPS

Industrial evaluation of vibro sieving system in starch industries

The vibro sieving system installed at M/s T.A.Perumal Sago Industry**,** Salem was evaluated with cassava starch slurry (Fig. 74). Samples collected from feed and two outlets of the machine were analysed and presented in Fig. 75. The sugar content and total cyanide content of the samples ranged from 0.43-0.85% and 0.35-1.00 µg.g^{-1} respectively. The machine was demonstrated to the starch and sago manufacturers and their suggestions were collected for the refinement of the machine.

Fig. 74. Performance evaluation of vibro sieving system

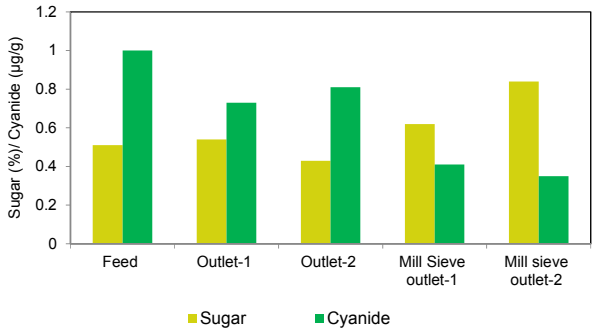


Fig. 75. Evaluation of vibro sieving system in M/s T. A. Perumal Sago industry

Evaluation of motorised cassava chipping machine

The motorised cassava chipping machine consists of two concentric mild steel drums, the annular space

between is divided into 24 small and big compartments for feeding the tubers (Fig. 76). A rotating disc at the bottom of the drum is made up of a V pulley and a thick round sheet fitted on the pulley carries the knives assembly. Thickness of chips can be changed by introducing spacing washers between the disc and the blade. Tubers are fed into the compartments from the top and the chips are collected at the bottom. The machine is supported on four legs. The size of the machine is 505 mm Φ X 660 mm height. The machine is powered with a one hp single phase electrical motor and the machine is operated at 150 rpm. The average out turn of the machine is up to 1.50 tonnes per hour for 3.23 mm thick chips (SD 1.09 and CV 0.3374). Five numbers of power operated chipping machines were fabricated, supplied to TNAU KVK and demonstrated to the farmers at Yethapur, Salem district.

Fig. 76. Motorised cassava chipping machine

Microwave heating and continuous drying system for cassava wet starch

The microwave drying experiments were conducted in a hot air assisted microwave dryer (Enerzi Microwave System, India-Model No: PTF-2515). The dryer consisted of two heaters and blowers as well as two magnetrons to generate a power range of 300 W to 2900 W for heating and drying the samples. A conveyor belt is attached with the machine for continuous drying of the food products. Trials were conducted at three power levels (400, 600 and 800 W), and three conveyor belt speeds (5 mm s^{-1}, 10 mm s^{-1}, 15 mm s^{-1}) with three loading densities (1.10, 2.10 and 2.80 kg m^{-2}). The time taken for drying the wet cassava starch from 33% moisture content to final moisture content of 11-13% (w.b.) was noted. Data were analysed for optimising the process and the results are presented in Fig. 77. Increase in power input from 400 to 800 W and loading density from 1.40 to 2.80 kg m^{-2} did not affect the moisture content of wet starch, whereas change of belt speed from 5 to 15 mm s^{-1} significantly reduced the moisture content of wet starch. Increasing power input from 400 to 800 W and belt speed from 5 to 15 mm s^{-1} reduced the drying time and increasing the loading density from 1.40 to 2.80 kg m^{-2} increased the drying time. The final moisture content of wet starch ranged from 11.09 to 12.82% (w.b) and the total drying time varied from 1.19 to 3.15 h.

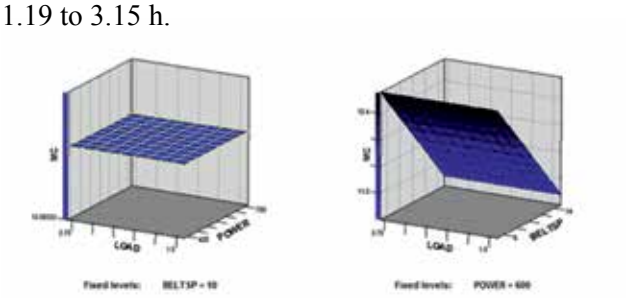


Fig. 77. Effect of process parameters on the moisture content of wet cassava starch

Ozonisation of wet cassava starch

The ozonisation trials were conducted in an ozonisation system consisting of O_2 concentrator, O_3 generator, a PVC cylindrical chamber of size 300 x 60 x 2 mm, O_3 analyser and O_3 destructor. The process parameters considered were concentration of ozone (3 levels: 500, 1000,1500 ppm), residence time (3 levels: 30, 60 and 90 minutes) and flow rate (3 levels: 2, 3 and 4 litres per minute). The treated samples were tested for colour values (L,a and b), water activity, HCN level and viscosity. The data were analysed and presented in Fig. 78. Increase in flow rate of ozone from 500 to 1500 lpm increased the colour values 'a' and 'b' but decreased 'L' value. The increase in concentration of ozone from 30 to 90 ppm increased the colour value 'b' and no pronounced effect was found in 'L' and 'a'. Rise in residence time from 2 to 4 hours has increased the colour value 'b' but lowered 'L'. No effect of residence time was found with the colour value 'a'. The water activities of the treated samples showed that a_w decreased with the increase in

flow rate and concentration. The colour values of the treated samples ranged from L-76.3 to 83.61, a-1.45 to 1.69 and b-7.13 to 7.52. The a_w ranged from 0.932 to 0.936.

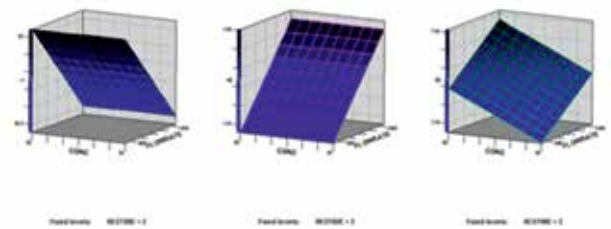


Fig. 78. Influence of flow rate and concentration of ozone on colour values (L, a & b) of wet cassava starch

Evaluation of a harvesting tool

A cassava prototype harvester developed at ICAR-CTCRI was evaluated in the institue farm (in upland under mound method) (Fig. 79) and at Chenkal village on farmers' fields (in lowland under flat method). Other harvesting methods using the ICAR-CTCRI lever, hoe and manual uprooting techniques were also tried for comparision. Results showed that the use of manual harvesting tools was preferable on relatively dryer soils, whereas manual uprooting technique was best suited for soils with relatively higher moisture contents. However, best efficiency of manual harvesting was achieved when cassava plants were coppiced before harvesting. The field capacity and percentage of tuber breakage in operating the cassava prototype harvester ranged from 15.72 to 40.20 man h ha^{-1} and 2.14 to 8.61%, respectively. Also, cassava uprooting force requirement, to a greater extent was influenced by tuber yield, depth of tuberization and number of tubers per plant, especially under mound method of land preparation in uplands.

Fig. 79. Cassava harvesting tool

INNOVATIVE APPROACHES FOR THE DEVELOPMENT OF TUBER CROPS BASED INDUSTRIAL PRODUCTS

Biodegradable films from modified starch-wax composites

Cassava starch was modified with propylene oxide to get etherified starch and with octenyl succinic anhydride to get esterified starch (Fig. 80). Composites were prepared using this modified starches with different waxes viz., carnauba wax, microcrystalline and candelilla wax by adding glycerol. The concentration of starch in the filmogenic solution varied from 3 to 5%, wax from 5 to 15%, protein from 5 to 15% and glycerol from 15 to 30%. Films were prepared by casting methods using 200 ml composite solutions. The physico-mechanical properties of the films viz., thickness, moisture content, solubility, colour and tensile force, elongation at break, sorption isotherms and water vapour transmission rate were analysed. Rheological properties viz. storage modulus, loss modulus, phase angle and viscosity under frequency sweep test were noted.

For the modified starch-wax composite based films, maximum thickness (0.223 mm) was obtained for the etherified starch-microcrystalline wax composites, maximum tensile force (28.56 N) for esterified starch-carnauba wax, minimum elongation at break (5.6%) for esterified starch-carnauba wax, maximum whiteness index (46.81) for esterifed starch-carnauba wax, minimum water vapour transmission rate (0.0096 g mm cm^{-2}) for esterified starch-carnauba wax, minimum moisture content (8.16%) for etherified starch-microcrystalline wax and minimum water absorption (12.58%) for esterified starch-microcrystalline wax composites.

Among the different composites containing modified starch and wax, the minimum storage modulus of 124Pa was obtained for the etherified starch with candelilla wax and maximum of 1076 Pa for the same starch with carnauba wax. The loss modulus value was minimum of 934 Pa for etherified starch with candelilla wax and maximum of 1685Pa for

the same starch with microcrystalline wax. Loss modulus ranged from 45.85° for etherified starch with carnauba wax and 80.4° for the same starch with microcrystalline wax.

Biodegradable films from modified starch-protein composites

Composites were prepared using the etherified and esterified starches with protein sources viz., whey protein concentrate and casein added with glycerol (Fig. 81). The concentration of starch in the filmogenic solution varied from 3 to 5%, protein from 5 to 15% and glycerol from 20 to 30%. The physico-mechanical properties of the films and the rheological properties of the filmogenic solutions were analysed.

By adding the protein sources with the modified starches, the following results were obtained: maximum thickness (0.241 mm) for etherified starch-casein, maximum tensile force (26.45 N) for esterified starch-whey protein, minimum elongation at break (10.23%) for esterified starch-whey protein concentrate, minimum moisture content (8.78%) for etherified starch-whey protein concentrate, maximum whiteness index (38.51) for esterified starch-whey protein concentrate, minimum water vapour transmission rate (0.017 g mm cm^{-2}) for esterified starch-whey protein concentrate and minimum water absorption (22.74%) for etherified starch-casein composites.The rheological analysis of the filmogenic solution containing protein sources showed that storage modulus was maximum (1230 Pa) for the composite containing etherified starch–casein and minimum (560 Pa) for esterified starch-whey protein concentrate.The loss modulus was maximum (1735Pa) for esterifed starch-whey protein concentrate and minimum (535 Pa) for esterified starch-casein composites. The phase angle value ranged from 31.7° for etherified starch-whey protein concentrate to 65.75° for etherified starch-casein composites.

Biodegradable films from native/modified starch-keratin composites

Composites were prepared using the etherified and esterified starches with keratin (Fig. 82). Starch in the filmogenic solution varied from 3 to 5%, keratin from 2 to 6% and glycerol from 20 to 30%. The physico-mechanical properties of the films and the rheological properties of the filmogenic solutions were analysed.

For the native starch-keratin composites, storage modulus ranged from 694 to 1355 Pa, loss modulus from 795 to 1315 Pa and phase angle from 33.50 to 6.00°. For the etherified starch, storage modulus ranged from 754 to 1275 Pa, loss modulus ranged from 867 to 1290 Pa and phase angle from 37.15 to 55.10°. For the esterified starch, storage modulus ranged from 501 to 1170 Pa, loss modulus from 627 to 1035 Pa and phase angle from 32.20 to 54.65°. The properties of the film made with native/modified starch with keratin showed that maximum thickness (0.17 mm) was obtained for etherified starch and minimum water absorption (16.82%) for esterified starch. Maximum tensile force (12.45 N), minimum elongation at break (30.45%), minimum moisture content (11.81%), maximum whiteness index (58.37), minimum WVTR (0.017 g mm cm^{-2}) was obtained for native starch-keratin composites.

Fig. 80. Biodegradable films from modified starch-wax composites

Fig. 81. Biodegradable films from modified starch-protein composites

Fig. 82. Biodegradable films from native starch-keratin composites

Preparation of particle boards from cassava stem

For the preparation of particle boards from cassava stems, drying characteristics of cassava stem under different methods was studied. During tray drying, the maximum average drying rate of 30.26 g $h^{-1}100g^{-1}$ bone dry matter was obtained for 2" long stem at 70°C and minimum of 10.14 g $h^{-1}100g^{-1}$ bone dry matter for 6" long stem at 50°C. The average drying rate varied from 30.26 to 14.17 g $h^{-1}100g^{-1}$bone dry matter at 70°C, 25.43 to 11.55g $h^{-1}100g^{-1}$ dry matter at 60°C and 20.55 to 10.14g $h^{-1}100g^{-1}$dry matter at 50°C. During oven drying, the maximum drying rate was only 11.36 g $h^{-1}100g^{-1}$bone dry matter for 2" long stem at 70°C, whereas minimum was 7.2 g $h^{-1}100g^{-1}$ bone dry matter for 6" long stem at 50°C. The average drying rate varied from 11.36 to 7.43 g $h^{-1}100g^{-1}$bone dry matter at 70°C, 11.24 to 7.43 g $h^{-1}100g^{-1}$ bone dry matter at 60°C and 10.54 to 7.20 g $h^{-1}100g^{-1}$ bone dry matter at 50°C. The average drying time to achieve about 10% moisture content was minimum of 21 h for 2" long stem at 70°C and maximum of 85 h at 50°C for 6" long stem under tray drying condition, whereas in oven drying, the maximum time of drying was for 6" long stem at 50°C (120 h), whereas minimum of 52.5 h for 2" stem at 70°C drying temperature.

Cassava starch based adhesives for corrugation and paper industries

Two types of adhesive formulations were prepared from modified starches viz., corrugating adhesives and binding pastes. Caustic alkali free corrugating adhesive formulations involving a preblended carrier starch and native starch components were prepared and tested. Corrugating adhesives based on broken sago were formulated and tested for tack and drying time. Native as well as oxidized starch based binding pastes were prepared and tested. The stability of starch based binding pastes was determined at different time intervals up to six months of storage.

Corrugating adhesives

Cassava starch was modified by oxidation using sodium hypochlorite to obtain starch with the required viscosity. Corrugating adhesives based on a preblended carrier starch component, which is oxidized cassava starch and a native starch component was developed. It doesn't involve the use of caustic alkali, which makes it more suitable for handling. Native cassava starch was mixed with powdered borax to form component 1 and oxidized cassava starch was mixed thoroughly with trisodium phosphate in different proportions. The two components were mixed together and the solid content was adjusted to prepare the corrugating adhesives. The adhesive samples were applied on paper boards (WCPM MG PB 300 GSM/17.2KG) at 71°C and evaluated for adhesive tack, energy and time for fibre tear. The tack of the adhesive bond measured using a spring scale, varied from 0.60-0.75 kg for different formulations and the drying time of the adhesive on paper board was in the range of 45-56 sec. The drying time increased with increase in starch content in the formulations.

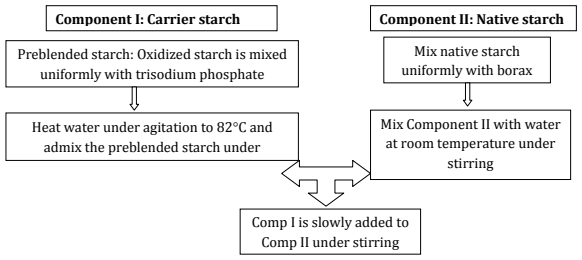
Broken sago, a by-product from sago industry was utilized for developing a corrugating adhesive based on a preblended carrier component and native starch. Instead of starch, sago powder was used as the carrier phase of the corrugating adhesive. The tack varied from 0.6-0.72 kg and the drying time was 72-106 sec. Drying time decreased with increase in sago content in the formulations and was higher compared to starch based adhesives.

Cassava starch based binding pastes

Adhesive pastes based on native as well as modified cassava starch has been developed as a multipurpose binding paste, especially for paper industries (Fig. 83).

Fig. 83. Binding pastes based on cassava starch

The advantages of the adhesive pastes include the absence of dextrin or sugar components, very good texture suitable for homogeneous application on binding surfaces and good storage stability. The adhesive paste can be stored at ambient temperature for more than six months without significant alteration in binding properties. The drying time was 2-3 min and tack was 0.70-0.80 kg for the samples (Fig. 84). Cassava starch based samples exhibited the same or higher tack in comparison to commercially available binding paste, some of which are not based on starch.



Scheme 1. Formulation of corrugating adhesive

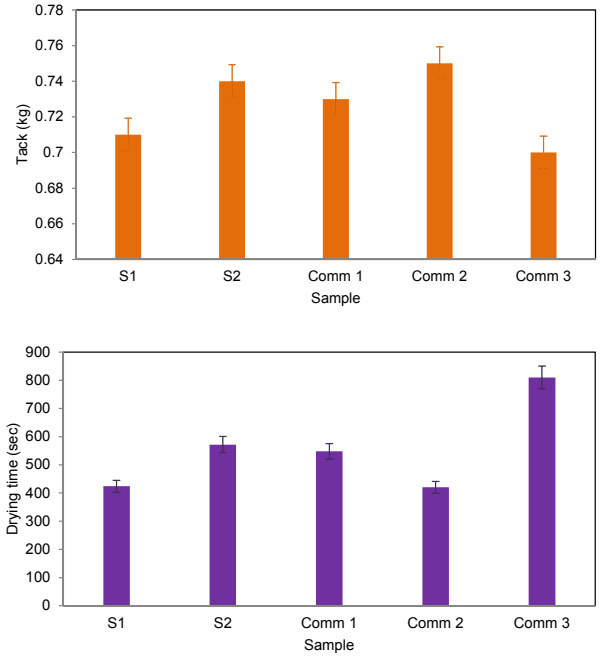


Fig. 84. Drying time and tack of cassava starch based binding pastes (S1 and S2) and commercial samples (Comm1, 2 and 3)

A ready-to-mix two-part moisture resistant adhesive with extended shelf life, which consisted of two components, that could be mixed together at the time of use was prepared and tested. It exhibited a tack of 0.68±0.06 kg and drying time of 2-4 min. Time for fibre tear was 1.67±0.52 sec.

The adhesive pastes were stored at ambient temperature and tested for tack and drying time at one month interval. The study showed that the adhesive pastes exhibited very good shelf life and storage stability and could be stored at ambient temperature for about six months without significant alteration in binding properties. The drying time was in the range of 451-465 sec and tack was in the range of 0.73-0.77 kg for sample S1 during storage period. The drying time was 460-475 sec and tack was 0.74-0.76 kg for the stored samples of S2. The two part adhesive showed fast drying compared to the other binding pastes.

Field evaluation of starch based superabsorbent polymer

A field experiment was initiated to study the effect of starch based superabsorbent polymer (SAP) on water saving and soil physical and chemical properties (Fig. 85). Sweet potato (var. Sree Arun) was used as the test crop. The treatments were as follows: T_1: SAP with 25% irrigation; T_2: SAP with 50% irrigation; T_3: SAP with 75% irrigation; T_4: SAP with 100% irrigation and T_5: Control (without SAP 100% irrigation). The SAP was applied at the rate of 1kg 200 m^{-2}. The initial soil properties were determined and the growth parameters are being taken at 15 days intervals. Observations up to 45 days after planting showed that the treatment T_3 followed by T_2 favoured growth, producing higher number of leaves, number of branches and vine length. The experiment is in progress.

Fig. 85. Field evaluation of starch based superabsorbent polymer

TUBER CROPS TECHNOLOGY ASSESSMENT, TRANSFER AND SOCIO-ECONOMIC STUDIES FOR SUSTAINABLE DEVELOPMENT

Strategic tuber crops technology intervention and impact assessment for sustainable development

The status of awareness and adoption of minisett technology and processing technologies were assessed amongst the trainees who have undergone training at the Institute on these aspects as well as non-trainees during the period. It can be conclusively inferred that a vast majority of the trainees (>80%) were fully aware of these technologies, unlike non-trainees who hardly knew them. Though, trainees were fully aware, only 37% and 25% of them attempted adopting minisett technology of cassava and elephant foot yam respectively. They opined that the trainings were informative; however, their adoption was rather restricted due to laboriousness and conditional nature such as lack of timely receipt of rainfall and unsuitability for planting large areas. Hence could not be adopted on a large scale. As regard to processing technology of cassava products, 78% of trainees attempted and the difficulties expressed were average market preference and demand limited to local markets.

The adoption of 19 identified processing technologies was measured using an adoption index specially developed for this purpose. The technology of waste water treatment and biogas production emerged as the most adopted one with an adoption index of 75, followed by hand operated chipping machine (28), mobile starch unit (20) and harvester (13). Pedal operated chipping machine, primary rasper and feed granulator were found less adopted with adoption index of 10. The remaining 11 technologies were not at all adopted. Hence, an attempt was made to measure the symbolic adoption of these technologies. Composite flour fried products alone had a symbolic adoption index of 51. Lack of capital, fluctuation in prices and market competitiveness were identified as the major constraints in adopting these technologies.

The cassava varieties were evaluated for both consumption and industrial use in on farm trials laid out in two districts of Maharashtra during 2014-2015 (Figs. 86 and 87). The yield performance of the seven cassava clones tried at Kadegoan, Sangli district under supplementary irrigation for consumption purpose indicated that Sree Athulya produced significantly higher yield (51.66 t ha^{-1}) compared to the other clones (Fig. 88). Next to this, the promising clones, Ci-888, 2-18 and 9 S-127 yielded above 30.00 t ha^{-1} and was on par. M4 gave the lowest yield of 11.00 t ha^{-1}. The other two lines, Ci-800 and CR-20-A2 yielded 27.00 and 22.00 t ha^{-1} respectively. The cooking quality of all these clones was assessed and the response of the farmers obtained on five quality parameters are presented in Table 3. It is clearly evident from the Table that though Sree Athulya gave the highest yield, as far as cooking quality is concerned, it ranked fifth. The pre-release clone, 2-18 ranked first and M4 second. It is well known that M4 is an excellent table purpose variety and no wonder it ranked second in spite of low yield. The other promising clone, 9S-127, got third rank.

To evaluate cassava varieties for industrial use, two trials were laid out, one each at Beed and Lolathgaon in Beed district with four promising cassava clones. At Beed, the mosaic resistant promising accession, CR-20-A2 produced the highest yield of about 27.00 t ha^{-1} on par with CR-35-8 (26.00 t ha^{-1}), which were significantly higher than the other two clones, Sree Athulya and 9S-127 (Fig. 89). Sree Athulya, the released triploid gave the lowest yield of 16.00 t ha^{-1}. At Lolathgaon too, a similar trend of yield performance was observed with CR-20-A2 and CR-35-8 yielding over 80.00 t ha^{-1} and were on par. Sree Athulya yielded 76.00 t ha^{-1} and 9S-127 about 56.00 t ha^{-1}. The yield trend noticed in this village is an indicator and testimony to the potential of these promising cassava clones and with proper management, their potential yield of more than 80.00 t ha^{-1} could be realized. The starch content of these clones, Sree Athulya,

CR-20-A2, CR-35-8 and 9S-127 were 31.55, 30.20, 30.60 and 28.20% respectively, pointing towards their suitability for industrial use.

Fig. 86. Harvesting and evaluation of cassava varieties in Maharashtra

Fig. 87. On farm trial of improved cassava varieties at Lolathgaon, Beed district

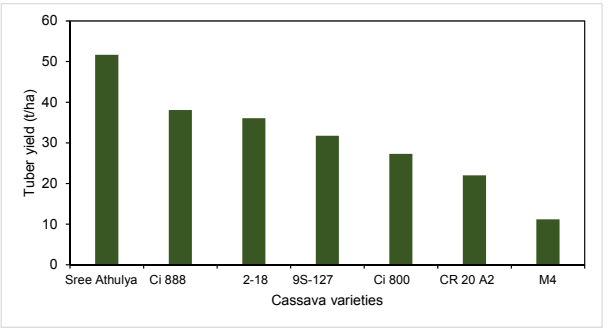


Fig. 88. Performance of cassava varieties at Sangli district, Maharashtra

Table 3. Assessment of tuber quality of cassava accessions at Sangli district, Maharashtra

Parameters	Sree Athulya	Ci-888	2-18	9S-127	Ci-800	CR-20 A2	M4
Taste	Good	Fair Blank taste	Good	Good	Fair sweet potato aroma	Not good No taste	Excellent coconut taste
Bitterness	Little bitter at the end	Not bitter	Not bitter	Not bitter	Little bitter at the end	Little bitter	Not bitter
Mealyness	Medium	Gummy, sticky	Little hard	Soft	Gummy, sticky	Hard, more fibre	Very soft
Colour	White	White	Light yellow	White	Light yellow	White	Crystal white
Overall assessment	Fair	Poor	Good	Good	Poor	Poor	Very good
Rank	V	VI	I	III	V	VII	II

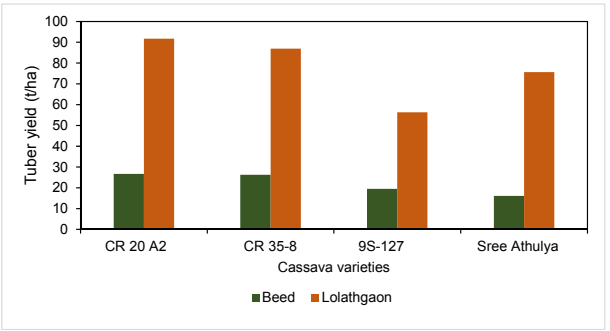


Fig. 89. Performance of cassava varieties for industrial use in Beed district

Development of optimum market positioning models for tuber crops product

A food choice survey conducted in Kerala, Tamil Nadu and Haryana among 196 consumers using the Food Choice Questionnaire (Steptoe et al., 1995) revealed that general health consciousness, familiarity and naturalness as well as sensory quality together explained 42% of the variance in the data.

The tapioca crisps developed at ICAR-CTCRI were subjected to consumer sensory evaluation (γ testing) with 31 consumers (Fig. 90). Three samples involving tapioca crisps, *Haldiram Bhujia* and local Bhujia were tasted by the consumers for their appearance, color, texture, aroma and taste on a 5-point hedonic scale. Results revealed that tapioca crisps were highly preferred over others for their aroma (Fig. 91).

Fig. 90. Consumer testing of tuber crops products in a national exhibition

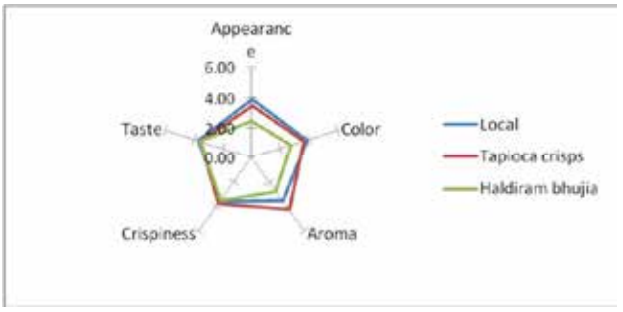


Fig. 91. Radar chart of sensory scores of test samples

ICT applications for technology transfer of tuber crops

E-Crop

Electronic device called the Electronic crop (E-Crop), which provides realistic agro advisory to the farmers was developed (Figs. 92 and 93). Many web based agro advisory services are already prevailing in India in many areas and for many crops. Most of them provide advance weather information and only few of them use crop simulation models for generating agro advisories. This device is an advanced system with low cost.

Fig. 92. E-Crop installed in sweet potato field for calibration purpose

Fig. 93. E-Crop in field

The work flow diagram of the device is given in Fig. 94.

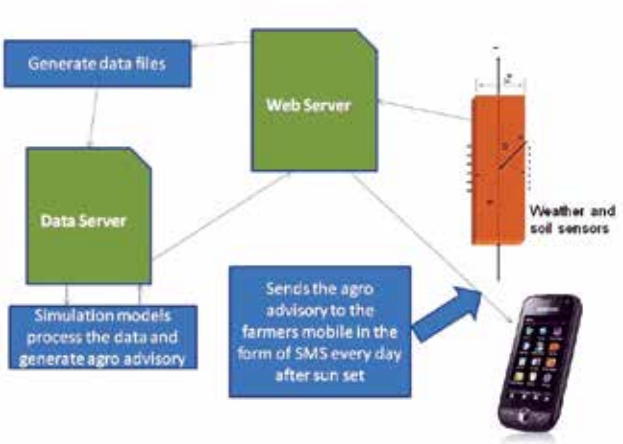


Fig. 94. Work flow diagram of E-Crop

The important parts of the device are:

1. Sensors to collect soil and weather data
2. Mounting unit to mount the unit firmly in the fields
3. SMS and internet access points

Inputs collected by the device are:

1. Maximum temperature (°C)
2. Minimum temperature (°C)
3. Relative humidity (%)
4. Solar radiation (MJ m^{-2} day^{-1})
5. Wind velocity (km h^{-1})
6. Rainfall (mm)
7. Soil moisture (mm)
8. Latitude (Floating point value)
9. Longitude (Floating point value)
10. Altitude (Floating point value)
11. Date (mm/dd/yyyy)

The device will be installed in the field. The sensors will collect the data on different weather parameters and soil parameters real-time and this data will be transferred to ICAR-CTCRI website http://www.ctcri.org. The model (s) will be stored in the data server and this server will download the weather data at around 7.30 PM automatically and the models will use the weather data to compute the crop growth and generate agro advisories. The crops grown, their date of planting and mobile number of farmer should be updated in the device from time to time. The agro advisory generated will be sent to the farmer as SMS. The data will be backed up in the internet server. Each unit costs between Rs 30,000-75,000.

Mobile apps version of Variety Identifier

Mobile apps version of Variety Identifier was developed (Fig. 95). It works under Android environment and the software is being tested so that it can be published both in Play store and ICAR-CTCRI website.

Fig. 95. Mobile apps on Variety Identifier

DEVELOPMENT OF COMPUTING TECHNOLOGIES FOR TUBER CROPS RESEARCH

SAS macro for super-scripted alphabets to interaction means in factorial experiments

Multiple comparisons of means were routinely carried out after analysis of variance of experimental data. A popular way to present the result of mean comparisons is by attaching super-scripted alphabets to the means, with a common letter shared in two means indicating that they are not significantly different. The commercial packages provide multiple comparisons by attaching alphabets for main effects but not for interaction effects in factorial experiments. A SAS macro has been developed in SAS which can be used along with PROC glm for attaching super-scripted alphabets to interaction means. This macro takes two data sets from Proc GLM created by the ODS DIFF and LSMEANS tables. If an ADJUST= option is used, the pdiffs from this are used. The pdiffs are converted to groups, labelled by numbers, and this is merged onto the lsmeans data set. Fig. 96 shows an example output of the macro.

BYGROUP=3 Effect=Fungicide_Concentrat

Obs	Department	Fungicide	LS Mean	Concentration	LetterGroup
9	D1	1	61.3333333	1	BCDE
10	D1	2	56.3333333	2	CDEF
11	D1	1	21.0000000	3	G
12	D1	2	69.0000000	1	ABC
13	D1	2	66.3333333	2	ABCD
14	D1	2	47.0000000	3	F
15	D1	3	68.3333333	1	ABCD
16	D1	3	60.6666667	2	BCDE
17	D1	3	52.3333333	3	EF
18	D1	4	726666667	1	AB
19	D1	4	75.0000000	2	A
20	D1	4	75.6666667	3	A
21	D1	5	70.0000000	1	AB
22	D1	5	56.0000000	2	DEF
23	D1	5	56.0000000	3	DEF

Fig. 96. An example of output of the macro for display of superscripted letters for interaction effects

Excel macro for creating horizontal minimum mean maximum bar chart

The distribution of data is usually visualized by boxplots. In situations where only descriptive statistics like mean, minimum and maximum are available a horizontal minimum, mean, maximum bar chart will help in data visualization. The excel macro (Fig. 97) first converts the summary data data to blank, bottom and top for plotting and all possible combinations mean, minimum and maximum are included in this macro (not clear).

	Min	Max	Average
Kerala	0.08	0.24	0.16
Odisha	0.03	0.44	0.18
Karnataka	0.03	0.35	0.14
Tamil Nadu	-0.08	0.9	0.18
Maharashtra	-0.15	0.1	-0.08
West Bengal	-0.16	0.2	-0.12
UP	-0.48	-0.08	-0.24
All	-0.6	-0.12	-0.24

	Blank	Bottom	Top
Kerala	0.08	0.08	0.08
Odisha	0.03	0.15	0.26
Karnataka	0.03	0.11	0.21
Tamil Nadu	-0.08	0.18	0.72
Maharashtra	-0.08	-0.07	0.1
West Bengal	-0.12	-0.04	0.2
UP	-0.08	-0.16	-0.24
All	-0.12	-0.12	-0.36

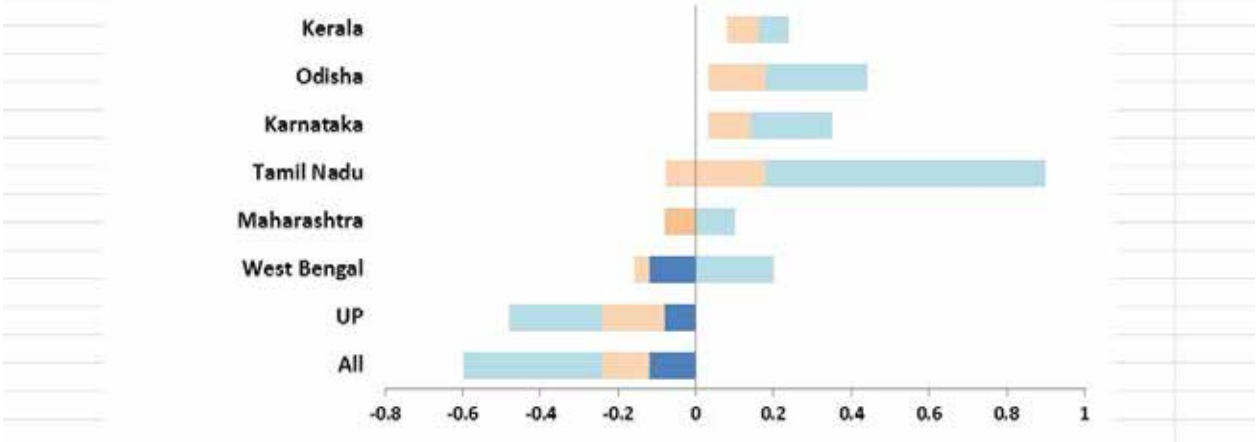


Fig. 97. The excel macro for creating horizontal minimum mean maximum bar chart

Development of online agro advisory system for tuber crops

Elephant foot yam growth simulation model EFYSIM was validated at Agali, Palakkad and validation trials are being done at different centres of ICAR-AICRP on tuber crops (Thiruvananthapuram, Dholi, Ranchi, Navsari, Dharward, Kovvur, Coimbatore, Kalyani, Faizabad and Bhubaneswar)

The crop was planted on 6 April 2014 at Agali and the data were taken twice and at harvest on 4 December 2014 (243th day after planting). The soil type of the experimental location is sandy clay. The site is located at 13.78^{o}N latitude and 77.05^{o}E longitude. Weather data for the experiment was downloaded from NASA website. The results of the trial is shown in Table 4.

Table 4. Results of validation trial of EFYSIM model at Agali, Palakkad

Parameter	Observed	Predicted	% Error
SHT(6/6/14)	55.15 cm	63.67 cm	15.43
SHT(6/10/14)	68.97 cm	15.21 cm	77.9
GIRTH(6/6/14)	14.17 cm	15.43 cm	9.12
GIRTH(6/10/14)	11.94 cm	3.69 cm	69.1
YIELD	56.79 t ha^{-1}	44.04 t/ha	22.45

The crop was cultivated under organic conditions. EFYSIM model was developed for simulating the growth of elephant foot yam under general growth conditions and is more suited for inorganic conditions. From the results of this trial, suitable modifications in the model can be made so that it can simulate the crop growth under organic conditions also.

ENHANCING FOOD SECURITY AND SUSTAINABLE LIVELIHOODS IN THE NORTH-EASTERN INDIA THROUGH TUBER CROPS TECHNOLOGIES

The North Eastern Hill Region (NEH) programme of the Institute aiming at ensuring food security through tuber crops technologies continued this year in the four implementing states of Manipur, Meghalaya, Nagaland and Tripura. Performance appraisal of the demonstrated technologies, particularly the high yielding varieties, introduction of simple post-harvest value addition technologies, laying out demonstration plots in more farmers' fields, study of value chain analysis of cassava and taro, capacity building activities etc. are the salient activities carried out during the period.

Performance appraisal of tuber crops varieties

The performance of the introduced high yielding varieties, Sree Jaya and Sree Vijaya in cassava, Muktakeshi in taro and Gajendra in elephant foot yam was assessed in the above four states using 12 criteria. The results are presented in Tables 5 and 6. Of the different tuber crops demonstrated, cassava var. Sree Jaya and Sree Vijaya were preferred by the farmers of Tripura, Nagaland and Manipur (Table 5, Fig. 98). These varieties showed over 75% establishment with very good growth, tuber shape, size and quality. The farmers opined that best cooking quality, absence of pests and diseases, good crop growth, good tuber size, yield and good market demand were the positive aspects of cassava varieties. There were no negative aspects. The value chain analysis of cassava in Nagaland (Fig. 99) indicated that both the tubers as well as the leaves were used for human consumption and as pig feed. It is interesting to note that with simple value addition, (dried leaves fetching Rs.12 kg^{-1} and grated tuber flakes Rs. 33 kg^{-1}), the farmers were able to get enhanced price for the value added commodity. Next to cassava, elephant foot yam var. Gajendra was most liked by the farmers of Tripura for its yield, good quality and less acrid tubers (Fig. 100). The performance of taro variety Muktakeshi demonstrated in Tripura, Nagaland, Manipur and Meghalaya was almost on par with local varieties (Fig. 101). Though the tubers had good taste and quality, the yield was poor with small sized tubers. As in case of cassava, in taro too, value addition has enabled the farmers to get good price for their product. Anishi - a semi-processed food from fermented taro leaves in Nagaland prepared during September-October and mostly used as vegetable substitute in human food is sold at Rs.400 kg^{-1}, whereas the fresh tubers are sold at Rs 20 kg^{-1} (Fig. 102).

Fig. 98. Demonstration plot of cassava var. Sree Jaya in Mon, Nagaland

Fig. 99. Cassava leaves being made into pig feed

Fig. 100. Demonstration plot of elephant foot yam var. Gajendra at West Tripura

Fig. 101. Demonstration plot of taro var. Muktakeshi at Mokokchung, Nagaland

Fig. 102. Processed tuber products for sale at Nagaland

Fig. 103. Farmer's seminar cum training on tuber crops at Kolasib, Mizoram

Fig. 104. Processing of cassava tubers into flakes

Fig. 105. Scientist-farmer interaction on tuber crops

Fig. 106. Workshop on tuber crops technologies

Fig. 107. Tribal women practising cassava slice preparation

In the area of post-harvest value addition, tiny interventions such as use of cassava slicer, chipping machine, grater etc. have improved the efficiency of preparation of various value added products (Figs. 103, 104, 105, 106, 107). In addition to the beneficiary farmers, additional number of farmers covering an approximate area of 30 ha was brought under demonstration programme in the implementing states. The necessary planting materials for this was mobilized from the beneficiary farmers and from the Institute, 4000 cassava stems, 3 tonnes of taro and 500 kg each of elephant foot yam and greater yam were supplied.

Capacity building programmes

To equip the officials of implementing agencies as well as the beneficiary farmers about the programme and advanced production and processing technologies of tuber crops, a series of capacity building programmes have been organized at various programme states as detailed below:

- Training on Value addition on Tuber Crops to NEH partners at ICAR-CTCRI, Thiruvananthapuram, during 24-29 March 2014
- Farmers Seminar cum Training on Tuber crops at Kolasib, Mizoram, on 4 August 2014
- Group Discussion on Community Tuber Crops Processing Incubation at Riha, Manipur, on 8 July 2014
- Group Discussion on ICAR-CTCRI NEH Action Plan at Ngahui, Manipur, on 8 August 2014
- Farmers Seminar on ICAR-CTCRI-NEH Programme and Tuber Crops at DKVK, Chebri, Tripura, on 3 November 2014
- Farmers Seminar on ICAR-CTCRI-NEH and Tuber Crops at Dengasi, Tura, Meghalaya, on 7 November 2014
- Group Discussion on ICAR-CTCRI-NEH programme at Jaluki B, Pheren, Nagaland, on 10 November 2014
- Field Day on Cassava Harvest at Alisopore, Tuensang, Nagaland, on 12 November 2014
- Group Discussion on ICAR-CTCRI-NEH Programme at Aboi, Mon, Nagaland,

LIVELIHOOD IMPROVEMENT OF TRIBAL FARMERS THROUGH TUBER CROPS TECHNOLOGIES IN TRIBAL AREAS

The primary objective of this programme is to enhance livelihood security of tribal farmers by careful application of improved tuber crop production and processing technologies. The specific objectives are:

- To assess existing level of livelihood profiles of tuber crops farmers indicating technology awareness and utilisation.
- To identify appropriate tuber crops interventions especially yam and yam bean cultivation and sweet potato in animal feed.
- To demonstrate the potential of proven tuber crops technologies through front-line demonstrations.

Table 5. Performance appraisal of cassava under ICAR-CTCRI-NEH programme

No.	Parameters	Cassava		
		Tripura	Nagaland	Manipur
1.	Establishment	> 75%	100%	> 75%
2.	Growth	Good	Very good	Good
3.	Disease symptoms	Nil	Nil	Nil
4.	Severity	NA	NA	NA
5.	Pest incidence	Nil	Nil	Nil
6.	Yield	3 kg plant^{-1}	4-5 kg plant^{-1}	3 kg plant^{-1}
7.	Yield comparison	Good	Very good	Good
8.	Shape	Good	Very good	Good
9.	Size	Good	Very good	Good
10.	Quality	Good	Very good	Good
11.	Positive	Best cooking quality, no pests and diseases	Less pest & diseases, good crop growth good tuber size, yield and good market demand	Best cooking quality, no pests and diseases
12.	Negative	-	-	-

Table 6. Performance appraisal of taro and elephant foot yam under ICAR-CTCRI-NEH programme

No.	Parameters	Taro				Elephant foot yam
		Tripura	Nagaland	Manipur	Meghalaya	Tripura
1.	Establishment	> 75%	100%	75-100%	75-100%	> 75%
2.	Growth	Good	Very good	Good to very good	Good to very good	Good
3.	Disease symptoms	Nil	Very less infected	Leaf blight	Nil	Tuber rotting , Yellowing of leaves
4.	Severity	0%	< 20%	20%	NA	less
5.	Pest incidence	Nil	< 20%	Nil	Weevil	Nil
6.	Yield	750 g plant^{-1}	750 g plant^{-1}	750 g plant^{-1}	500 g plant^{-1}	3 kg plant^{-1}
7.	Yield comparison	Poor	Good	Good	Good	Good
8.	Shape	Good	Good	Poor-Good	Poor-Good	Good
9.	Size	Good	Good	Poor-Good	Poor-Good	Good
10.	Quality	Good	Very good	Very good	Very good	Good
11.	Positive	Low acrid, Good quality	Less duration, Less diseases, Good cooking Eating quality	Better taste, less pest & diseases, Leaves can be used for consumption	Low acrid, Good quality	Low acrid, cooking quality
12.	Negative	Poor yield	Small size tuber, Less yield	Small size tubers, short duration of storage	Poor yield	-

- To develop capacity of scientists and development workers in KVKs, development departments, NGOs as well as progressive farmers.
- To establish tuber crops value addition units and test marketing centres in potential areas.
- To organize the awareness and technical seminars, Kisan Melas etc.
- To assess the impact of tuber crops technology interventions on food security, nutritional security and livelihoods of the beneficiaries through participatory mode.

The collaborating partners for implementation are Ramakrishna Mission, Narayanpur, Chhattisgarh, Ramakrishna Mission, Ranchi, Jharkhand, ORRISSA (NGO), Kandhamal, PRAGATI (NGO), Koraput. A total of 260 beneficiaries from seven villages were impacted. Quality planting materials of elephant foot yam (var. Gajendra) 7500 kg, taro (var. Muktakeshi) 6000 kg, yam (var. Orissa Elite) 6000 kg, cassava stems 3500, yam bean seeds 100 kg and sweet potato cuttings 1.1 lakhs were distributed to 260 tribal farmers of Jharkhand, Chhattisgarh and Odisha (Table 7). Two one day on-farm trainings each at Gurgurjhari and Kulli villages were organized in Ranchi district, Jharkhand state in collaboration with Ramakrishna Mission, Ranchi on Root and tuber crops production and value addition (Figs. 108 and 109). The on-farm trainings in these villages were conducted twice, one before planting and the other during crop growth. Besides, three month old chicks and ducks worth Rs. one lakh were distributed in Kulli and Gurgurjhari villages of Jharkhand (Fig. 110). In Koraput (Odisha), 35 days old poultry birds were provided to tribal households in two adopted villages. In Kandhamal districts of Odisha, small farm implements for field operations and wire mesh for fencing was provided to 29 adopted tribal farmers (Fig. 111). A demonstration on improved cultivation of elephant foot yam and integrated disease management was conducted in one acre area in Baruatoli village of Ranchi district. A three day training programme was organized for tribal farmers of Jharkhand at Regional Centre of ICAR-CTCRI, Bhubaneswar. A three day training programme was organized for tribal farmers of Kandhamal and Koraput districts of Odisha state at Regional Centre, ICAR-CTCRI, Bhubaneswar (Table 8). Kisan Gosthi and training on tuber crop technologies were conducted at RKM, Narayanpur, and Abujmar in Chhattisgarh (Figs. 112, 113, 114, 115).

Fig. 108. Demonstration of arrowroot starch extraction

Fig. 109. Demonstration trial in taro

Fig. 110. Distribution of ducks and chicks

Fig. 111. Distribution of farm implements

Fig. 112. View of farmers training

Fig. 113. View of farmers training

Table 7. Quantity of planting materials distributed

Crop & Variety	Ranchi, Jharkhand	Narayanpur, Chhattisgarh	Koraput, Odisha	Kandhamal, Odisha	Total
Elephant foot yam (var. Gajendra)	3000 kg	2000 kg	1000 kg	500 kg	7500 kg
Taro (var. Muktakeshi)	2000 kg	2000 kg	1000 kg	1000 kg	6000 kg
Yam (var. Orissa Elite)	1000 kg	1000 kg	2000 kg	2000 kg	6000 kg
Cassava stems (var. Sree Vijaya, Sree Jaya and Vellayani Hraswa)	-	2000 Nos.	1000 Nos.	500 Nos.	3500 Nos.
Yam bean seeds (var. RM-1)	25 kg	25 kg	25 kg	25 kg	100 kg
Sweet potato (var. Kishan and ST-14)	-	-	60,000	50,000	1,10,000

Fig. 114. Exhibition on genetic diversity of tuber crops

Fig. 115. Training cum custodian meet on Protection of Plant Varieties & Farmers Right on tropical tuber crops

Table 8. Trainings conducted under the TSP programme

Date	Location	Training programmes
19 May 2014	Barwatoli, Angara block, Ranchi	Integrated management of fungal diseases of elephant foot yam
22 May 2014	Kulli, Jharkhand	Livelihood improvement through tuber crops
23 May 2014	Gurgurjhari, Ranchi, Jharkhand	Livelihood improvement through tuber crops
23 July 2014	Dayanidhiguda, Odisha	Farming system involving tuber crops
06 August 20 14	Mallickpada, Odisha	Farming system involving tuber crops
12 August 2014	Gurgurjari, Jharkhand	Livelihood improvement through tuber crops
13 August 2014	Kulli, Jharkhand	Livelihood improvement through tuber crops
9 September 2014	Brawada, Chhattisgarh	Livelihood improvement through tuber crops
16-18 October 2014	Regional Centre, ICAR-CTCRI, Bhubaneswar, Odisha	Livelihood improvement through tuber crops
22 January 2015	Regional Centre, ICAR-CTCRI, Bhubaneswar, Odisha	Training cum custodian meet on Protection of Plant Varieties & Farmers Right on tropical tuber crops

EXTERNALLY AIDED PROJECTS

1. **Adapting clonally propagated crops to climatic and commercial changes** (EU funded INEA Taro Programme; PI: Dr. Archana Mukherjee)

Multiplied, distributed and conducted participatory trials in seven different locations of Odisha with exotic and indigenous taro lines. Through participatory approach, evaluated and selected 37 exotic taro lines with desirable traits. Participatory breeding trials were conducted. Seeds comprising of different combinations among the exotic taro lines as well as combinations between exotic and indigenous lines were generated. A stock of seed samples of 25 different combinations has been collected. Seedlings raised *in vitro* of 10 different combinations and seed cultures are being maintained. Immune lines to leaf blight and early maturing taro were identified. Hybrid seeds were generated between exotic and indigenous taro (Fig. 116).

2. **Development of standards of DUS testing for varietal gene bank in elephant foot yam and taro** (PPV & FRA, New Delhi; PI: Dr. Archana Mukherjee)

DUS facility was developed. Varietal gene bank of elephant foot yam and taro were established (Fig. 117). DUS guidelines for taro and elephant foot yam based on primary, secondary and tertiary essential as well as optional characteristics were developed and submitted. In conclusion, DUS guidelines were developed for taro and elephant foot yam.

Fig. 116. Participatory breeding trials in taro under INEA project

Fig. 117. Varietal gene bank of taro and elephant foot yam at Regional Centre, ICAR-CTCRI, Bhubaneswar

3. **DUS testing centre for cassava and sweet potato** (PPV & FRA, New Delhi; PI: Dr. M. N. Sheela)

With the objective of maintaining the varietal gene bank of cassava and sweet potato, released and reference varieties of cassava (36) and sweet potato (44) were maintained in the field gene bank and DUS testing trials were conducted (Fig. 118). Planting material of released varieties of cassava and sweet potato were supplied to farmers and research institutions.

Fig. 118. A view of the sweet potato varietal gene bank maintained in the DUS field gene bank

4. **Indo-Swiss cassava network project** (Indo Swiss Collaboration on Biotechnology (ISCB) and Department of Biotechnology, Govt. of India, New Delhi; PIs: Dr. M. N. Sheela and Dr.T. Makeshkumar

For developing a reliable protocol for genetic transformation in cassava, four varieties viz., H-226, H-165, Sree Apoorva and Sree Athulya were used for FEC induction and these showed positive results after two months. Cassava mosaic virus clones (SLCMV/ ICMV full length and partial dimers) in *E. coli* (31 clones) and *Agrobacterium* (18 clones) were obtained from Madurai Kamaraj University for the purpose. CMD resistant transgenic line (TMS 60444) having resistance to ACMV available at ETH was imported. CMD resistant clones available at ICAR-CTCRI viz., CR-43-7, CR-43-2, CR-24-4, 9S-127, 11S-33, 8S-501-2 and S-1284 (Figs. 119 and 120) were selected for large scale multiplication for conducting trials in Tamil Nadu. *In vitro* cultures of high starch CMD resistant clones were established (30 cultures) for micropropagation. Planting material of released varieties viz., Sree Athulya, Sree Apoorva and H-226 were planted in the field for large scale multiplication. The CMD resistant clones were screened for the presence of virus through multiplex PCR using virus specific primers.

Fig. 119. 8S-501-2, a CMD resistant clone

Fig. 120. S-1284, a CMD resistant clone

5. **Tuber crops development project, Kerala** (Department of Agriculture, Govt. of Kerala; PI: Dr. James George)

The project was initiated during November 2013. The objectives of the project are large scale production of clean and disease free planting materials in cassava, yams and elephant foot yam through micro-propagation and minisett techniques; to lay out demonstration plots of tuber crops for popularization of agro-techniques and new varieties for higher economic returns; to conduct need based and skill oriented training programmes to farmers on planting material production, agro-techniques and value addition and exposure visits to research institutes and model farms (Figs. 121 and 122).

Physical achievements

Districts covered	:	Four (Kollam, Palaghat, Malappuram and Kasaragod)
Tuber crops covered	:	Cassava, elephant foot yam, greater yam
Total area covered	:	36 ha
Cassava	:	20 ha (Malappuram: 15 ha and Attappadi: 5 ha)
Elephant foot yam	:	8 ha (Kollam: 6 ha and Attappadi: 2 ha)
Greater yam	:	8 ha (Kasaragod: 6 ha and Attappadi: 2 ha)
No. of beneficiaries	:	600

Grama Panchayats covered under the project

Kinanoor (Kasaragod)	:	150 units of 10 cents each for greater yam
Mankada (Malappuram)	:	50 units of 25 cents each for cassava
Kootilangadi (Malappuram)	:	100 units of 25 cents each for cassava
Thazhava (Kollam)	:	150 units of 10 cents each for elephant foot yam

Tribal belt of Attapadi (Palakkad Dt.)

Pudur (Attappadi)	:	50 units of 25 cents each for cassava
Agali (Attappadi)	:	50 units of 10 cents each for elephant foot yam
Sholayur (Attappadi)	:	50 units of 10 cents each for greater yam

Varieties distributed (Table 9)

Cassava	:	Sree Jaya, Sree Vijaya, CTM-806, CTM-815, CTM-818, CTM-820
Elephant foot yam	:	Gajendra
Greater yam	:	Kovvur-1
Training programmes conducted	:	12
Exposure visits arranged for farmers	:	4

Fig. 121. Awareness programme at Vellamunda Krishi Bhavan (left) and project review meeting at Agali Krishi Bhavan (right) under Tuber crops development project

Fig. 122. Harvest festival of cassava at Koottilangadi gramapanchayat under Tuber crops development project

Table 9. Quantity of planting material produced and projected area expansion for cassava

Panchayat/ District	Crop	Area covered (ha)	Total production	Projected area expansion (ha)
Mankada (Malappuram)	Cassava	5	1,20,000 stems	50
Kootilangadi (Malappuram)	Cassava	10	2,40,000 tons	100
Kinanoor (Kasaragod)	Greater yam	6	150 tons	60
Thazhava (Kollam)	Elephant foot yam	6	180 tons	30
Tribal region of Attapadi, Palakkad district				
Pudur	Cassava	5	1,20,000 stems	50
Sholayur	Greater yam	2	56 tons	20
Agali	Elephant foot yam	2	70 tons	10

Under the extended project in phase II, Rs. 75 lakhs was provided by the State Department of Agriculture, Govt. of Kerala during November 2014. Under this programme four new districts were selected and tuber crops were allotted as given in Table 10, for tuber crops development.

Table 10. Crop and its distribution in selected districts (Phase II)

Crop	Varieties	District/Panchayat	No. of units x unit area (cents)
Cassava	CMR lines, Sree Jaya, Sree Vijaya	Trichur (Mattathur) Wayanad (Vellamunda)	100 x 10 50 x 10
Yams	Kovvur-1	Kannur (Ayyankunnu) Wayanad (Thavinhal)	100 x 10 50 x 10
Elephant foot yam	Gajendra	Pathanamthitta (Elanthur) Wayanad (Ambalavayal)	100 x 10 50 x 10

6. **Network on organic farming in horticulture crops (NOFH)** (ICAR-Indian Institute of Spices Research, Kozhikode, as Lead Centre; PI: Dr. G. Suja)

The field experiment on Development of Technology for Organic Production in Chinese potato was planted on 31 October 2014 (Fig. 123). All the treatments as per the technical programme were imposed. Samples of organic manures and inputs used were taken for chemical analyses. The major chemical parameters (pH, organic C, available N, P and K) of the soil prior to experimentation were estimated. The physical properties of the soil viz., bulk density, particle density, porosity, water holding capacity, aggregate stability and texture were also determined. The activity of soil enzymes, dehydrogenase, acid phosphatase and urease were assessed. All the soil properties for site characterization were also done. The experiment is in progress and the crop has completed 5.5 months. The growth characters (plant height, canopy spread, leaf production, LAI) and biomass production and partitioning were measured at 2 months interval. The changes in the major chemical properties of the soil as influenced by treatments were studied at 45 days interval. The crop is yet to be harvested.

Fig. 123. The field experiment on Organic production of Chinese potato

7. **Enhancing the economic viability of coconut based cropping systems for land use planning in Kerala state** (Department of Agriculture, Govt. of Kerala and Kerala State Planning Board; PI: Dr. K. Susan John)

The project aims at development of best management practices (BMP's) with focus on surface and sub soil acidity, plant available soil macro, secondary

and micro nutrient contents and plant tissue nutrient contents in tuber crops, elephant foot yam and cassava, as intercrops in coconut gardens. The project also further envisages validation and demonstration of BMP's for enhancing crop production in farmer's field in the selected agro-ecological units and development of customized fertilizer formulation for the cultivation of elephant foot yam intercropped in coconut garden for better profit, soil and tuber quality for the three agro-ecological units of Kerala.

8. **Assessment of soil fertility and preparation of soil fertility maps for various agro-ecosystems of Odisha** (Directorate of Horticulture, Govt. of Odisha; PI: Dr. Laxmi Narayana)

The project was sponsored under Rashtriya Krishi Vikas Yojana and an amount of Rs. 42.3 lakhs has been released during the first year of the project. Under the project, the Soil Science Laboratory had been strengthened by installing double beam UV-VIS spectrophotometer, environmental shaker, electronic balance, pH meter, conductivity meter, mechanical stirrer, hydrometer, refrigerator, stainless steel hydraulic laboratory stools, racks, quartz double distillation unit, plastic ware, reagents and chemicals. Two Laboratory Assistants and two Skilled Assistants have been recruited for the project work. The Deputy Directors of Horticulture representing various districts of Odisha have collected profile soil samples from horticulture based cropping systems and sent to this institute for analysis.

9. **Contract Research Project**

Characterisation of new magnesium fertilizer products, their effect on soil properties and yield of tropical tuber crops (Swamy Engineering Consultants, 22-A, Kumar Nagar South, IIIrd Street (Opposite Surya Theatre), Tirupur 641 603, Tamil Nadu; PI: Dr. G. Byju)

Natural rock mineral fertilizers are gaining importance worldwide. We have developed two natural rock mineral fertilizers from mine wastes of a quarry in Tirupur, Tamil Nadu, which contain different minerals such as websterite, magnesite, diopside, pyroxenite etc. The two products developed were characterised and two patent applications were filed for the following products; i. bioactive multinutrient rock mineral fertilizer (patent application No. 6247/CHE/2014) and ii. multinutrient rock mineral fertilizer (patent application No. 6248/CHE/2014). Nutrient release characteristics of the new natural rock mineral fertilizers are being studied by conducting a pot experiment.

10. **IISR outreach project on PhytoFuRa- Taro leaf blight** (ICAR Network Project; PI: Dr. M. L. Jeeva)

Isolation and characterization of *Phytophthora colocasiae*

Twenty *P. colocasiae* isolates were added to the existing culture collection and a total of 70 isolates are being maintained at ICAR-CTCRI repository. All isolates were confirmed to the species level using species specific PCR. They produced an expected band size of 220 bp when amplified using RL-F/RL-R primer pairs. The genetic diversity of the *P. colocasiae* isolates were performed using Random Amplified Microsatellite (RAMS) markers. A total of 40 isolates were amplified using the primers. The results showed that a considerable amount of genetic diversity existed among *P. colocasiae* collected from various geographical boundaries of India. The isolates from similar origins were grouped into sub-populations and their degree of diversity was calculated. Genetic diversity varied among populations with the percentage of polymorphic loci (PPB) values ranging from 45.45% (Kerala) to 72.73% (Andhra Pradesh), with an average of 61.37%. The average Nei's gene diversity (H) was estimated to be 0.10 within populations and 0.11 for the pooled populations. The dendrogram generated from the RAMS data grouped *P. colocasiae* isolates irrespective of their geographical origin or phenotypic characters. This reinforces the fact that *P. colocasiae* frequently move across the country creating new strains in the process. Multigene molecular phylogeny was carried out using selected target genes/loci. A total of 50 *P. colocasiae* isolates representing the breadth of major taro growing regions of India were used for the study.

Amplification of targets ITS rDNA, Beta Tubulin, Larger Subunit (LSU) has been completed.

qPCR based resistance screening of taro

A rapid and reliable method for resistance screening in taro cultivars has been established using the developed qPCR assay. The method attempts to quantify the pathogen load in the infected plant tissue using absolute quantification approach. The hypothesis is that the pathogen load in an infected tissue directly correlates to the resistance exhibited by the taro cultivar. The more susceptible the plant, the more is the pathogen load and vice versa.

Identification of *P. colocasiae* genes differentially expressed during infection on taro

The aim of the study was to provide useful insights into the *P. colocasiae* genes that are differentially expressed during susceptible interaction with taro using a suppression subtractive hybridization (SSH) approach. Using this approach we have identified specific suite of genes that may have a putative role in pathogenicity of *P. colocasiae*. We have used the adequacy of Reverse northern, qRT-PCR analysis to validate our findings.

The results of the study revealed that a greater portion of the genes identified belong to the biological process category followed by molecular and cellular component category (Fig. 124).

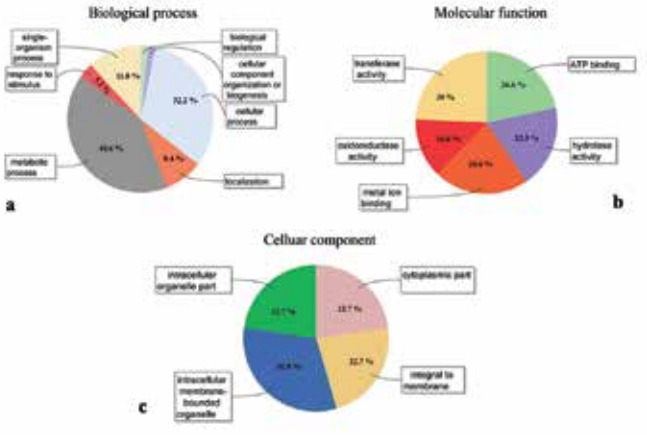


Fig. 124. Gene ontology annotations of *P. colocasiae* ESTs obtained through the SSH technique (a) biological process (b) molecular function (c) cellular function

Identification of resistant gene analogues (RGAs) in taro

The majority of the plant disease resistance (R) genes cloned so far contain nucleotide-binding sites (NBS) and a leucine-rich repeat (LRR) domain. Here, an attempt was made to isolate the putative RGAs (NBS-LRR domains) from representative taro cultivars previously classified as resistant (R), moderately resistant (MR), susceptible (S) and highly susceptible (HS) (Fig. 125).

Reported degenerate primers targeting various motifs have been procured and PCR cycling conditions have been standardized. Currently, sequencing of the amplified fragments (approx. 500 bp) is being carried out.

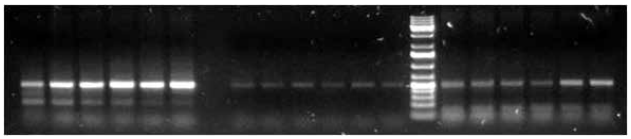


Fig. 125. Amplification of RGAs using degenerate primers

11. Participatory technology transfer of cassava based biopesticides for the management of vegetable pests

(Department of Agriculture, Govt. of Kerala; PI: Dr. C. A. Jayaprakas)

The pest incidence in the vegetable crops in farmers' fields were recorded. The biopesticide reformulated for the management of leaf feeding caterpillars in vegetable crops were sprayed at different concentrations. Training programmes were conducted for the farmers on the use of ICAR-CTCRI developed biopesticides periodically.

12. Development of mosaic resistant transgenic cassava (ICAR; PI: Dr. T. Makeshkumar)

FEC production was carried out with cassava varieties, H-226, H-165, Sree Apoorva and Sree Athulya. Only H-165 and transgenic tobacco lines have shown response for FEC production. Seeds of transgenic tobacco lines were grown in transgenic glass house for challenge inoculation. Transformation of TMS 60444 FEC with different gene constructs (viz.,

SLCMV//Rep iv2; SLCMV//TrAP iv2; SLCMV//Syn) was done.

13. **Improving the livelihoods of smallholder cassava farmers through better access to growth markets** (Cassava Gmarkets; PI: Dr. J.T.Sheriff)

The process variations in the production of high quality cassava flour (HQCF) were recorded. Simulation studies were conducted to optimise loading density (3, 5 and 7 kgm^{-2}) of cassava chips during drying under open yard, solar yard and mechanical tray. Freshly harvested cassava tuber was peeled, washed and converted into either chips or gratings (Fig. 126). The chips were directly dried under open sun/solar yard with 3, 5 and 7 kg m^{-2} loading densities. The gratings were pressed in a hydraulic press and the force was held for 1.5 h. The percentages of moisture and starch loss during pressing were recorded. The hourly moisture loss of the chips and grating samples at different loading densities and the type of drying were analysed. The starch and sugar content of HQCF ranged from 78.00 to 82.84% and 1.50 to 4.60%, respectively.

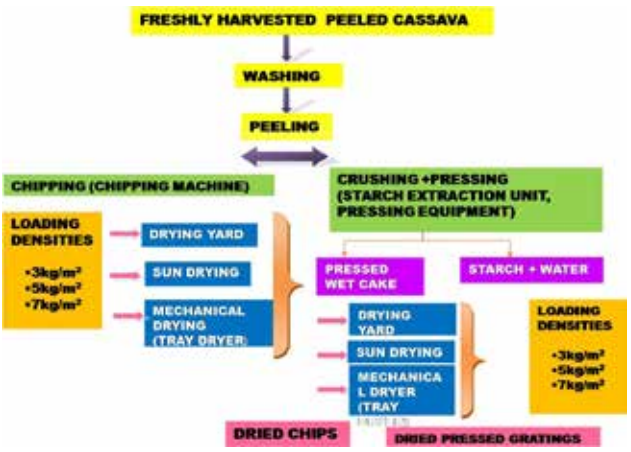


Fig. 126. Improving the livelihoods of smallholder cassava farmers through better access to growth markets

14. **Development of a process for the production of low-moist gelatinised dough for using in cassava papad making machine** (Contract Research Project; PI: Dr. J.T. Sheriff)

Under this project a process for the production of low-moist gelatinised dough for using in cassava (tapioca) *papad* making machine was developed and the technology was transferred to M/s Boosters International, Kanyakumari District (Fig.127). The ratio of cassava flour and the amount of normal and hot water required for mixing and kneading was optimised. Effect of addition of whey protein and cassava starch on dough consistency was studied. The effects of resting time on dough consistency, dough consistency on *papad* size and source of drying on quality of *papad* were analysed. The moisture in the dough for obtaining 120 mmØ sheet was optimized and cassava starch and reduction of moisture in the dough were analysed. The process has been licensed to M/s Boosters International Kanyakumari District, Tamilnadu and a joint patent has been filed.

Fig. 127. Cassava papad

15. **Refinement of starch indicator developed by CTCRI and design of next generation gadget for measuring starch content of cassava (*Manihot esculenta* Crantz.) tubers** (Department of Science & Technology, Govt. of India, New Delhi; PI: Dr. J.T. Sheriff)

Electrical properties of cassava tubers were measured using LCR meter (Agilent E4980A) in the varieties Sree Jaya, 4-2, C-77, CMR-205, MVD-1, H-165, CO-2 and Sree Apoorva in the frequency range of 100 Hz to 2 MHz. The frequency range of 10 KHz-1MHz significantly influenced the properties. The capacitance, impedance, dissipation factor and phase angle values ranged from $1.14x10^{-10}$to $2.952x10^{-7}$, 1.05 to 9.13, 0.052 kΩ to 4.09 kΩ and -43.51 to -6.6°, respectively.The properties of H-97, Sree Prakash, Sree Visakham, Sree Rekha, Sree Sahya and CO-3 tubers were measured in the frequency range of 10 KHz to 1 MHz. The capacitance, impedance, dissipation factor and phase angle values ranged from 2.2 $x10^{-10}$ to 8.62 x 10^{-9}, 0.64 to 2.32, 0.053 to 1.57 kΩ and -57.33 to -20.00°, respectively.

The varieties C-43/11, CMR-73, CMR-15, CMR-1, CMR-8, CO-1, H-226, Co-4, Mnga, Sree Harsha, CMR-24-4, AVU-27, AVU-15, 9S-125, 9S-236, Pulladu Kappa, Sree Vijaya, Sree Harsha and CMR-1 were analysed in the frequency range of 700 Hz to 1 MHz and correlated with biochemical attributes. The capacitance, impedance, dissipation factor and phase angle values ranged from 2.2 x 10^{-10} to 4.657 $X10^{-8}$, 0.64 to 6.06, 0.053 to 2.72 kΩ and -43.08 to -9.38°, respectively.

Electrical properties of the cassava varieties, AVU-27, AVU-15, 9S-125, 9S-236, Pulladu Kappa were analysed in the frequency range of 20 KHz to 40 KHz and correlated with biochemical attributes. Correlation between electrical and biochemical properties of cassava was established. Microwave studies were conducted in four varieties of cassava, Sree Jaya, H-226, M-4, CMR-100 using Vector Network analyser in S-band frequency. The real (ε^1) and imaginary (ε'') part of di-electric constant varied from 5.31 to 84.92 and 0.0036 to 0.4368, respectively. Tanδ and loss factor values ranged from 0.422 to 489.09 x 10^{-4}, respectively.The hardness of the peeled and unpeeled cassava tubers were measured for the proximal, middle and distal regions of 19 varieties, Sree Jaya, 4-2, H-165, CO-2, Sree Apoorva, H-97, Sree Prakash, Sree Visakham, Sree Rekha, Sree Sahya, CO-3, C-43-11, CO-1, CO-4, Mnga, Sree Harsha, CR-24-4, H-226 and CR-43-7. Hardness of the peeled and unpeeled tubers varied from 1.1836 to 3.033 N and 0.6714 to 2.481 N, respectively. The hardness values were correlated with electrical and biochemical properties of the tuber.

16. **Techno-incubation centre** (Small Farmers' Agribusiness Consortium, Department of Agriculture, Govt. of Kerala; PI: Dr. M.S.Sajeev)

A Techno-Incubation Centre was established at ICAR-CTCRI with the financial support from Govt. of Kerala under Small Farmers' Agribusiness Consortium, a Society under the Kerala Agriculture Department (Fig. 128). The Centre with its Flour Production Unit, Snack food Manufacturing Unit and Fried Chips Manufacturing Unit (FCMU) undertake the following activities (i) edible grade flour production from cassava tubers and its further processing into value added snack foods including fried snack foods and oil free extruded ready-to-eat snacks (ii) production of low glycaemic pasta products as food for diabetic and obese people as well as nutritionally enhanced pasta for children and youth and (iii) manufacturing fried cassava chips and strips with good texture and taste respectively. The prospective entrepreneurs will also get an idea on the essential infrastructural requirement for setting up a processing unit on tapioca based value added products. Besides, training will also be a major activity under the Techno-Incubation Centre, so that a large number of people could derive benefit from it. This benefit could be translated into an income generating activity not only for the entrepreneurs, but also for the cassava farmers through backward integration. Foundation stone for the centre was laid on 17 August 2013 and the completed building with infrastructure facilities was inaugurated by Shri. Oommen Chandy, Hon'ble Chief Minister of Kerala on 31 July 2014 (Fig. 128). Five training programmes were organized for about 70 prospective entrepreneurs on the production of value added products (Fig. 129).

Fig. 128. Inauguration of techno-incubation centre by Shri. Oommen Chandy, Hon'ble Chief Minister of Kerala

Fig. 129. Training programme on production of value added products

17. **High value compounds from tuber crops**
(ICAR Consortia Research Platform Project; PI: Dr. A.N.Jyothi)

Tubers of the purple-fleshed *Dioscorea alata* (Da-340) and leaves and tubers of sweet potato accessions, S-1467 and ST-13 respectively were dried using different drying techniques for the evaluation of anthocyanin retention. Purple coloured *D. alata* flour prepared by a controlled drying technique was subjected to biochemical compositional analysis. The moisture content of the fresh tuber was 75.67%. The proximate analysis revealed that it was composed of starch (63.32%), total sugars (3.40%), crude protein (7.23%), crude fibre (9.69%) and total ash (3.99%). The total polyphenols, flavonoids and anthocyanins were 0.272% (dry wt. basis), 0.179% (dry wt. basis) and 0.129% (fresh wt. basis) respectively. The diosgenin content was 0.09% (dry wt. basis). Studies on pH dependence of colour of anthocyanins from *D. alata* tubers showed that it changed from bright red to pale green as the pH varied from 1.00 to 13.00. Chlorophyll was removed from the methanolic extract of anthocyanins from sweet potato leaves and subjected to column chromatography using Amberlite XAD7. The partially purified anthocyanins were concentrated and subjected to column chromatography using Sephadex LH20.

18. **Participatory development of a web based user friendly cassava expert system**
(Kerala State Council for Science, Technology and Environment; PI: Dr. Santhosh Mithra)

Discussions were held with industrialists, traders of cassava starch and sago and farmers of Tamil Nadu. Salem district, Tamil Nadu has the maximum number of industrial units producing starch and sago from cassava tubers. Visit to these places were made to explore the possibilities of widening the online cassava market with the participation of manufacturers, traders and farmers. Sree Visakham Cassava Expert System (Fig. 130) was presented before the starch and sago manufacturers and traders and the feedback in the form of suggestions were collected (Fig. 131). They readily agreed to register in the online market and offered all support to this venture. Similar meetings of farmers and agents were arranged at Erode and Sandhiyoor. The participants actively participated in the discussions, gave their suggestions, agreed to register in the online market and offered full support to this venture.

Fig. 130. Home page of Sree Visakham Cassava Expert System

Fig. 131. Data collection and evaluation through participatory method for the development of cassava expert system

Technologies Assessed, Transferred, Consultancy and Patent Services

Technologies transferred

The Institute Technology Management Unit (ITMU) has been active in carrying out the following IP activities during the period 2014-2015. The unit had engaged with public/private parties for the commercialization of the following technologies:

1. **Value added fried products and fried chips from tapioca on a consultancy mode to the following parties**
   - CARD-KVK, Kolabhagom Post, Thadiyoor, Thiruvalla, Pathanamthitta, Kerala.
   - Mr. Pradeep Kumar, M/s Avita PB Nutriments Pvt. Ltd., Thiruvananthapuram.
   - Mitraniketan-KVK, Vellanad, Thiruvananthapuram.
2. **Licensing of technology for the production of quick cooking dehydrated cassava tubers to** CARD-KVK, Kolabhagom Post, Thadiyoor, Thiruvalla, Pathanamthitta, Kerala.
3. **Collaborative (contractual) agreement for product development of mineral and biomineral fertilizer** with M/s. Swamy Engineering Consultants, 22-A, Kumar Nagar South, IIIrd Street, Tirupur, Tamil Nadu.
4. **Licensing of technology for the production of low-moist gelatinized dough for using in cassava (tapioca) papad making machine** to M/s Boosters International, 7-72/2, Nedumangadu Road, Aravaimozhi, Kanyakumari Dist, Tamil Nadu.
5. **Integration of sweet potato production and processing in Belgaum on a consultancy mode** with M/s Belgaum Minerals, 91 Vinaya Nagar, Hindalga Road, Belgaum.
6. **A cassava-rice based extruded product** developed under Contract Research Project sponsored by M/s Kalady Rice Millers Consortium was released by the firm in the brand name ”LALA” on 31 July 2014.
7. **Fabrication and supply of Hand operated cassava chipping machine, Mobile starch extraction plant and Cassava harvester** to CIP-SWCA, Bhubaneswar; NEH; AICRP on Tuber Crops, Kalyani Centre and P.K. Devadasan, Calicut for Rs. 620400.

Patent services

The unit had taken initiative in filing two patent applications.

1. **Bioactive Multinutrient Rock Mineral Fertilizer (Application No.6247/CHE/2014)**
2. **Multinutrient Rock Mineral Fertilizer (Application No.6248/CHE/2014)**

Agreement with CARD-KVK

Agreement with Mitraniketan-KVK

Agreement with M/s Swamy Engineering Consultants

Technologies assessed

- K efficient cassava genotypes viz., Aniyoor for edible and 7 III E3-5 for industrial use
- INM strategy for tannia.
- Nutrient efficient biofertilizers (N fixers, P solubilizers and K solubilizers) as substitutes to chemical fertilizers in elephant foot yam.
- Organic farming of yams and taro.

Technologies developed/in pipeline

Potential tuber crops genotypes

- The CMD resistant cassava hybrids with good culinary quality, 11S-33 and early bulking, 8S501-2.
- Early maturing, nutrient efficient, weevil tolerant white and orange-fleshed sweet potato viz., S-30/16, S-30/15 and Baster-45.
- Four greater yam hybrids with high yield and culinary quality viz., Dah-821, Dah-319, Dah-9-196 and Dah-23F for conducting AICRP trials in seven yam growing states of India.
- The purple-fleshed yams, Da-331 and Da-340 with high yield and anthocyanin content for release in Kerala.
- The white yam hybrid, DRh-657 with compact tuber shape, high yield and cooking quality for release in Kerala.
- Ten TLB tolerant taro accessions viz., C-84, C-203, C-370, C-388, C-565, C-679, C-690 (violet), C-717, C-723 and IC-012470.
- Salt tolerant varieties, Samrat and CIP-440127 of sweet potato for island ecosystem of Andaman & Nicobar Islands.
- High yielding sweet potato varieties for hill ecosystem of Gajapti and Koraput districts of Odisha, viz., Kisan and orange-fleshed sweet potato variety, ST-14.

DUS guidelines

- DUS testing guidelines for cassava, sweet potato, taro and elephant foot yam to facilitate the registration of varieties.

Production technologies

- Supplementary irrigation at the rate of 100% of cumulative pan evaporation through drip system during 13-24 weeks after planting produce maximum corm yield in elephant foot yam.
- Drip fertigation at three days interval with 50 numbers of split or at four days interval with 40 numbers of split of recommended dose of fertilizer (N-P_2O5-K_2O 120-60-120 kg ha^{-1}) in elephant foot yam.
- Rice (var. Aiswarya)-pulse (black gram var. Co-6)-short-duration cassava (var. Sree Vijaya) is a feasible sequential cropping system with saving of half FYM & N and full P to cassava.

Soil nutrient management technologies

- Nutrient zonation maps for SSNM of cassava, elephant foot yam and sweet potato in major growing environments of India.
- Customised fertilizers incorporating major, secondary and micronutrients for cassava, elephant foot yam and sweet potato for major growing environments of India.
- Soil test based fertilizer-cum-manurial recommendation for cassava, including

secondary and micronutrients. The rate of application was FYM @ 5 t ha^{-1}+ NPK @ 78:0:48 kg ha^{-1} along with Mg and Zn as $MgSO_4$ and $ZnSO_4$ @ 10 and 2.5 kg ha^{-1} respectively resulted in a tuber yield of 26.75 t ha^{-1} on par with the highest dose of NPK@ 125:50:125 kg ha^{-1} along with 12.5 t ha^{-1} FYM (30.84 t ha^{-1}).

- Cassava thippi compost @ 3 t ha^{-1} (24.66 t ha^{-1}) is an alternative to commonly used organic manures in cassava viz., FYM @ 12.5 t ha^{-1} (26.64 t ha^{-1}), green manuring *in situ* with cowpea (27.18 t ha^{-1}), vermicompost @ 4 t ha^{-1} (22.15 t ha^{-1}) and coir pith compost @ 5 t ha^{-1} (21.78 t ha^{-1}).
- Cassava as a sustainable crop for continuous cultivation: Even after continuous cultivation of cassava for 10 years without any manures and fertilizers, the yield of 17.93 t ha^{-1} was maintained.
- Low input management strategy for cassava comprising of NPK efficient genotypes, AC. No. 905 and 906 along with soil test based nutrient management as FYM @ 12.5 t ha^{-1} and NPK @106:0:83 kg ha^{-1} along with Mg and Zn as $MgSO_4$ and $ZnSO_4$ @ 2.5 and 12.5 kg ha^{-1} respectively resulted in a tuber yield of 33.68 and 34.72 t ha^{-1} with a B:C ratio of 4.43 and 4.57 respectively.
- Aniyoor in the name of Sree Pavithra was recommended by the Kerala State Sub Committee on Seeds to be released as K efficient cassava variety.
- INM strategy for yam bean : Integrated use of lime @ 5.0 q ha^{-1} + FYM @ 10 t ha^{-1} + optimum dose of NPK (N, P_2O_5 and K_2O @ 80:60:80 kg ha^{-1}) + $ZnSO_4$ @ 10 kg ha^{-1} produced highest tuber yields and quality attributes of yam bean in acid Alfisols.
- Usage of graded doses of NPK for yield and quality in yam bean : Use of increased doses (sub optimal, optimal and super optimal doses) of NPK showed an increasing trend of tuber yields of yam bean under acid soils.
- Technologies on use of various organic sources (FYM, vermicompost and green manure) for yield and quality of yam bean and their residual effect on soil quality were generated.
- Two new multinutrient, natural, rock mineral fertilizers: Two customized natural rock mineral fertilizers were developed from the Magnesite and Dunite mines of Tirupur, Tamil Nadu. The multinutrient fertilizer mixture when enriched with N fixing bacteria and algae, P solubilising bacteria, K mobilizing bacteria such as *Pseudomonas putida, Azospirillum brasiliense, Bacillus pumilus and Bacillus sphaericus* increase the bioavailability of different plant nutrients. The new mineral fertilizer product has the advantages of easy storage and free from damage on prolonged storage.

Protection technologies

- Chemical extraction of kairomones from sweet potato, effective against sweet potato weevil.
- Sex pheromone technology against sweet potato weevil.
- IDM technology for diseases of elephant foot yam.
- Corm treatment with vermiwash (10%) and application of vermicompost for the management of collar rot incidence in elephant foot yam.
- A reliable *in vitro* leaf disc method to screen taro for leaf blight resistance.
- A method to identify differentially expressed genes of *Phytophthora colocasiae* during infection in taro.
- Reversion phenomenon in CMD established with symptoms and real time analysis.

- RT-LAMP and NASH based detection of *Dasheen mosaic virus* in elephant foot yam.
- Full genome of *Dasheen mosaic virus* and *Taro bacilliform virus* of taro in elephant foot yam and partial genome of *Dasheen mosaic virus* and *Taro bacilliform virus* of taro.
- Specific primers for the diagnosis of *Yam Maclura virus* and *Yam mild mosaic virus*.
- Gene constructs for SLCMV and infectious clones.

Value added products

- Process for preparing lacto-pickle from elephant foot yam.
- Process for the production of low-moist gelatinised dough for cassava papad.
- Technologies developed for cassava-rice based extruded product, sweet potato based gluten-free spaghetti, n*utriose* fortified noodles and high protein starch noodles, functional sago with high protein and calcium content, noodles using resistant starch enhanced (annealed) cassava starch, cereal grain type pasta including cassava-maida and cassava-rice blends, sweet potato spaghetti enriched with bioactive pigments and purple yam flour based pasta rich in anthocyanins, composite flour containing orange-fleshed sweet potato with wheat/ragi.
- Tuber crop-based value added products such as wheat:orange-fleshed sweet potato composite flour, orange-fleshed sweet potato flour with ragi flour, validated and demonstrated in farmers, particularly in tribal farmers' households under Tribal Sub-plan in Koraput, Phulbani districts of Odisha.

Post-harvest machineries

- Motorized cassava chipping machine.

User interface

- Electronic Crop (E-Crop) was developed.
- The climate-based ecological niche model, ECOCROP, has been calibrated and methodology developed using geoinformatics tools for studying climate change impact on cassava, sweet potato, elephant foot yam and yams and for developing suitable management strategy to minimize climate change impact.
- Technology to develop site specific natural resource management at farm level has been developed using geoinformatics tools. As a case study, complete information about the soil physical and chemical characteristics of the 130 locations of the ICAR-CTCRI farm have been used to generate kriged maps of the various parameters using geospatial analyst tool of ArcGIS 10. The technology is found to be very effective in interpolating such data that are spatially related and can be used to develop site specific crop management at field level. Based on the information generated, a decision support tool, Fertcalc_CTCRI was developed for nutrient management of the farm. The tool has been uploaded in www.ctcri.in.
- Sree Vishakam Thirunal Cassava Expert System with cassava protector, online market, agro advisory for online use (**http://www.ctcritools.in/cassava expert**).
- EFYSIM: A simulation model for elephant foot yam growth for offline use.

Education and Training

Education

ICAR-CTCRI is recognized as an approved Research Centre by University of Kerala, Kannur University and Manonmaniam Sundaranar University for undertaking Ph. D programmes on tuber crops. During the period, the institute has offered exposure training to students, imparted technical guidance for 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 M.Sc. Course on Integrated Biotechnology.

Particulars of the programme	Number of participants
M. Sc. project work of students	12
M. Sc. course on Integrated Biotechnology	11
Ph. D programmes	15

Trainings organized by ICAR-CTCRI

- Fifty nine exposure trainings on "Production and Processing of Tuber Crops". The programmes benefited about 1000 farmers, 110 extension officers and 871 students from Kerala, Tamil Nadu, Arunachal Pradesh and Maharashtra.
- Four Farmers Training-cum-Workshop were organised at Kolasib (Mizoram), West Tripura (Tripura), West Garo Hills (Meghalaya) and Pheren (Nagaland). Over 300 beneficiary farmers were trained on improved technologies for tuber crops production and utilisation.
- Three Training Programmes of five days duration each on "Tuber Crops for Livelihood and Nutritional Security in Watershed Areas of Keonjhar, Odisha" during 30 April-4 May 2014, 20-24 May 2014 and 9-13 June 2014. The training programmes were sponsored by Project Director, Watersheds, Keonjhar, Odisha. A total of 90 farmers in three batches had been imparted three days training on various agricultural technologies including tuber crops technologies and two days field visits.
- Training on "Group Enterprises for Value Addition in Agricultural and Allied Sector" with a lecture on "Promotion of rural agro processing centre by farmers and promotion of Farmers interest group for management of PHT and value addition" on 11 June 2014 organized by SAMETI, Thiruvananthapuram.
- A Training Programme on "Production and Value Addition in Tuber Crops" in collaboration with PRAGATI NGO at Dayanidhiguda, Koraput block of Koraput district, Odisha on 23 July 2014. Around 60 farmers and farm women attended the training programme. The event was marked by trainings on agro-techniques and preparation of home-made products from tuber crops, distribution of yam bean seeds to farmers, visits to FLDs and tuber crops nursery plots being laid out by SOVA NGO, sweet potato fields (cv. ST-14) and nursery plot of tuber crops being maintained by PRAGATI NGO in collaboration with ICAR-CTCRI.
- A Farmers' Seminar-cum-Training Programme on "Production and Value Addition in Tuber Crops" and "Improved Agro-techniques in Tuber Crops Cultivation with Perspective to Mizoram"in collaboration with ICAR Research Complex for NEH Region, Mizoram Centre, Kolasib, Mizoram on 4 August 2014 under the ICAR-CTCRI-ICAR NEH project "Enhancing food security and sustainable livelihoods in the North-Eastern India through tuber crops technologies". About 60 farmers and farm women from Bilkhawthlir and Kolasib blocks of Kolasib district, Mizoram attended

the training programme. Distributed yam bean seeds to the farmers as an introduction of new technology.

- Training on "Tuber Crops Production and Processing" for 50 farmers of Kanyakumari district sponsored by National Horticulture Mission through Department of Horticulture, Tamil Nadu, during 1-5 September 2014.
- Harvest festival on 30 October 2014 at ICAR-CPCRI Kasaragod, where the banana fields were treated with ICAR-CTCRI developed biopesticide.
- Training Programme on "ICAR-CTCRI Developed Biopesticide" at Kootilangadi and Mankada, during 28-29 January 2015.
- Training programme to ATMs of ATMA on "Value Addition in Tuber Crops" on 26 February 2015.
- Training programme on "Value Added Products from Tuber Crops", at Techno-Incubation Centre, ICAR-CTCRI, during January-March 2015.
- Training programme on "Advanced Production Technology of Tropical Tuber Crops and their Value Addition" sponsored by Government of Assam during 15-21 February 2015. Fifteen farmers from the state and two officials from the Department of Agriculture participated in the training.
- Training on "Value Addition in Tuber Crops" for the field level functionaries of ICAR-CTCRI NEH and TSP programmes during 24-29 March 2015.
- More than 125 classes on production, protection, processing and value addition aspects were handled by scientists of various divisions under different programmes within and outside the institute that benefitted department officials, subject matter specialists, students and farmers all over the country. The specific topics covered were improved varieties, tissue culture, agro-techniques with special focus on organic management, INM, IPM, vermicomposting, biopesticides and biocontrol strategies, post-harvest management and value addition.

Trainings attended by ICAR-CTCRI staff

Sl. No.	Name	Particulars of the training	Period
1.	N. Krishna Radhika, B. S. Prakash Krishnan	Writing Better Research Proposals for Early Career for Root and Tuber Crops Scientists organized by ISTRC and ISRC	20 May 2014
2.	Dr. V. Ravi	Climate Change Adaptation and Mitigation at Lucknow	2-4 June 2014
3.	Dr. G. Byju	Remote Sensing for Decision Makers at Indian Institute of Remote Sensing (IIRS), Dehradun, Uttarakhand	17-20 June 2014
4.	Dr. C. Mohan, Dr. A. Asha Devi, N. Krishna Radhika	User Training on 3500 Genetic Analyser at Whitefield, Bangalore	20-22 August 2014

5.	Dr. M. S. Sajeev, Dr. V. S. Santhosh Mithra	Management development programme on Consultancy Project Management at NAARM, Hyderabad	22-27 August 2014
6.	Dr. G. Byju	Microwave Remote Sensing Applications, National Remote Sensing Centre (NRSC), Department of Space, Hyderabad	17-30 September 2014
7.	Smt. K. Padmini Nair	Hindi Workshop-2014 (Workshop No. 412) At Central Hindi Training Institute, New Delhi	27-31 October 2014
8.	Dr. M. Nedunchezhiyan	Advanced Techno-Management for Scientists at Administrative Staff College of India, Hyderabad	27 October to 28 November 2014
9.	Shri. T. Vijaya Kumara Kurup	Cadre Specific Programme for ICAR Officials at ISTM, New Delhi	23 November to 5 December 2014
10.	Shri. Davis Joseph	Records Management for Records Officers conducted by NAI Regional Centre, Puducherry	26-28 November 2014
11.	Dr. P. S. Sivakumar	Outcome Budget for Officers Dealing with Preparation of Outcome Budget at ISTM	5-6 January 2015
12.	Dr. J. T. Sheriff	Training programme for technical committee members of Bureau of Indian Standards at National Institute of Training for Standardisation, Noida	27-28 January 2015

Awards and Recognitions

Awards

- Dr. S. K. Chakrabarti received the Shri. L. C. Sikka Endowment Award of National Academy of Agricultural Sciences for the biennium 2013-2014 for his outstanding contribution towards ensuring food and nutritional security.
- Dr. S. K. Chakrabarti received the Dr. S. Ramanujam Award of ICAR-Central Potato Research Institute for the block year 2008-2011 for his outstanding research/leadership in potato improvement/production.
- Dr. A. Jeevalatha, Dr. R. Baswaraj, Dr. Ravinder Kumar, Dr. S. K. Chakrabarti and Dr. B. P. Singh received the Indian Potato Association-Kaushalaya Sikka Award for the year 2014 for their outstanding contribution in the field of potato disease diagnostics.
- Dr. G. Padmaja, Dr. J.T. Sheriff, Dr. M.S. Sajeev, Dr. A.N. Jyothi and Ms. L. Rajalekshmi received the ICAR Team Research Award for outstanding Interdisciplinary Team Research in Agriculture and Allied Sciences for the Biennium 2011-2012.
- Dr. K. Susan John received the International Potash Institute (IPI)- Fertilizer Association of India (FAI) Award-2014 for promoting balanced and integrated fertilizer use with emphasis on potassium considering the research and extension accomplishments for the last 10 years. The award carried Rs. 50000, gold medal, certificate and a citation.

Dr. S. K. Chakrabarti receiving Dr. S. Ramanujam award from Shri. Virender Kashyap, Hon'ble Member of Parliament, Shimla, Himachal Pradesh and Dr. Gurbachan Singh, Chairman, ASRB, New Delhi

Dr. S. K. Chakrabarti receiving IPA-Kaushalaya Sikka award from Her Excellency Smt. Urmila Singh, Hon'ble Governor, Himachal Pradesh and Dr. N. K. Krishna Kumar, DDG (Hort.Sci.), ICAR

Dr. G. Padmaja, Dr. J.T. Sheriff, Dr. M.S. Sajeev, Dr. A.N. Jyothi amd Ms. L. Rajalekshmi who received the ICAR Team Research Award with Dr. S. K. Chakrabarti, Director, ICAR-CTCRI

Dr. K. Susan John receiving the International Potash Institute (IPI)- Fertilizer Association of India (FAI) Award-2014 from Shri. J.P. Mohapatra, Secretary, Ministry of Chemicals and Fertilizers at New Delhi

- Dr. R.C. Ray bagged the Samanta Chandrasekhar Award for the year 2013 for outstanding contribution in the field of Life Sciences, instituted by Odissa Vigyana Academy, Department of Science & Technology, Govt. of Odisha.
- Dr. R. C. Ray received the Eminent Agricultural Scientist Award 2014, awarded by Odisha Krushaka Mancha, Odisha.
- Dr. Archana Mukherjee received the EAES International Award 2014.

Best stall in exhibitions

- The Regional Centre Stall got second prize at the Regional Agriculture Fair held at Central Potato Research Station, Patna, during 19-22 March 2015.
- The Regional Centre Stall got second prize in National Farmers Fair and Vegetable Show at ICAR-Indian Institute of Vegetable Research, Varanasi, during 30-31 January 2015.

Best oral presentation awards

- Ms. K. B. Vinutha, bagged the Second position for the Best Paper in the UGC sponsored National Seminar-cum-Workshop on Plant Systematics and Herbarium Techniques-Celebrating Diversity in the Understanding of Science organized by the Dept. of Botany, KKTM Govt. College, Kodungallur in collaboration with Botanical Survey of India and Association for the Advancement of Biodiversity Science during 24-25 September 2014.
- Ms. Tanmayee Samantaray and Dr. Rajasekhara Rao Korada received the Best Oral Paper Award for the paper "Sweet potato weevil pheromone technology: A messiah for weevil management" at the National Entomologists' Meet, held at Indian Institute of Natural Resins and Gums (IINRG), Ranchi, Jharkhand, India, during 5-7 February 2015.

Best poster presentation awards

- Dr. R. Muthuraj bagged Best Poster Award for the work entitled "Aeroponic technology an alternative efficient method for potato seed production" presented at the 6th Indian Horticulture Congress: An International Meet on Horticulture for Inclusive Growth held at TNAU, Coimbatore, during 6-9 November 2014.
- Ms. Tanmayee Samantaray and Dr. Rajasekhara Rao Korada bagged the Best Poster Award for the paper titled "From the discovery to the field: A successful journey of sweet potato weevil sex pheromone" at the National Symposium on Entomology as a Science and IPM as a Technology- the Way Forward, held at CAU, Pasighat, Arunachal Pradesh, India, during 14-15 November 2014.
- Ms. S. Kamala and Dr. T. Makeshkumar, received the Best Poster Award for the research paper titled "A reverse transcription loop mediated isothermal amplification assay for rapid detection of *Dasheen mosaic virus* in *Amorphophallus paeoniifolius*" at the 67th Annual Meeting of IPS & National Symposium on Understanding Host–Pathogen Interaction through Science of Omics, held at ICAR-IISR, Kozhikode, during 16-17 March 2015.

Award of Ph.D.

- Ms. P. Parvathy Chandran has been awarded Ph.D. degree in Chemistry by University of Kerala for her thesis entitled "Starch based superabsorbent polymers: Synthesis, characterization and water sorption behaviour" undertaken under the guidance of Dr. A. N. Jyothi.
- Ms. S. Kamala has been awarded Ph.D. degree in Biotechnology by University of

Kerala for her thesis entitled, "Diagnosis and management of *Dasheen mosaic virus* infecting *Amorphophallus paeoniifolius* through biotechnological approaches" undertaken under the guidance of Dr. T. Makeshkumar.

Institute awards

The Sardar Patel Outstanding Agricultural Institute Award for 2005 was won by this Institute. The Award money was received in 2006. The interest from the money was utilized to award the following best technical, administrative and skilled support staff of ICAR-CTCRI for 2014.

- Shri M. Easwaran, Technical Officer: Best technical staff award
- Shri. M. Padmakumar: Best administrative staff award
- Shri. Bijoykumar Naik: Best skilled support staff award

Recognitions

- Dr. S. K. Chakrabarti was Chief guest for the inauguration of World Space Week by Vikram Sarabhai Space Centre, Thiruvananthapuram, Kerala.
- Dr. S. K. Chakrabarti was Chief guest for the inauguration of National Seminar on Challenges and Innovative Approaches in Crop Improvement held at Agricultural College and Research Institute (TNAU), Madurai, during 16-17 December 2014.
- Dr. S. K. Chakrabarti was Chief guest for the inauguration of National Seminar on New Perspectives on Proteomics organizd by IUCGGT, University of Kerala on 27 March 2015.
- Dr. T. Makeshkumar was conferred as Fellow of Indian Phytopathological Society.
- Dr. Archana Mukherjee was recognized as a lead speaker and delivered a lecture on "Distant hybridization and tropical tuber crops: Designing for adaptive food-nutrition and livelihood" in the National Seminar on Distant Hybridization on Horticultural Crops at ICAR-Indian Institute of Horticultural Research, Bangalore, during 22-23 January 2015.
- Dr. R.C.Ray was recognized as session chair (Food Safety) and keynote speaker on the topic "Preservation of vegetables by lactic acid fermentation for food and nutrition security" at the 2nd Asian Food Safety and Security Associations (AFSA), Dong Nai University of Technology, Bien Hoa city, Vietnam, during 15- 18 August 2014.
- Dr. R.C.Ray was recognized as session chair (Bio-processing) and delivered a plenary lecture on "Bioprocessing sweet potatoes for bioethanol: Prospects and limitations" at the 1st International Conference on Bioenergy, Kapurthala, Punjab, during 14-17 March 2015.
- Dr. M. N. Sheela was recognized as external examiner for the evaluation of the M.Sc./ Ph.D thesis of Kerala Agricultural University.
- Dr. M. N. Sheela was recognized as member of the National Accreditation Committee of the Seed Farm of the National Horticultural Board.
- Dr. G. Byju was recognized as Member, Academic Council, Kerala Agricultural University.
- Dr. G. Byju was recognized as Member, Executive Committee, National Institute of Plant Science Technology (NIPST), Mahatma Gandhi University, Kottayam, Kerala.
- Dr. G. Byju was recognized as Guest Faculty at IIITMK, Government of Kerala, Technopark for the M. Sc. Geoinformatics programme for handling the course "Geoinformatics applications in agriculture".
- Dr. K. Susan John was recognized as expert,

Technical Committee for the purchase of Atomic Absorption Spectrophotometer for Fertilizer Quality Control Laboratory, Department of Agriculture, Government of Kerala.

- Dr. K. Susan John was recognized as external examiner for U.G. and P.G at Kerala Agricultural University and University of Horticultural Sciences, Bagalkot Karnataka.
- Dr. K. Susan John was invited to deliver a talk on '"Soil fertility related constraints and recommendations to crop production in Kerala" in connection with the World Soil Day Celebration on 5 December 2014 at Kanakakkunnu Palace, Thiruvananthapuram organized by Department of Soil Survey and Soil Conservation, Government of Kerala.
- Dr. G. Byju and Dr. V. Ramesh were recognized as experts in the technical committee for the purchase of Atomic Absorption Spectrophotometers for soil testing laboratories of Kerala State during March 2015.
- Dr. G. Suja was recognised as an invited speaker to deliver a lead lecture on the topic "Crop diversification with tropical tuber crops for food and livelihood security" in the National Symposium on Agricultural Diversification for Sustainable Livelihood and Environmental Security organized jointly by the Indian Society of Agronomy and Punjab Agricultural University (PAU) at PAU, Ludhiana, during 18-20 November 2014.
- Dr. G. Suja was invited as a resource person to deliver a lecture titled "Food and nutritional security-Tuber crops good candidates" at the 23rd Refresher Course on Environmental Sciences at the UGC-Academic Staff College, University of Kerala, Thiruvananthapuram, on 16 January 2015.
- Dr. M. L. Jeeva was recognized as examiner for M. Sc./Ph.D. at Kerala Agricultural University and University of Agricultural Sciences, Dharwad.
- Dr. K. I. Asha was recognized as external examiner for evaluation of Ph.D. Thesis at Arya Vaidya Sala, Kottakkal, Malappuram, Kerala.
- Dr. K. I. Asha was recognized as external examiner in the board of examiners of the M.Sc. Genetics and Plant Breeding CSS I Examination at Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram, during 15-17 May 2014.
- Dr. T. Makeshkumar was recognized as Co-organising Secretary, VIROCON 2014.
- Dr. T. Makeshkumar was Member, Organising Commiittee of ISMPP Meeting, Madurai, IPS meeting in Calicut and Member of IBSC in ICAR-IISR, Kozhikode.
- Dr. T. Makeshkumar was recognized as examiner for Ph.D. thesis evaluation at University of Agricultural Sciences, Bangalore, Bharathiar University, Coimbatore, Kuvempu University, Shimoga and Tamil Nadu Agricultural University, Coimbatore
- Dr. A. Asha Devi was recognized as external examiner for M.Sc. (Int.) Biotechnology thesis, College of Agriculture, Vellayani.
- Dr. Shirly Raichal Anil was recognized as external examiner in the board of examiners of the M.Sc. Genetics and Plant Breeding CSS IV Examination, Department of Botany, University of Kerala, Kariavattom, Thiruvananthapuram.
- Dr. C. Mohan was recognized as external examiner for conducting the M.Sc. thesis viva voce at Agricultural College and Research Institute, Killikulam, Vallanad.

- Dr. P. Sethuraman Sivakumar successfully completed a year-long Post-Doctoral Research at the Eating Behaviour Research Clinic, Department of Psychology, Florida State University, Tallahassee, USA under the Fulbright–Nehru Postdoctoral Fellowship.
- Dr. P. Sethuraman Sivakumar is recognized as Global Ambassador by the Centre for Global Engagement, Florida State University, Tallahassee, USA for his efforts to promote the Indian culture among the US citizens under the Global Ambassadors Programme.
- Dr. P. Sethuraman Sivakumar was awarded Outreach Lecturing Fund of the International Institute of Education, Washington DC, USA to deliver the Fulbright invited lecture on functional foods at the University of Hawaii, Hilo, USA, during 28-29 January 2014.
- Dr. V. S. Santhosh Mithra served as examiner for two M. Tech thesis in the Department of Future Studies, University of Kerala.
- Drs. M. L. Jeeva, S. S. Veena, T. Makeshkumar, M. N. Sheela, A. Asha Devi, A.N. Jyothi and J. Sreekumar are recognized as guide for M.Sc. (Int.) Biotechnology course at College of Agriculture, Vellayani, Thiruvananthapuram.
- Dr. Rajasekhara Rao Korada was recognized as a lead speaker to deliver a lecture on "Plant-insect chemical dialogues: Understanding the complex interactions" in the National Symposium on Entomology as a Science and IPM as a Technology- The Way Forward, organized by the Entomological Society of India at Central Agricultural University, Pasighat, Arunachal Pradesh, during 14-15 November 2014.
- Dr. Rajasekhara Rao Korada was recognized as a lead speaker to deliver a lecture on "Plant insect chemical interactions: The way forward" in the National Entomologists' Meet, organized by Society of Advancement of Natural Resins and Gums at Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand, during 5-7 February 2015.
- Drs. C. A. Jayaprakas, M. N. Sheela, M. L. Jeeva, T. Makeshkumar, G. Byju, K. Susan John and G. Suja are recognized as guide for Ph.D. program in University of Kerala, Kariavattom, Thiruvananthapuram.
- Dr. K. I. Asha is recognized as guide for Ph.D. program in Calicut University, Calicut.
- Dr. C. Mohan is recognized as guide for Ph.D. program at Tamil Nadu Agricultural University, Coimbatore.

Linkages and Collaborations in India and Abroad

The Institute has International collaborations with International Potato Centre (CIP), Lima, Peru; International Centre for Tropical Agriculture (CIAT), Cali, Columbia; CIRAD, France and EMBRAPA, Brazil. ICAR-CTCRI is also a partner to the CIP-IFAD project on Root and tubers for food security. An Indo-Swiss project on cassava mosaic disease is ongoing since 2014.

Extra mural funding is provided through 25 external aided projects including one International Network Project on Taro funded by European Commission and national funding agencies are ICAR, NAIP, Government of India-DST, DBT, DIT, UGC and NABARD, KSPB, SHM, RKVY, KSCSTE etc. Linkages were established with KVK, Mithranikethan, Thiruvananthapuram and CARD KVK, Pathanamthitta for validation and demonstration of the on station results on INM in tannia, K efficient cassava genotypes and nutrient efficient biofertilizers in elephant foot yam.

The North-Eastern Hill Region programme and Tribal Sub Plan sanctioned during 12th plan have been implemented by distributing planting materials, conducting seminars, training programmes and demonstrations in KVKs and NGOs of the implementing States as functional partners.

Under Tuber crops development scheme funded by Department of Agriculture, Govt. of Kerala, the planting materials of cassava, elephant foot yam and greater yam have been distributed to the farmers by conducting training programs and exposure visits.

The Institute has established active linkage with Indian Institute of Remote Sensing (IIRS), Dehradun, Uttarakhand, for conducting a study on acreage estimation of cassava in Salem district using temporal Landsat–8 OLI images and kernel based possibilistic c-means (PCM) classification approach. Atmospherically corrected temporal images were developed (using ATCOR) that greatly reduces the influence of atmosphere and solar illumination. The NDVI images are also generated to reduce the spectral dimensionality of the data. Collaboration has been established with the Department of Agriculture, Govt. of Kerala and Kerala State Planning Board under an external funded project on "Enhancing the economic viability of coconut based cropping systems for land use planning in Kerala state". MoU has been signed with Indian Institute of Crop Processing Technology (IICPT), Thanjavur for mutual utilisation of research facilities.

The Regional Centre has established active linkages with CIP, OTELP, Bhubaneswar, Directorate of Horticulture and Agriculture, Bhubaneswar, PRAVA several NGOs' and SAUs' and ICAR Institutes and other development agencies for conducting front line demonstrations, capacity building, information exchange etc. Besides the Regional Centre has collaboration with Central Rice Research Institute (ICAR-CRRI), Cuttack for isolation and identification of stink bug pheromones and plant volatiles and with Central Research Institute for Jute and Allied Fibres (ICAR-CRIJAF), Barrackpore for jute volatiles and jute pests.

ICAR-All India Coordinated Research Project on Tuber Crops, Head Quarters, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala

All India Coordinated Research Project on Tuber Crops (AICRPTC), functioning since 1968, is the largest national network of tropical root and tuber crops covering 16 states and one Union territory (Andaman and Nicobar Islands). A new centre was added during 2014, in Himachal Pradesh. Presently, AICRPTC centres are located in 13 State Agricultural Universities, four ICAR Institutions and one Central Agricultural University. The details of the centres and their mandate crops are mentioned below:

Sl. No.	Name of the coordinating centres	Year of start	Mandate crops
1	ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram 695 017, Kerala	1968	Cassava, sweet potato, yams and aroids
2	Rajendra Agricultural University, Dholi, Muzaffarpur (Dt.) 843 121, Bihar	1968	Sweet potato, taro, yams, elephant foot yam and yam bean
3	Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu	1968	Cassava at Yethapur (Salem), sweet potato, taro, elephant foot yam and yams at Coimbatore
4	Dr. YSR Horticultural University, Venkataramannagudem 534 101, Andhra Pradesh	1969	Cassava at Venkataramannagudem sweet potato and aroids at Rajendranagar, taro, elephant foot yam and yams at Kovvur
5	Assam Agricultural University, Jorhat 785 013, Assam	1971	Cassava, sweet potato, taro, elephant foot yam and yams
6	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri (Dt) 415 712, Maharashtra	1975	Cassava, sweet potato, taro, elephant foot yam and yams
7	ICAR Research Complex for NEH Region, Barapani 793 103, Meghalaya	1975	Cassava, sweet potato and aroids
8	Bidhan Chandra Krishi Viswavidyalaya, Nadia, Kalyani, 741 235, West Bengal	1976	Sweet potato, taro, yam bean, elephant foot yam and yams
9	Regional Centre of ICAR-CTCRI, Bhubaneswar 751 019, Odisha	1983	Cassava, sweet potato, aroids and yams
10	Birsa Agricultural University, Kanke, Ranchi 834 006, Jharkand	1987	Sweet potato, taro, elephant foot yam and yam bean
11	Indira Gandhi Agricultural University, Kumharwand, Jagdalpur (Baster) 494 005, Chhattisgarh	1987	Cassava, yams, sweet potato, elephant foot yam and taro
12	Narendra Dev University of Agriculture and Technology, Faizabad 224 229, Uttar Pradesh	1987	Sweet potato, taro and elephant foot yam
13	Navsari Agricultural University, Navsari 396 450, Gujarat	1994	Cassava, sweet potato, taro and yams

14	ICAR-Central Agricultural Research Institute, Port Blair 744 101, Andaman & Nicobar Islands	2000	Cassava, sweet potato and yams
15	Central Agricultural University, Iroisemba, Imphal 795 004, Manipur	2006	Cassava, sweet potato, aroids and yams
16	Maharana Pratap University of Agriculture and Technology, Udaipur 313 001, Rajasthan	2006	Aroids, yams and sweet potato
17	University of Horticultural Sciences, Bagalkot 587 103, Karnataka	2007	Sweet potato and aroids
18	CSK Himachal Pradesh Agricultural University, Palampur 176 062, Himachal Pradesh	2014	Taro and elephant foot yam

Achievements of ICAR-AICRP on Tuber Crops during 2014-2015

The mandate of ICAR-AICRPTC is to generate region-specific value added varieties, agronomic interventions and production system technologies including disease and pest management of tropical tuber crops along with creating awareness among the farming community, policy makers and researchers.

Collection, conservation and characterization of genetic resources

One of the major objectives of ICAR-AICRP on tuber crops is the collection, conservation and evaluation of the genetic stocks of tuber crops from the various agro-climatic zones for manifold purposes ranging from food production to climate change resilience. Constant efforts are therefore, being made to collect the indigenous germplasm of different tuber crops from different agro-climatic zones through coordinating centres. A total of 4400 accessions of different root and tuber crops were maintained at different field gene banks in various ICAR-AICRP Tuber Crops centres. Maximum accessions of ten tuber crops (1312) were maintained at RAU, Dholi. Sweet potato accessions was contributing a major share to the total (1858) followed by taro (837) and cassava (612). The centres are maintaining a total of 1063 accessions of taro, 258 collections of elephant foot yam and 153 accessions of yam bean.

New yam collections from Wayanadu, Kerala

During 2014-2015, IC numbers were obtained for 119 germplasm accessions and details of 509 accessions were submitted to NBPGR for obtaining IC numbers. A team from ICAR-CTCRI and AAU, Jorhat, made an exploration trip to North East regions during November 2014 and collected 42 germplasm of different tuber crops. The finger printing of the collections of taro and elephant foot yam were validated to find out the duplicates and Expressed sequence tag-PCR based markers as well as corresponding primers were developed from ESTs and were successfully screened in 70 genotypes of taro.

Testing of genetic resources at various agro climatic environments

Under the new IET on K-efficient cassava lines, the maximum tuber yield (42.40 t ha^{-1}) was obtained from TCa-14-6 at Yethapur, TCa-14-8 at VR Gudem, TCa-14-4 at Imphal and TCa-14-3 at Thiruvananthapuram. Under IET on cassava for culinary uses, TCa-13-3

produced maximum tuber yield (16.80 t ha^{-1}) at Imphal, TCa-13-7 at Jagdalpur (19.09 t ha^{-1}) and TCa-13-2 at Thiruvanathapuram. Under URT on cassava short-duration lines, maximum tuber yield was obtained from TCa-12-9 (46.30 t ha^{-1}) at VR Gudem, TCa-12-6 at Yethapur and TCa-12-5 at Thiruvananthapuram. Under MLT on cassava mosaic resistant entries, TCMS–7 was superior at VR Gudem and Dapoli and TCMS-1 at Thiruvananthapuram and all the entries were symptom free at different locations.

Among the entries evaluated in IET for weevil resistance, TSp-12-4, performed superior coupled with less weevil damage at Thiruvananthapuram, Kalyani and Rajendranagar. At Dholi, TSp-12-6 produced highest marketable tuber yield (16.00 t ha^{-1}). Under IET on sweet potato, maximum tuber yield was obtained from TSp-12-8 at Kalyani and TSp-12-10 at Barapani. Under MLT on orange-fleshed sweet potato entries, maximum marketable yield was obtained from NFSP-1 (27.69 t ha^{-1}) at Imphal.

The MLT of elephant foot yam with the promising lines from Coimbatore, Jagdalpur and Kalyani conducted across the centres revealed that BCA-3 performed well at Kalyani centre. Gajendra gave highest yield at Kovvur, whereas Appakudal local gave maximum yield at Coimbatore.

Taro entry, TTr-12-2 was superior in yield under IET at Ranchi. The entry TTr-12-5 produced the highest corm and cormel yield at Kalyani, TTr-12-7 at Coimbatore and TTr-12-8 at Dholi. Under MLT on Banda, IGB-5 produced maximum yield at Jagdalpur and BCB-2 at Kalyani. In multi-location trial, IG Col E-9 produced maximum yield at Jagdalpur (22.19 t ha^{-1}).

Field view of IET on taro, ICAR-RCNEH, Barapani

Under IET on greater yam, highest tuber yield was obtained in the entry TGy-12-3 at Kovvur, Thiruvananthapuram and Bhubaneswar. The entries TGy-12-4 performed better at Udaipur and TGy-12-7 at Jagdalpur. Under URT, IGDa-2 gave the highest yield at Jagdalpur (39.72 t ha^{-1}) and Da-25 at Jorhat and Navsari.

In lesser yam, significantly superior tuber yield of 15.10 t ha^{-1} was obtained from the entry DE-17 at Ranchi under MLT. Maximum yield was obtained in RAU-2 at Jorhat. Under IET on aerial yams, TDb-13-6 produced maximum aerial tuber yield at Jagdalpur (13.57 t ha^{-1}) and Ranchi, TDb-13-5 performed better followed by TDb-13-1 at Dapoli. In the new IET initiated in yam bean, TYb-14-8 was superior at Bhubaneswar, TYb14-9 at Dholi and TYb14-5 at Kalyani.

Agro techniques

Phenology studies in cassava indicated that the variety Sree Vijaya expressed earliness in phenological attributes compared to H-226 at all centres. Among the two varieties of sweet potato, Sree Bhadra performed better than local variety in respect of all phenological parameters, like early sprouting, tuber initiation, yield attributes and yield at all centres, except Dharwad, Faizabad and Udaipur. The entry Gajendra exhibited very sharp and distinct phenological traits both in terms of vegetative as well as yield attributing parameters at Ranchi, Kalyani, Dholi and Thiruvananthapuram. Muktakeshi exhibited better performance in all aspects like vegetative growth, yield attributes, productivity and harvest index as compared to the local variety. However, phenological expressions were early in local variety in most of the locations. Phenology studies in greater yam indicated better attributes of Sree Keerthi compared to local variety at all centres.

Under site specific nutrient management studies in cassava, maximum tuber yield was obtained with soil test based application of nutrients at Yethapur

(35.16 t ha^{-1}). Under SSNM experiment in elephant foot yam, higher tuber yield and high B:C ratio were obtained in cv. Gajendra under the treatment, where nutrients were applied based on soil test data in most of the locations, however this was on par with the application of recommended dose of nutrients.

Site specific nutrient management in elephant foot yam, a view from TNAU, Coimbatore

Farming system studies involving tuber crops implemented in Khanjuguda (village), Chakapada (Block), Kandhamal (District), Odisha state produced 1739.10 kg of rice equivalent yield and net return of Rs 34770/0.40 ha, whereas sole crop of paddy produced 800 kg of rice and net return of Rs 13000/0.40 ha. Under farming system studies involving tuber crops in tribal areas of Port Blair, the tribal farmers could generate an amount of Rs. 5500 to Rs. 9650 from pigs and the total income generated from the system ranged from Rs. 29000 to Rs. 52650**.** Tuber crops based farming system implemented in unit area of 0.26 ha generated a net income of Rs. 53453 along with generation of year round employment to the family in Assam.

In the new experiment on micro nutrient studies, positive response to tuber yield was observed in cassava at Yethapur and VR Gudem. In sweet potato, application of micro nutrients, especially soil application of Borax @ 1.5 kg ha^{-1} resulted in higher tuber yield.

Introduction of fingerlings under farming system studies, IGAU, Jagdalpur centre

Pests and disease management

Under integrated management of sweet potato weevil, mulching with cassava leaves and spraying of biopesticide Nanma had good effect against weevil infestation in sweet potato at Kalyani, Dholi and Ranchi.

The evaluation of seven coded taro entries against taro leaf blight indicated that TCBl-3 and TC bl-4, TCBl-2 and TC bl-1 were promising against blight disease at Kalyani. The entries viz., TC bl-12-4 and TCbl-12-5 exhibited lower level of disease incidence and highest cormel yield at Dholi. At Rajendranagar, TCBl-4 showed minimum blight incidence.

Soil application and tuber treatment with *Trichoderma* and Carbendazim spray (1%) was effective in reducing the anthracnose incidence and increasing tuber yield in greater yam at Rajendranagar and Jagdalpur.

Planting material production

Planting materials of improved varieties of tuber crops were multiplied and distributed by all the centres. The centres have multiplied and distributed 38.80 tonnes of elephant foot yam, 652650 sweet potato vines and 162900 cassava stems to cater to the needs of various locations.

Dr. YSR Horticultural University, Andhra Pradesh receiving the best AICRPTC centre award for the year 2013-14 from Hon'ble DDG, Hort.

Research-extension interface

The centres were regularly involved in organising training programmes, conducting demonstrations, participating in exhibitions, radio and television programmes. Farmers training on cultivation and protection technology of tuber crops, seed production technology and popularization of tuber crops were organized and lectures delivered by Kalyani centre. These activities enabled the development of a model village house (Tuber Crops Family) for awareness to the farmers regarding cultivation and nutrition of root and tuber crops. Two trainings on value addition in tuber crops for women self-help groups were organized by Dapoli centre and 11 trainings were organized by Jagdalpur centre. ICAR-CARI centre has conducted two days training programme on "Organic Cultivation of Tuber Crops" at Big Lapathy, Car Nicobar, during 16-17 December 2014 and three days training on "Production Technology of Tuber Crops for Livelihood Options" at Vikash Nagar and Bada Enaka villages of Kamorta, Nancowrie group of Islands during 18- 20 February 2015.

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Susan John, K., Shanida Beegum, S. U. and Ravi, V. 2015. Management of the waste lands of Kerala by exploiting the carbon sequestration potential and climate resilience of cassava. In: *Abstract Book of the Proceedings of the 27th Kerala Science Congress*, 27-29 January 2015, Camelot Convention Center, Alappuzha, Kerala, pp.198-199.

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Vinutha, K. B., Asha Devi, A. and Sreekumar, J. 2014. Molecular analysis of genetic diversity in taro (*Colocasia esculenta* (L.) Schott.) using SSR markers. *National Seminar cum Workshop on Plant Systematics and Herbarium Techniques - Celebrating Diversity in the Understanding of Science*, 24-25 September 2014, Department of Botany, KKTM Govt. College, Kodungallur in collaboration with Botanical Survey of India and Association for the Advancement of Biodiversity Science.

Other Publications

Annual Report of ICAR-CTCRI, 2013-2014.

Research Highlights of ICAR-CTCRI, 2013-2014.

40th IRC Salient Achievements, ICAR-CTCRI, 2013-2014.

40th IRC Proceedings and Activity Milestones, ICAR-CTCRI, 2013-2014.

Quinquenniel Review Team (QRT) Report and Recommendations 2008-2013 on AICRP on Tuber Crops.

Annual report of AICRP on Tuber Crops, 2013-2014.

Technical Report for Annual Group Meeting of AICRP TC held at Birsa Agricultural University, Ranchi, 20-22 May 2014.

Proceedings of Annual Group Meeting of AICRP TC held at Birsa Agricultural University, Ranchi, 20-22 May 2014.

Proceedings of Midterm Review Meeting of All India Coordinated Research Project on Tuber Crops, 2014, held at Regional Centre, ICAR-CTCRI, Bhubaneswar.

Technical Report, 15th Annual Group Meeting of All India Coordinated Research Project on Tuber Crops, held at Dr YSR Horticulture University, VR Gudem, Andhra Pradesh.

Doordarshan Programmes

Nedunchezhiyan, M. 2014. Expert on the short story on seed/planting material selection for tuber crops planting. Krishi Darshan of Prasara Bharati, Doordarshan on 23 June 2014.

Nedunchezhiyan, M. 2014. Expert on the short story on technology of land preparation for tuber crops cultivation. Krishi Darshan of Prasara Bharati, Doordarshan on 26 June 2014.

Nedunchezhiyan, M. 2014. Expert on the short story on technology of tuber crops planting methods. Krishi Darshan of Prasara Bharati, Doordarshan on 27 June 2014.

Nedunchezhiyan, M. 2014. Expert of live phone in programme on yam and taro cultivation. Pallishree of Prasara Bharati, Doordarshan on 14 July 2014.

Nedunchezhiyan, M. 2014. Expert of live phone in programme on status of tuber crops cultivation. Pallishree of Prasara Bharati, Doordarshan on 14 July 2014.

Susan John, K. 2015. Expert of live phone in programme of Krishidarshan of DD4 in Doordarshan on 20 February 2015 at 5.30 p.m. on the topic "Tropical tuber crops: Implications for food security under changing global climate".

Radio Talks

Suja, G. 2015. Question Answer Session in the Club FM Musical Programme broadcast on 5 December 2014, 8.45-9.30 am on the occasion of World Soil Day.

Susan John, K. 2015. Interview on "The need to protect soil for sustaining life and agriculture" (Malayalam) on 5 January 2015 for the Farm and Home section of AIR broadcast on 8 January 2015.

Ongoing Projects

Institute projects

Sl. No	Project code	Project title	PI	Co-PIs
1	HORT CTCRI SIL 2013 001 01440	Collection, conservation, characterization and evaluation of germplasm of tropical root and tuber crops	M. N. Sheela	Archana Mukherjee, A. Asha Devi, K. I. Asha, G. Byju, C. A. Jayaprakas, M. L. Jeeva, A. N. Jyothi, Kalidas Pati, N. Krishna Radhika, T. Makeshkumar, R. S. Misra , K. Rajasekhara Rao Korada, Shirly Raichal Anil, J. Sreekumar, S. S. Veena
2	HORT CTCRI SIL 2013 002 01441	Varietal improvement in tropical tuber crops	Archana Mukherjee	K. I. Asha, A. Asha Devi , E. R. Harish, A. N. Jyothi, Kalidas Pati, N. Krishna Radhika, K. Laxminarayana, T. Makeshkumar, C. Mohan, M. Nedunchezhiyan, K. Rajasekhar Rao Koroda, S. Ramanathan, R. C. Ray, M. N. Sheela, Shirly Raichal Anil, G. Suja, S. S. Veena
3	HORT CTCRI SIL 2013 003 01442	Biotechnological approaches for improvement of tropical tuber crops	C. Mohan	A. Asha Devi, Archana Mukherjee, S. K. Chakrabarti , M. L. Jeeva, A. N. Jyothi, Kalidas Pati, N. Krishna Radhika, K. Laxminarayana , T. Makeshkumar, M. Nedunchezhiyan, V. Ravi, R. Saravanan, M. N. Sheela, J. T. Sheriff, J. Sreekumar
4	HORT CTCRI SIL 2013 004 01443	Crop and water management in tropical tuber crops	C. S. Ravindran (Till Dec 2014) G. Suja	G.Byju , James George, M. Nedunchezhiyan, V. Ramesh, V. Ravi, C. S. Ravindran, J. Sreekumar, G. Suja, S. Sunitha, K. Susan John
5	HORT CTCRI SIL 2013 005 01444	Soil health and plant nutrition in tropical tuber crops	G. Byju	James George, A.N. Jyothi, K. Laxminarayana, R.S.Misra, M. Nedunchezhiyan, V.Ravi, M.N. Sheela, J. Sreekumar, G. Suja, K. Susan John, V. Ramesh, C.S. Ravindran, S.S.Veena
6	HORT CTCRI SIL 2013 006 01445	Abiotic stress management in tropical tuber crops	V. Ravi	K. Laxminarayana, M. Nedunchezhiyan, R. Saravanan, M. N. Sheela, K. Susan John, M. Madhumita Das (DWM) M. Sankaran, T. Subramani (CARI)
7	HORT CTCRI SIL 2013 007 01446	Production of disease free planting materials in tropical tuber crops	James George	Archana Mukherjee, A. Asha Devi, T. Makeshkumar, R. Muthuraj, C. S. Ravindran, M. N. Sheela, S. Sunitha
8	HORT CTCRI SIL 2013 008 01447	Ecofriendly strategy for the management of insect pests in tuber crops	C.A. Jayaprakas	E.R. Harish, C. A. Jayaprakas, Kalidas Pati, T.Makesh Kumar, Rajasekhara Rao Korada

9	HORT CTCRI SIL 2013 009 01448	Integrated management of fungal diseases of tropical tuber crops	R. S. Misra	K. I. Asha, G. Byju, M. L. Jeeva , A. N. Jyothi, M. Nedunchezhiyan, S. S. Veena
10	HORT CTCRI SIL 2013 010 01449	Characterization, diagnosis and management of viruses of tuber crops	T.Makeshkumar	S.K.Chakrabarti, M.L.Jeeva, Shirly Raichal Anil, T. Makeshkumar, J.Sreekumar
11	HORT CTCRI SIL 2013 011 01450	Development of functional foods from tuber crops	G. Padmaja (Till Sep. 2014) J. T. Sheriff	Archana Mukherjee, A. N. Jyothi, R.S Misra, G. Padmaja, V.Ravi, R. C. Ray, M. S. Sajeev, J. T. Sheriff, M. N. Sheela, P.S Sivakumar
12	HORTCTCRISIL 201301201451	Innovative approaches for the development of tuber crops based industrial products	M. S. Sajeev	A. N. Jyothi, M. S. Sajeev, J.T. Sheriff, K. Susan John
13	HORT CTCRI SIL 2013 013 01452	Pre and post-harvest machinery for cost effective cultivation and processing of tuber crops	J. T. Sheriff	A. N. Jyothi, M.S. Sajeev, J. T. Sheriff, G. Suja
14	HORT CTCRI SIL 2013 014 01453	Tuber crops technology assessment, transfer and socio-economic studies for sustainable development	M. Anantharaman, P. Sethuraman Sivakumar	M.Anantharaman, G. Byju , C. A. Jayaprakas, T. Makeshkumar, M. Nedunchezhian, S. Ramanathan, V. Ravi, V. S. Santhosh Mithra, P. Sethuraman Sivakumar, J. T. Sheriff, J. Sreekumar
15	HORT CTCRI SIL 2013 015 01454	Generation and application of computing technologies for tuber crops research and development	J.Sreekumar	G. Byju, A. N. Jyothi, T. Makeshkumar, C. Mohan, V. Ravi, V.S.Santhosh Mithra, J.Sreekumar, G. Suja
16	HORT CTCRI SIL 2013 016 01455	Enhancing food security and sustainable livelihoods in the North-Eastern India through tuber crops technologies	M.Anantharaman	M. Anantharaman, S. K. Chakrabarti, K. Laxminarayana, R.S. Misra, S. Ramanathan, M.S. Sajeev, P. Sethuraman Sivakumar, J. T. Sheriff
17	HORT CTCRI SIL 2013 017 01456	Livelihood improvement of tribal farmers through tuber crops technologies in tribal areas	R.S. Misra	M. Anantharaman, Archana Mukherjee, C. A. Jayaprakas , Kalidas Pati, James George, K. Laxminarayana, M. Nedunchezhiyan, G. Padmaja, K. Rajasekhara Rao, S. Ramanathan, C. S. Ravindran, J.T. Sheriff

Externally aided projects

Sl. No	Title	PI	Co- PIs	Funding agency
1	Adapting clonally propagated crops to climatic and commercial changes	Archana Mukherjee	J. Sreekumar	EU funded International Network for Edible Aroids (INEA) Project on Taro
2	Development of standards of DUS testing for varietal gene bank in elephant foot yam and taro	Archana Mukherjee	Kalidas Pati	PPV& FRA
3	DUS testing centre for cassava and sweet potato	M. N. Sheela	Archana Mukherjee	PPV& FRA
4	Indo-Swiss cassava network project	T. Makeshkumar, M. N. Sheela	Nil	Indo Swiss collaboration on Biotechnology (ISCB) – Department of Biotechnology, Govt. of India
5	Development of tuber crops -Kerala	James George	C.S. Ravindran, C. A. Jayaprakas, M. N. Sheela, S.Ramanathan, G. Byju, T. Makeshkumar, S. Sunitha, M. L. Jeeva, M. S. Sajeev, R. Muthuraj, V. R. Sasankan, D. T. Rejin	Department of Agriculture, Govt. of Kerala
6	Net work on organic farming in horticulture crops	G. Suja	S. Sunitha, V. Ramesh, A. N. Jyothi, P. Subramanian	ICAR Network Project with Indian Institute of Spices Research as Lead Centre
7	Enhancing the economic viability of coconut based cropping systems for land use planning in Kerala state	K. Susan John	S. Sunitha, S.S. Veena	Department of Agriculture, Govt. of Kerala
8	Assessment of soil fertility status and preparation of soil fertility maps for various agro-ecosystems of Odisha	K. Laxminarayana	M. Madumita Das, DWM, Bhubaneswar	Department of Horticulture, Govt. of Odisha under RKVY
9	Characterization of new magnesium fertilizer products, their effect on soil properties and yield of tropical tuber crops	G. Byju	G. Suja	Contract Research Project: Swamy Engineering Consultants, 22-A, Kumar Nagar South, IIIrd Street (Opp. Surya Theatre), TIRUPUR 641 603, Tamil Nadu
10	*Phytophthora, Fusarium and Ralstonia* diseases of horticultural and field crops	M.L. Jeeva	S. S. Veena, R.S.Misra	ICAR Network Project
11	Participatory technology transfer of cassava based biopesticides for the management of vegetable pests	C. A. Jayaprakas	S. Ramanathan, S. Sunitha Prof. C.K. Peethambaran P.G. Rajendran (CISSA, Thiruvananthapuram) T.S. Manojkumar, S. Leena, (KVK, Kasaragod)	Department of Agriculture, Govt. of Kerala

12	ORP on management of sucking pests of Horticultural crops	C. A. Jayaprakas	E. R. Harish	ICAR Network Project
13	CRP on borers	Rajasekhara Rao Korada	C. A. Jayaprakas	Consortia Research Platform
14	CRP on nanotechnology	M.S. Sajeev	A. N. Jyothi	Consortia Research Platform on Development of nano starch based and bionano composites for thermo plastic films and foam type packaging
15	Development of mosaic resistant transgenic cassava	T. Makeshkumar	S.K. Chakrabarti, M.N. Sheela	ICAR Network Project
16	Disease diagnostics in tropical tuber crops	T. Makeshkumar	M. L. Jeeva	Consortia Research Platform on Diagnostics & vaccines, ICAR
17	Improving the livelihoods of smallholder cassava farmers through better access to growth markets	J.T. Sheriff		Cassava Gmarkets
18	Development of a process for the production of low-moist gelatinised dough for using in cassava *papad* making machine	J. T. Sheriff	A. N. Jyothi, G. Padmaja, M. S. Sajeev	Boosters International 7-72/2 Nedumangadu Road,Aralvaimozhi-Via Chenbagaramanputhur-629 304, Kanyakumari District Tamilnadu
19	Refinement of starch indicator developed by CTCRI and design of next generation gadget for measuring starch content of cassava (*Manihot esculenta* Crantz.) tubers	J. T. Sheriff	G. Padmaja, V. Ravi, M. S. Sajeev, A. N. Jyothi,	Department of Science and Technology, Govt. of India
20	Techno-incubation centre	M.S. Sajeev	J.T.Sheriff, A. N. Jyothi, Namrata Aagush Giri	Small Farmers Agribusiness Consortium, Dept. of Agriculture, Govt. of Kerala
21	High value compounds from tuber crops	A. N.Jyothi	J. Sreekumar, Shirly Raichal Anil	ICAR (Consortia Research Platform Project)
22	Development and evaluation of starch based functional polymers for controlled plant nutrient delivery	A.N. Jyothi	M. S. Sajeev, K. Susan John	Kerala State Council for Science, Technology and Environment, Govt. of Kerala
23.	Participatory development of a web based user friendly cassava expert system	V. S. Santhosh Mithra	M. Anantharaman, S. Ramanathan and G. Byju	Kerala State Council for Science, Technology and Environment, Govt. of Kerala
24	FoodSTART	R. S. Misra	M. Anatharaman, M. Nedunchezhiyan, K. Laxminarayana, V. S. Santhosh Mithra	CIP-IFAD

Institute Research Council, Research Advisory Committee, Institute Management Committee

Institute Research Council

The 40th Annual Institute Research Council meeting of ICAR-CTCRI was held during 31 March to April 2 2014 under the chairmanship of Dr. S. K. Chakrabarti, Director, ICAR-CTCRI. Dr. M. L. Jeeva, Secretary, IRC welcomed the chairman and all the scientists. She congratulated the scientists, Dr. A.N. Jyothi, Dr. S. Mohan, Dr. K. Rajasekhara Rao and Dr. K. Laxminarayana who were promoted as Principal Scientists during 2013-2014. She also congratulated Dr. S. K. Chakrabarti, who received Dr. S. Ramanujam Award for Outstanding Research/ Leadership in Potato Improvement/Production for the block year 2008-2011 and Sanghamythry Award instituted by the Sanghamythry Farmers Producer Co. Ltd, Pallichal, Thiruvananthapuram, for popularizing cassava based biopesticides; Dr. James George who received best paper award in the International Conference on Water Quality and Management for Climate Resilient Agriculture held at Jalgaon, Maharashtra; Dr. Shirly Raichal Anil for the receipt of Ph. D degree and Dr. A. Abraham Award instituted by the Indian Society for Root Crops for the best paper in Journal of Root Crops, and all the scientists who have visited abroad for various purposes.

The Director in his introductory remarks expressed his pleasure for the successful conduct of four days International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climate (ICTRT 2013) during 09-12 July 2013 at Thiruvananthapuram. He urged all the scientists of the institute to include the recommendations of ICTRT in the project activities. He also emphasized to incorporate RAC recommendations into research activities. He expressed his happiness about the good number of deputation of our scientists abroad for the purpose of training, consultancy and attending meetings/seminars during last year. He expressed his happiness for the award of ISO 9001: 2008 certificate and congratulated Dr. V. Ravi, Principal Scientist, Division of Crop Production (Scientist in charge, PME) and the team involved in ISO certification preparation. He also congratulated the scientists who were promoted as Principal Scientists for their good performance. He congratulated Dr. G. Byju, Scientist in Charge, Farm and Principal Scientist, Division of Crop Production for good maintenance of farm. He expressed his satisfaction about the condition of different experimental plots, infrastructure development especially, the new wing for Division of Crop Improvement and new building for Accounts Section. He also highlighted the major achievements of each Division.

40th Annual Institute Research Council Meeting

It was followed by presentation of progress of the ongoing institute projects, division wise in five sessions. Each session was led by the Head with briefing of overall achievements, followed by presentation of progress in each activity by the Activity Leaders. The document on salient achievements 2013-2014 was distributed to all the members of IRC. In total, 17 projects with 51 activities were discussed and the proceedings were discussed during plenary session. The IRC members appreciated and honored Dr. G. Padmaja and Dr. C. S.Ravindran, who will superannuate during 2014, for their outstanding contribution in research and other institutional activities at ICAR-CTCRI. The

decisions taken, recommendations and technologies developed from the institute and externally aided projects have been documented as Proceedings and Activity Milestones 2014-2015.

Research Advisory Committee

The first meeting of RAC VII was held on 24 and 25 February 2015, with the newly constituted committee in the Golden Jubilee Hall, ICAR-CTCRI.

Dr. P. Rethinam, Former ADG, ICAR, chaired the meeting. The following members were present:

1. Dr. Umesh Srivastava, Former ADG, Hort.Sci., ICAR
2. Dr. P.S. Naik, Former Director, ICAR-IIVR
3. Dr. V.G. Malathi, Adjunct Faculty & Emeritus Scientist, TNAU
4. Dr. Srinivasa Murthy, Principal Scientist, ICAR-IIHR
5. Dr. S. K. Chakrabarti, Director, ICAR-CTCRI
6. Dr. Suja G., Principal Scientist, ICAR-CTCRI (Member Secretary)

First meeting of Research Advisory Committee Meeting VII of ICAR-CTCRI

The following members were absent:

1. Dr. T. Janakiram, ADG (H.II), ICAR
2. Dr. Saiprasad G.V.S. Lead Scientist, Agriscience, ITC Limited, Bengaluru
3. Shri. Salim P. Mathew (IMC Rep)

The meeting commenced at 11.00 am after a field visit by the chairman and members.

Dr. Suja, G., Member Secretary, RAC, welcomed the Chairman and members of RAC and all the scientists. Dr. S.K. Chakrabarti, Director, ICAR-CTCRI gave a brief account of ICAR-CTCRI, highlighted the achievements made and the priorities for research as indicated in vision 2050 and QRT report 2014. Dr. James George, Project Coordinator, AICRP on Tuber Crops also briefed about the activities and achievements of AICRP on tuber crops.

Members of RAC gave their preliminary observations. Dr. P. Rethinam, Chairman, in his opening remarks indicated that root and tuber crops played a vital role in the global as well as national food security. These groups of crops are being used both for home consumption and in industry. The cassava mosaic disease and sweet potato weevil continued to be the limitations for the successful production of these crops and needed more concerted efforts for their management. He insisted that the available six mosaic resistant varieties of cassava should be multiplied fast and distributed to the farmers. Quality planting materials of released high yielding varieties and hybrids should be produced adequately through involvement of farmers, NGOs, AICRPs, Self help groups etc. Since these crops greatly contributed to health and wellness of people due to the presence of antioxidants, vitamins, minerals etc. the health and nutritional aspects of tuber crops need to be highlighted. Proper labeling of value added products

with the nutrient contents would attract the consumers in both urban and rural areas.

The action taken report of the third meeting of RAC VI was presented by the Member Secretary, which was discussed and approved.

The project leaders presented the salient achievements and highlighted the future thrusts. Based on the presentations and discussions as well as effective interaction of RAC members the following recommendations were approved by the SMD for consideration and implementation:

Recommendations

Crop Improvement

- There is a need to explore pockets in Bastar tribal area for collection of different tuber crops. Biodiversity of tuber crops in the NEH should be maintained at the AICRP Centre, Jorhat. Quarantine measures should be taken up within the institute whenever germplasm accessions are brought from elsewhere. Also areas for specific traits such as drought and salinity tolerance etc. should be identified. Core collection may be developed in cassava and sweet potato germplasm. Also efforts may be made to sort out duplicates.
- Efforts may be intensified for developing diploid and triploid cassava hybrids for earliness, CMD resistance, high starch content and nutritional quality. There is a need to develop short-duration (70-75 days) sweet potato.
- Since CMD is a long lasting problem, priority should be given to develop resistant lines. In future only CMD resistant cassava varieties should be released. Whatever varieties identified/ tested should be multiplied and distributed to the farmers.

Crop Production

- Studies on drip fertigation to enhance water and nutrient use efficiency may be extended to all tropical tuber crops in a phased manner. In the context of climate change, emphasis may be given to integrate water management techniques and water conservation practices while taking up future studies.
- Cost of production of quality planting material and the annual planting material requirement of different tuber crops may be worked out.
- Based on the research results available in ICAR-CTCRI and ICAR-AICRP, GAP should be developed for cassava, sweet potato and elephant foot yam.

Crop Protection

- Decision support system and diagnostic tools for major diseases may be developed. Detailed pathogenicity experiments may be conducted for anthracnose and collar rot.
- On a priority basis, whitefly genotypes occurring on cassava and sweet potato needs to be identified. To begin with it can be analysed for ICAR-CTCRI, thereafter Kerala and then extended to cassava growing tracts of the whole country in a phased manner.

Crop Utilization

- Mechanisation for cultivation of tuber crops may be given priority and intensive research may be initiated.
- Technologies for processing and value addition in taro may be developed.

Extension and Social Sciences

- Agro advisory system may be developed. Variety identifier needs to be refined.
- ICAR-CTCRI may look into PPP mode for efficient commercialization of its varieties and technologies. Front-line demonstrations of important varieties and technologies may be enhanced in collaboration with KVKs so that knowhow may reach the farming community.
- Demand estimation of tuber crops for household consumption and industries may be initiated.

General

- The word 'Sree' prefix with ICAR-CTCRI varieties may be registered as the trademark and may be used for naming varieties or products from ICAR-CTCRI.
- Efforts may be made to work out crop forecasting, drought assessment and disease forecasting in cassava and other tuber crops using remote sensing, agro-meteorology and land based observations.

Institute Management Committee

The 12th Institute Management Committee Meeting of ICAR-CTCRI was held on 20 December 2014 under the Chairmanship of Dr. S. K. Chakrabarti, Director, ICAR-CTCRI, Thiruvananthapuram, in the conference hall and the following Members/ Dignitaries/Officers attended the meeting.

1.	Dr. S.K. Chakrabarti Director, ICAR- CTCRI, Thiruvananthapuram	Chairman
2.	Dr. V. Krishnakumar Head, Regional Centre of ICAR-CPCRI, Kayamkulam, Kerala	Member
3.	Sh. V.K. Raju Additional Director, Dept. of Agriculture, Govt. of Kerala	Member
4.	Dr. V.L. Geethakumari Prof. & Head, Dept. of Agronomy, College of Agriculture, Vellayani	Member
5.	Dr. P. Murugesan Principal Scientist & SIC, IIOPR Regional Station, Palode	Member
6.	Dr. C.S. Ravindran, Head, Division of Crop Production, ICAR-CTCRI, Thiruvananthapuram	Special Invitee
7.	Dr. C.A. Jayaprakas Head, Division of Crop Protection, ICAR-CTCRI, Thiruvananthapuram	Special Invitee
8.	Dr. (Mrs.) M.N. Sheela Head, Division of Crop Improvement, ICAR-CTCRI, Thiruvananthapuram	Special Invitee
9.	Dr. J.T. Sheriff Head, Division of Crop Utilization, ICAR-CTCRI, Thiruvananthapuram	Special Invitee
10.	Dr. S. Ramanathan Principal Scientist, Section of Extension and Social Sciences, ICAR-CTCRI, Thiruvananthapuram	Special Invitee
11.	Dr. V. Ravi Principal Scientist & SIC (PME), ICAR-CTCRI, Thiruvananthapuram	Special Invitee
12.	Dr. M.S. Sajeev Principal Scientist & SIC (E&M), ICAR-CTCRI,Thiruvananthapuram	Special Invitee
13.	Dr. (Mrs.) S. Sunitha, Principal Scientist, AICRP on Tuber Crops Cell, ICAR-CTCRI,Thiruvananthapuram	Special Invitee
14.	Smt. R. Sari Bai FAO, ICAR-CTCRI, Thiruvananthapuram	Special Invitee
15.	Shri. Davis Joseph Administrative Officer, ICAR-CTCRI, Thiruvananthapuram	Member Secretary

At the outset, Chairman, IMC & Director, ICAR-CTCRI, Sreekariyam, Thiruvananthapuram, welcomed all the members present in the XII Institute Management Committee Meeting of the Institute. The meeting started with a brief note by the Director, about the mandate of the institute and also the research activities being carried out, along with the various achievements by the scientists of this Institute, since last IMC meeting. This was followed by a brief discussion by all the members of the IMC who appreciated the efforts of the institute in fulfilling their mandated activities and wished that the research programs being undertaken by the scientists at present as well as those to be contemplated in future would address not only the Council's expectations, but also the welfare of the growers of tuber crops in Kerala as well as other parts of India.

After the introductory remarks by the Chairman, IMC, Dr. Ravi, Principal Scientist and In-charge PME Cell made a power point presentation on the research achievements of the institute as well as the performance indicators of the institute, which was appreciated by one and all. Thereafter, Dr. S. Ramanathan, Principal Scientist, presented the salient features of QRT Recommendations. This was followed by brief discussion by the HODs' about their performances and achievements.

The Finance & Accounts Officer presented the Plan BE of 2014-2015 and also the Non-Plan BE 2014-2015 and Expenditure during the financial year 2014-2015.

Then, the action taken report of the XI IMC Meeting was presented by the Member Secretary which was passed by the house. The Member Secretary presented the agenda items in the house for perusal, discussion and recommendation by the esteemed IMC members. IMC approved the proposed work, the purchase of equipments, furniture and fixtures after observing all codal formalities during 2015-2016.

Participation of Scientists in Conferences, Meetings, Workshops, Symposia etc. in India

Programme	Particulars of the programme	Name of the participants
Group Meeting of Project	Kerala State Planning Board (KSPB) Office, Thiruvananthapuram, 22 April 2014	Dr. K. Susan John
QRT Meeting of Rajendra Agricultural University, Dholi, Birsa Agricultural University, Ranchi and Narendra Dev University of Agriculture and Technology, Faizabad	Rajendra Agricultural University, Dholi Centre, Patna, 25-28 April 2014	Dr. James George
Meeting of Research Advisory Committee	Indian Institute of Crop Processing Technology, Thanjavur, Tamil Nadu, 25-26 April 2014 and 6-7 November 2014	Dr. J. T. Sheriff
Interactive Meeting of ICAR Directors' and Vice-Chancellors of SAUs	Indian Council of Agricultural Research, at NASC Complex, New Delhi, 28 April 2014	Dr. S. K. Chakrabarti
QRT Meeting of Assam Agricultural University, Jorhat, Regional Centre, NEH and Central Agriculture University, Imphal	Assam Agricultural University, Jorhat Centre, Kahikuchi, Guwahati, 29 April - 1 May 2014	Dr. James George
Second Review Meeting of EU FSTP funded Improving the Livelihoods of Smallholder Cassava Farmers Through Better Access to Growth Markets (Cassava Gmarkets)	Thiruvananthapuram, 14-19 May 2014	Dr. J. T. Sheriff
14th Annual Group Meeting of AICRP on Tuber Crops	Birsa Agricultural University, Ranchi, 20-22 May 2014	Dr. S. K. Chakrabarti Dr. James George Dr. S. Sunitha Dr. M. N. Sheela Dr. C. S. Raveendran Dr. C. A. Jayaprakas Dr. R. S. Misra Dr. M. S. Sajeev Dr. C. Mohan Dr. T. Makeshkumar Dr. V. S. Santhosh Mithra Dr. M. Nedunchezhiyan
National Symposium on Plant Pathology in Genomic Era	Indira Gandhi Agricultural University, Raipur and Indian Phytopathological Society, New Delhi, 26-28 May 2014	Dr. T. Makeshkumar

Workshop on Priority Setting, Monitoring and Evaluation in National Agricultural Research System: Status, Experiences and Way Forward	National Agricultural Innovation Project-International Food Policy Research Institute, at NASC Complex, New Delhi, 27 May 2014	Dr. S. K. Chakrabarti
Regional Workshop on Research Prioritization and Reconciliation in Eastern India	ICAR Research Complex for Eastern Region, Patna, Bihar, 28 May 2014	Dr. K. Laxminarayana
Global Conference on Technological Challenges and Human-Resource for Climate Smart Horticulture-Issues and Strategies	Confederation of Horticultural Associations in India at Navsari Agriculture University, Navsari, Gujarat, 29 May 2014	Dr. S. K. Chakrabarti
Horticulture-PGR Meeting	ICAR-Indian Institute of Horticultural Research, Bengaluru, 30 May 2014	Dr. S. K. Chakrabarti
Review Meeting on Germplasm Related Issues	Navsari Agricultural University, Navasari Centre and ICAR-Indian Institute of Horticultural Research, Bengaluru, 30-31 May 2014	Dr. James George
Foundation Day Lecture of NAAS	National Academy of Agricultural Sciences, at NASC Complex, New Delhi, 5 June 2014	Dr. S. K. Chakrabarti
Conference of ICAR Directors' and Vice-Chancellors of SAUs	Indian Council of Agricultural Research, at NASC Complex, New Delhi, 6 June 2014	Dr. S. K. Chakrabarti
Workshop on Impact of Capacity Building Programmes	National Agricultural Innovation Project, at NASC Complex, New Delhi, 6-7 June 2014	Dr. S. K. Chakrabarti
The Executive Committee Meeting of National Institute of Plant Science Technology (NIPST)	M.G. University, Kottayam, 11 June 2014	Dr. G. Byju
Workshop on Scoping Studies for Climate Change	Hotel South Park, Thiruvananthapuram, 17 June 2014	Dr. V. Ramesh
Meeting on Sustainable Intensification of Potato in a Rice Based System in Odisha for Increased Productivity and Profitability	Directorate of Horticulture, Government of Odisha, 19 June 2014	Dr. K. Laxminarayana
Brain Storming Session on Take it to Farmers-The Farmers' Rights through Awareness	National Academy of Agricultural Sciences, NASC Complex, New Delhi, 24 June 2014	Dr. S. K. Chakrabarti
Interactive Meeting with taro farmers of Baruasagar, Jhansi, on problems related to diseases, pests and marketing	Narendra Dev University of Agriculture and Technology, Faizabad and Baruasagar, Jhansi, 26-28 June 2014	Dr. James George
Industry – Academia Linkage Meeting	Kerala State Industrial Development Corporation, Thiruvananthapuram, at Kochi, Kerala, 25 July 2014	Dr. S. K. Chakrabarti

Academic Council meeting of TNAU	Tamil Nadu Agricultural University, Coimbatore, 26 July 2014	Dr. S. K. Chakrabarti
Foundation Day and Award Ceremony 2014 of ICAR	Indian Council Agricultural Research, at NASC Complex, New Delhi, 29-30 July 2014	Dr. S. K. Chakrabarti
123rd Academic Council Meeting	Kerala Agricultural University, Vellanikkara, Thrissur, 30 July 2014	Dr. G. Byju
Interactive Meetings with TSP farmers	Kandhamal District, Odisha, 5-6 August 2014	Dr. James George
Group Meeting of the Network Project on Organic Horticulture	ICAR-Indian Institute of Spices Research, Kozhikode, 13 August 2014	Dr. G. Suja
Launch Workshop of CRP on Borers in Horticulture	Indian Institute of Horticultural Research, Bangalore, 18 August 2014	Dr. K. Rajasekhara Rao
Foundation Day Celebration of Central Potato Research Institute	ICAR-Central Potato Research Institute, Shimla, 22 August 2014	Dr. S. K. Chakrabarti
National Conference on Sustainability and Profitability of Coconut, Arecanut and Cocoa Farming-Technological Advances and Way Forward	ICAR-Central Plantation Crop Research Institute, Karasaragod, Kerala, 22-23 August 2014	Dr. James George
Meeting on Town Official Language Implementation Committee	Aayakar Bhavan, Rajaswa Vihar, Bhubaneswar, 27 August 2014	Dr. K. Laxminarayana
Seminar on Elementar Instruments with Special Emphasis on CHNSO and TOC Analyser	National Institute for Inter-disciplinary Science and Technology, Thiruvananthapuram, 1 September 2014	Dr. K. Susan John
Meeting with Dr. Jose Graziano da Silva, Director General, FAO	Indian Council of Agricultural Research, at NASC Complex, New Delhi, 8 September 2014	Dr. S. K. Chakrabarti
Workshop on EBSCO Discovery and Information Services, E-books, Altmetrics and Research Databases	Taj Vivanta, Thycaud, Thiruvananthapuram, 17 September 2014	Dr. K. Susan John
22nd meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crop	Indian Council of Agricultural Research, New Delhi, 22 September 2014	Dr. James George
Review Meeting of Foreign Aided Project	Krishi Anusandhan Bhavan-II, ICAR, 23 Septemeber 2014 and 28 January 2015	Dr. J. T. Sheriff Dr. T. Makeshkumar
First National Conference of Agricultural Tamil Society	Tamil Nadu Agricultural University, Coimbatore, 23 September 2014	Dr. J. T. Sheriff

Mid-term Review Meeting of AICRP on Tuber Crops	Regional Centre, ICAR-Central Tuber Crops Research Institute, Bhubaneswar, 24 September 2014	Dr. S. K. Chakrabarti Dr. James George Dr. S. Sunitha Dr. M. N. Sheela Dr. C. S. Raveendran Dr. C. A. Jayaprakas Dr. R. S. Misra Dr. M. S. Sajeev Dr. C. Mohan Dr. T. Makeshkumar Dr. V. S. Santhosh Mithra Dr. M. Nedunchezhiyan
XXV AICRPS National Workshop	Uttar Banga Krishi Viswa Vidyalaya, Pudibari, West Bengal, 26 September 2014	Dr. James George
124th Academic Council Meeting	Kerala Agricultural University, Vellanikkara, Thrissur, 15 October 2014	Dr. G. Byju
BRICS Biomed Project Proposal: Aiming at Innovation, Patenting, Product Development and Spinoffs by Dr. S. G. Prakash Vincent, Chairman Associate (India Academic), BRICS Biomed Corporation	Department of Biotechnology, University of Kerala, Kariavattom, 21 October 2014	Ms. N. Krishna Radhika
TSP Training Programme of All India Coordinated Research Project on Tuber Crops	Regional Centre, ICAR-Central Tuber Crops Research Institute, Bhubaneswar, 22-23 October 2014	Dr. James George
Brainstorming Session on Creating and Sustaining Interest in Agriculture among Youth	ICAR-Central Institute of Brackish Aquaculture, Chennai, 25 October 2014	Dr. P. S. Sivakumar
Workshop on Open Access of Agricultural Information for Inclusive Development	National Academy of Agricultural Research Management, Hyderabad, 29-30 October 2014	Dr. K. Susan John
Annual Workshop on Technology Commercialization	ICAR-Indian Institute of Horticultural Research, Bangalore, October 2014	Dr. M. Anantharaman
National Seminar on Emerging Problems of Potato	ICAR-Central Potato Research Institute, Shimla, 1-2 November 2014	Dr. S. K. Chakrabarti Dr. R. Muthuraj
National Seminar on Frontiers of Polymers and Advanced Materials	Department of Chemistry, University of Kerala, Kariavattom, Thiruvananthapuram, 5-7 November 2014	Dr. A. N. Jyothi
Indian Horticultural Congress	Horticultural Society of India at CODISSIA Trade Fair Centre, Coimbatore, 6 November 2014	Dr. S. K. Chakrabarti
Global Agro Meeting	Department of Agriculture, Government of Kerala, Kochi, 6-7 November 2014	Dr. M. S. Sajeev

Sixth Indian Horticulture Congress: An International Meet on Horticulture for Inclusive Growth	Tamil Nadu Agricultural University, Coimbatore, 6-9 November 2014	Dr. R. Muthuraj
National Symposium on Entomology as a Science and IPM as a Technology-The Way Forward.	College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh, India, 14-15 November 2014	Dr. C. A. Jayaprakas Dr. K. Rajasekhara Rao
Meeting of Indo-Swiss Cassava Network Partners	Tamil Nadu Agricultural University, Coimbatore, 16 November 2014	Dr. T. Makeshkumar
National Symposium on Agricultural Diversification for Sustainable Livelihood and Environmental Security	Punjab Agricultural University, Ludhiana, 18-20 November 2014	Dr. G. Suja
National Seminar on Developments in Soil Science-2014	Acharya N G Ranga Agricultural University, Hyderabad, 24-27 November 2014	Dr. K. Laxminarayana
Expert Committee Meeting for the Selection of Dairy Equipments	Thiruvananthapuram, 25 November 2014	Dr. J. T. Sheriff
Tuber Crops Farmers Seminar	All India Coordinated Research Project on Tuber Crops Centre of Dr. Bala Saheb Konkan Krishi Vidhyalay, Dapoli, 2-4 December 2014	Dr. James George
State Level Seminar on the Eve of World Soil Day Celebration	Department of Soil Survey and Soil Conservation, Government of Kerala, Thiruvananthapuram, 5 December 2014	Dr. K. Susan John
National Seminar on Unshackling the Fertilizer Sector	Fertilizer Association of India, New Delhi, 10-12 December 2014	Dr. K. Susan John
Annual Group Meeting of AICRP on Arid Zone Fruits	All India Coordinated Research Project on Arid Zone Fruits at SKN Agricultural University, Jobner, 12 December 2014	Dr. S. K. Chakrabarti
National Seminar on Extension Management Strategies for Sustainable Agriculture-Challenges and Opportunities	Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, 12-13 December 2014	Dr. P. S. Sivakumar
Awareness Meeting for Cassava Farmers at Thrissur District under the newly sanctioned Project, Development of Tuber Crops	Thrissur, Kerala, 15-16 December 2014	Dr. James George
National Seminar on Challenges and Innovative Approaches in Crop Improvement	Agricultural College and Research Institute (TNAU), Madurai, 16-17 December 2014	Dr. S. K. Chakrabarti
23rd National Conference on Recent Trends in Virology in Omics Era (Virocon 14)	Tamil Nadu Agricultural University, Coimbatore, 18-20 December 2014	Dr. T. Makeshkumar

Workshop on Advanced Robotics and Embedded Systems	Keltron Knowledge Centre, Ernakulam, Kerala, 18-20 December 2014	Dr. V. S. Santhosh Mithra
Silver Jubilee Symposium on Strategic Approaches for Horticulture Research, Education and Development-Way Forward.	National Academy of Agricultural Sciences, at NASC, New Delhi, 26-27 December 2014	Dr. S. K. Chakrabarti
Karshika Mela Seminar	Gandhiji Study Centre, Newman Grounds, Thodupuzha, Kerala, 27 December 2014	Dr. G. Suja
Awareness Meeting for Cassava Farmers at Pathanamthitta District under the newly sanctioned Project, Development of Tuber Crops	Elanthoor Krishi Bhavan, Kerala, 29 December 2014	Dr. James George
29th Carbohydrate Conference	Center of Innovative and Applied Bioprocessing, Mohali, Punjab, 29-31 December 2014	Dr. A. N. Jyothi
Agriculture and Industry Seminar, 82nd Shivagiri Theerthadana Celebrations 2014	Sree Narayana Dharma Sangom Trust, Shivagiri, Kerala, 31 December 2014	Dr. G. Suja
Workshop on Outcome Budgeting	Institute of Secretariat Training and Management, New Delhi, 5-6 January 2015	Dr. P. S. Sivakumar
Biennial Workshop of AICRP on Post-Harvest Technology	University of Agricultural Sciences, Bangalore, 5-8 January 2015	Dr. M. S. Sajeev
Training Programme under the scheme Development of Tuber Crops – Kerala State Govt. Project No. 2 for *Amorphophallus* farmers	Elanthur, Pathanamthitta, Kerala 6 January 2015	Dr. James George
Tuber Crops Farmers Seminar	Rajendra Agricultural University, Dholi, 14-15 January 2015	Dr. James George
Second Meeting of the Institute Management Committee	ICAR-Central Plantation Crops Research Insitute, Kasaragod, 16 January 2015	Dr. James George
23rd Refresher Course on Environmental Sciences	UGC-Academic Staff College, University of Kerala, Thiruvananthapuram, 16 January 2015	Dr. G. Suja
Training-cum-Custodian Meet on Protection of Plant Varieties and Farmers Right on Tropical Tuber Crops.	PPVFRA, at the Regional Centre of ICAR-CTCRI, Bhubaneswar, 22 January 2015	Dr. S. K. Chakrabarti
National Seminar on Distant Hybridization on Horticultural Crops	ICAR-Indian Institute of Horticultural Research, Bangalore, 22-23 January 2015	Dr. Archana Mukherjee
Seminar on Plant Pathogen Interactions	Department of Computational Biology, University of Kerala, 23 January 2015	Dr. S. S. Veena

Winter School on Bioinformatics and its Emerging Dimensions in Agriculture	Kerala Agricultural University, Vellanikkara, 28 January 2015	Dr. J. Sreekumar
27th Kerala Science Congress	Camelot Convention Center, Alappuzha, 27-29 January 2015	Dr. C. Mohan
Workshop of the Kerala State Planning Board Coordinated Project on Enhancing the Economic Viability of Coconut Based Cropping Systems for Land Use Planning in Kerala State	Kerala State Planning Board, Pattom, Thiruvananthapuram, 2 February 2015	Dr. K. Susan John Dr. S. S. Veena
Twelfth Agricultural Science Congress on Sustainability Livelihood Security for Smallholder Farmers	National Dairy Research Institute, Karnal, Haryana, 3-6 February 2015	Dr. S. K. Chakrabarti Dr. R. Muthuraj
Yam Harvest Festival Meeting	Kanhangad, Kasaragod, Kerala 4 February 2015	Dr. James George
Annual Workshop of AICRP on FIM	Tamil Nadu Agricultural University, Coimbatore, 4-6 February 2015	Dr. J. T. Sheriff
Awareness Meeting on Development of Tuber Crops – Kerala State Govt. Project No. 2 for Yams	Iritty, Kannur, Kerala 5 February 2015	Dr. James George
National Entomologists' Meet	ICAR-Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand, 5-7 February 2015	Dr. K. Rajasekhara Rao
Awareness Meeting on Development of Tuber Crops – Kerala State Govt. Project No. 2 for Yams and Cassava	Wayanad, Kerala, 6-7 February 2015	Dr. James George
Training Course on Genomics and Proteomics in Plants and Microbes Towards Translational Research	ICAR-Indian Institute of Spices Research, Kozhikode, Kerala, 10 February 2015	Dr. S. K. Chakrabarti
36th Annual Conference and National Symposium on Challenges and Management Approaches for Crop Diseases of National Importance - Status and Prospects	Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, 12-14 February 2015	Dr. T. Makeshkumar
Eastern Zone Regional Agricultural Fair	ICAR-Central Potato Research Institute, Shimla at Regional Station, Patna, 19-21 February 2015	Dr. S. K. Chakrabarti
27th National Convention of Agricultural Engineers	Thiruvananthapuram, Kerala, 22-23 February 2015	Dr. G. Byju

National Meeting on New/ Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops	ICAR-National Bureau of Agricultural Insect Resources, 23 February 2015	Dr. K. Rajasekhara Rao
MIS/FMS Meeting	ICAR-ICWA on 24 February 2015.	Dr. Kalidas Pati
National Farmers Meeting on Horti cultural Crops	Horticulture Division of Indian Council of Agricultural Research at Tamil Nadu Agricultural University, Regional Research Station, Paiyur, 4-5 March 2015	Dr. S. K. Chakrabarti Dr. J.T. Sheriff
National Seminar on Sustainable Soil Health Management	International Fertilizer Industry Association-Fertilizer Association of India, New Delhi, 16-17 March 2015	Dr. K. Susan John
67th Annual Meeting of IPS and National Symposium on Understanding Host – Pathogen Interaction Through Science of Omics	ICAR-Indian Institute of Spices Research, Kozhikode, 16-17 March 2015	Dr. T. Makeshkumar
Research Advisory Committee Meeting of Kerala Agricultural University	Kerala Agricultural University, Mannuthy, Trichur, 17 March 2015	Dr. James George
Post-Harvest Evaluation Training Programme	Agali, Attapadi, 18 March 2015	Dr. James George
National Workshop on Application of Wireless Sensor Networks and Robotics in Agriculture and Rural Development	Thiruvananthapuram, 17-18 March 2015	Dr. V. S. Santhosh Mithra
Cassava Farmers' Training Programme	Mattathur Krishi Bhavan, Kerala, 19 March 2015	Dr. James George
21st Meeting of the Programme Advisory Committee	Ministry of Environment, Forests and Climate Change, New Delhi, 19 March 2015	Dr. G. Suja
3rd Meeting of the Institute Management Committee	ICAR-Central Plantation Crop Research Institute, Karasaragod, Kerala, 27 March 2015	Dr. James George

Visits Abroad

Name of the scientists	Period	Place	Purpose
Dr. R.C. Ray	15- 18 August 2014	Bien Hoa city, Vietnam	2nd Asian Food Safety and Security Associations (AFSA) held at Dong Nai University of Technology
Dr. P. Sethuraman Sivakumar	18 August 2013 to 13 August 2014	Tallahassee, USA	Fulbright Postdoctoral Research at the Eating Behavior Research Clinic, Department of Psychology, Florida State University, Tallahassee, USA
Dr. P. Sethuraman Sivakumar	27–29 March 2014	New York, USA	Attended the International Conference on Eating Disorders (ICED 2014): "Coming of Age as a Global Field" held at New York, USA
Dr. M. N. Sheela, Dr. K. Susan John, Dr. K.I. Asha and Dr. S. Sunitha	17- 22 August 2014	Brisbane, Australia	Attended and presented oral research papers at the 29th International Horticultural Congress (IHC-2014)
Dr. K.I. Asha	8-19 September 2014	Ghent, Belgium	Attended the "Advanced Course on Modern Breeding Techniques for Cassava" held at the Ghent University, Faculty of Bioscience Engineering, Coupure Links Ghent, Belgium
Dr. Shirly Raichal Anil	23-27 September 2014	Dhaka, Bengladesh	Sweet Potato Breeder's Meeting for South Asia and South-East Asia

Dr. K. Susan John, Dr. S. Sunitha, Dr. M. N. Sheela and Dr. K. I. Asha (from left to right) at Brisbane, Australia (IHC 2014)

Dr. M. Nedunchezhiyan (5th from left) and Dr. M. S. Sajeev (8th from left) at Manila, Philippines

Dr. M. Anantharaman Dr. R.S. Misra	8-14 December 2014	Manila and Baguio, Philippines	Supervision Meeting of CIP-IFAD-FoodSTART project
Dr. J. Sreekumar	3 –6 February 2015	Vanuatu	3rd Annual Meeting of the EU funded project on INEA
Dr. M. Nedunchezhiyan and Dr. M. S. Sajeev	25-31 January 2015	China	Study tour on "Sweet potato Processing" at the Institute of Agro Products Processing Science and Technology, Sichuan Academy of Agrl Science (IAPST of SAAS), Chengdu, Sichuan, China under Food START Project, International Potato Centre

Distinguished Visitors

The following distinguished persons visited ICAR-CTCRI during the year:

- Her Excellency the Governor of Kerala, Smt. Shiela Dixit.
- Shri. Oommen Chandy, Honourable Chief Minister, Kerala.
- Shri. K. P. Mohanan, Honourable Minister for Agriculture, Kerala.
- Shri. M. A. Vaheed, Honourable Member of Legislative Assembly, Kazhakuttom, Thiruvananthapuram.
- Dr. S. Ayyapan, Secretary, DARE and Director General, ICAR.
- Dr. G. Madhavan Nair, former Chairman of Indian Space Research Organisation and Secretary to the Department of Space, Government of India.
- Dr. M. Chandradathan, Director, Vikram Sarabhai Space Centre (Indian Space Research Organization), Thiruvananthapuram.
- Dr. K. E. Lawande, Vice Chancellor, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra.
- Dr. Vijayan Nair, Director, Sugarcane Breeding Institute.
- Prof. George Varghese, Director, Kerala State Council for Science, Technology and Environment, Sasthra Bhavan, Pattom, Thiruvananthapuram.
- Dr. Jitendra Kumar, Director, ICAR-Directorate of Medicinal and Aromatic Plant Research, Anand.
- Dr. Keith Tomlins, Professor of Food Science, Natural Resources Institute, University of Greenwich, United Kingdom.
- Dr. Francis Alacho, African Innovation Institute, Uganda.
- Prof. Lateef Sanni, Federal University of Agriculture, Abeokuta, Nigeria.
- Shri. K. Jyothishkumar, Doordarshan Kendra, Thiruvananthapuram
- Dr. Ram C. Chaudhary, Chairman, Participatory Rural Development Foundation, Gorakhpur.
- Dr. Maria Andrade, Sweet Potato Breeder, International Potato Centre (CIP).
- Dr. Subba Reddy Palli, Professor of Entomology, University of Kentucky.

Shri. Oommen Chandy, Hon'ble Minister of Kerala and
Shri. K. P. Mohanan, Minister for Agriculture, Govt. of Kerala, are being
described the activities of the Techno-Incubation Centre by
Dr. G. Padmaja, Head, Division of Crop Utilization, ICAR-CTCRI

Managerial Personnel

Director	:	Dr. S. K. Chakrabarti
Project Coordinator	:	Dr. James George
Head, Regional Centre, Bhubaneswar	:	Dr. R. S. Misra
Administrative Officer	:	Shri. Davis Joseph
Finance and Accounts Officer	:	Smt. R. Sari Bai
Central Public Information Officer	:	Dr. C.A. Jayaprakas
Vigilance officer	:	Dr. V. Ravi

Head of Divisions/Section

Crop Improvement	:	Dr. (Mrs.) M. N. Sheela
Crop Production (Head i/c)	:	Dr. V. Ravi
Crop Protection	:	Dr. C. A. Jayaprakas
Crop Utilisation (Head i/c)	:	Dr. J.T. Sheriff
Extension and Social Sciences	:	Dr. M. Anantharaman

Personnel

Director	Dr. S. K. Chakrabarti
Project Coordinator (AICRP on Tuber Crops)	Dr. James George
Dr. S. Sunitha	Principal Scientist

Head of Division/Section

Crop Improvement	Dr. (Mrs) M. N. Sheela
Crop Production (Rtd. on 31.12.2014)	Dr. C. S. Ravindran
Crop Production (in charge)	Dr. V. Ravi
Crop Protection	Dr. C. A. Jayaprakas
Crop Utilization (Rtd. on 31.10.2014)	Dr. G. Padmaja
Crop Utilization (in charge)	Dr. J.T. Sheriff
Social Sciences	Dr. M. Anantharaman

Division of Crop Improvement

Dr. Asha K. I	Principal Scientist
Dr. C. Mohan	Principal Scientist
Dr. (Mrs) Asha Devi	Principal Scientist
Dr. (Mrs) Shirly Raichal Anil	Senior Scientist
Ms. N. Krishna Radhika	Scientist

Division of Crop Production

Dr. V. Ravi	Principal Scientist
Dr. G. Byju	Principal Scientist
Dr. G. Suja	Principal Scientist
Dr. K. Susan John	Principal Scientist
Dr. V. Ramesh	Senior Scientist

Division of Crop Protection

Dr. M. L. Jeeva	Principal Scientist
Dr. S. S. Veena	Principal Scientist
Dr. T. Makeshkumar	Principal Scientist
Shri. Harish. E. R	Scientist

Division of Crop Utilization

Dr. J. T. Sheriff	Principal Scientist
Dr. M. S. Sajeev	Principal Scientist
Dr. A. N. Jyothi	Principal Scientist
Shri. Saravanan Raju	Scientist (SG)

Section of Extension & Social Sciences

Dr. S. Ramanathan	Principal Scientist
Dr. Sheela Immanuel	Principal Scientist
Dr. T. Srinivas	Principal Scientist
Dr. V. S. Santhosh Mithra	Senior Scientist
Dr. J. Sreekumar	Senior Scientist
Dr. P. S. Sivakumar	Senior Scientist

Library/PME Unit/Photography

Smt. K. S. Sudha Devi (Rtd. on 30.11.2014)	Assistant Chief Technical Officer
Smt. T. K. Sudhalatha	Senior Technical Officer
Shri. V. S. Sreekumar	Technical Officer
B. S. Deepa	Technical Assistant

Field/Farm/Lab.Technicians

Shri. A. S. Sabu (Transferred to RS, IIOPR, Palode on 28.3.2015)	Chief Technical Officer
Dr. S. Chandra Babu (Rtd. on 31.05.2014)	Chief Technical Officer
Shri. M. Manikantan Nair (Rtd. on 31.05.2014)	Assistant Chief Technical Officer
Smt. L. Rajalekshmi	Assistant Chief Technical Officer
Shri. R. Bharathan	Assistant Chief Technical Officer
Dr. L. S. Rajeswari	Assistant Chief Technical Officer
Shri. M. Easwaran	Assistant Chief Technical Officer
Shri. A. Madhu	Senior Technical Officer
Shri. I. Puviyarasan	Senior Technical Officer
Shri. C. S. Salimon	Senior Technical Officer
Shri. M. Kuriakose	Senior Technical Officer
Shri. G. Venukumaran	Technical Officer
Shri. L. V. Ajithkumar	Technical Officer
Shri. V. L. Mathew	Technical Officer
Shri. V. R. Sasankan	Technical Officer
Shri. V. Ganesh	Technical Officer
Shri. B. Renjith Kishore	Technical Officer
Shri. Patric M. Mascrene	Technical Officer
Shri. S. Natarajan	Technical Officer
Shri. G. Suresh	Technical Assistant
Shri. N. P. Ramadasan	Technical Assistant
Shri. A. S. Manikuttan Nair	Senior Technical Assistant
Shri. Luke Armstrong	Technical Assistant
Shri. T. Raghavan	Senior Technician
Shri. G. Shajikumar	Technical Assistant
Shri. B. Satheesan	Technician
Shri. D. T. Rejin	Technician
Shri. T. M. Shinil	Technician
Dr. S. Shanavas	Technical Assistant
Shri. B. S. Prakash Krishnan	Technical Assistant

Administrative and Accounts

Shri. Davis Joseph	Administrative Officer
Smt. R. Sari Bai	Finance and Accounts Officer
Shri. T. Jayakumar	Assistant Administrative Officer
Smt. Jessymol Antony	Assistant Finance and Accounts Officer
Smt. K. Padmini Nair	Personal Assistant
Shri. S. Sasikumar	Personal Assistant
Shri. M. Padmakumar	Personal Assistant
Smt. S. Sunitha	Stenographer Grade - III

Shri. P. C. Noble	Assistant Administrative Officer
Smt. B. Presanna	Assistant
Shri. T. Vijayakumara Kurup	Assistant
Shri. P. S. Suresh Kumar	Assistant
Shri. J. Unni	Assistant
Shri. K. Unnikrishnan Nair	Assistant
Smt. S. Geetha Nair	U.D.C
Shri. S. Harendra kumar	Assistant
Smt. V. Sathyabhama	U.D.C
Shri. O. C. Ayyappan	U.D.C
Shri. S. Sreekumar	U.D.C
Shri. C. Chandru	L.D.C
Shri. R. S. Adarsh	L.D.C
Shri. N. Jayachandran	L.D.C
Mrs. C. G. Chandra Bindhu	L.D.C

Canteen Staff

Shri. S. Radhakrishnan Nair	Skilled Support Staff

Supporting Staff

Smt. S. Ushakumari	Skilled Support Staff
Shri. K. P. Somasekaran (Rtd on 31.3.2015)	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	Skilled Support Staff
Smt. C. T. Chellamma	Skilled Support Staff
Smt. M. Syamala	Skilled Support Staff
Shri. K. Velayudhan	Skilled Support Staff
Shri. P. Ramankutty	Skilled Support Staff
Shri. T. Lawrence	Skilled Support Staff
Shri. N. Appu	Skilled Support Staff
Shri. K. Sivadas	Skilled Support Staff
Smt. J. Thenmozhi	Skilled Support Staff
Shri. M. Sam (Rtd. on 31.01.2015)	Skilled Support Staff
Shri. L. Samynathan	Skilled Support Staff
Shri. C. Krishnamoorthy	Skilled Support Staff
Shri. S. Sreekumaran	Skilled Support Staff
Shri. T. Manikantan Nair	Skilled Support Staff
Shri. K. Chandran	Skilled Support Staff

Regional Centre, Bhubaneswar

Dr. R. S. Misra	Head, Regional Station
Dr. R. C. Ray	Principal Scientist
Dr. Archana Mukherjee	Principal Scientist
Dr. M. Nedunchezhiyan	Principal Scientist
Dr. K. Rajasekhara Rao	Principal Scientist
Dr. K. Laxminarayana	Principal Scientist
Dr. Kalidas Pati	Scientist

Technical

Shri. Sushanta Kumar Jata	Technical Assistant
Shri. N. C. Jena	Technical Officer
Shri. Niranjan Pattnaik	Senior Technical Assistant
Shri. Bharat Kumar Sahoo	Technical Assistant
Shri. Pramod kumar Mati	Senior Technical Assistant
Shri. Bibhudi Bhusan Das	Senior Technical Assistant
Shri. Keshab Paikaray	Technician

Administrative and Accounts

Shri. Kalakar Malik (Rtd. on 31.01.2015)	Assistant Administrative Officer
Shri. P. K. Acharya	Private Secretary
Shri. K. Lakshamana Rao	U.D.C

Supporting Staff

Shri. Ramachandra Das	Skilled Support Staff
Shri. Bijoykumar Nayak	Skilled Support Staff
Shri. Akshayakumar Nayak	Skilled Support Staff
Shri. Purna Samal	Skilled Support Staff
Shri. Bhajaman Malik	Skilled Support Staff
Shri. Sauri Pradhan	Skilled Support Staff
Shri. K. C. Jena	Skilled Support Staff
Shri. Ramesh Nayak	Skilled Support Staff
Shri. Babuli Sethi	Skilled Support Staff
Shri. Fakirchandran Bhoi	Skilled Support Staff
Shri. Samsudin Khan	Skilled Support Staff

Other Information

ICAR Regional Committee Meeting at Thiruvananthapuram

The ICAR Regional Committee (VIII) meeting was held at ICAR-CTCRI during 2-3 May 2014. Her Excellency Smt. Sheila Dixit, Governor of Kerala inaugurated the meeting. In her inaugural address, the Governor emphasized the need to concentrate on strengthening our efforts at mitigating the regional imbalance in water availability. Lauding the efforts of the initiatives made by the research institutions in the region, she mentioned that ICAR region VIII comprising Kerala, Tamil Nadu, Karnataka, Pudhucherry and Lakshadweep had made significant strides in the productivity of crops, livestock and fisheries over the years. The farmers too have played a major role in the progress of this region with their innovations, she said. She released publications and products of ICAR-CTCRI during the inaugural session. Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR in his introductory remarks complemented the efforts of Sugarcane Breeding Institute (ICAR-SBI), Coimbatore and ICAR-CTCRI, Thiruvananthapuram in organizing this Regional Committee Meeting that will be analyzing and discussing in depth and make recommendations on the location specific problems peculiar to the region. Remembering the eminent Agricultural Scientist Dr. Norman E. Borlaug, whose birth centenary falls this year and whose last words were, "Take it to the farmer", the Director General informed that for the first time, progressive farmers from the region are participating in the meeting. Dr. N. Vijayan Nair, Director of ICAR-SBI and Member Secretary, ICAR Regional Committee No. VIII proposed a formal vote of thanks. About 150 delegates, Vice Chancellors, Directors of Research, Directors of Extension Education and Deans of the SAUs, Directors of ICAR Institutes, Project Coordinators and Heads of ICAR Regional/Research Centres and officials of the development departments of Agriculture, Animal Husbandry, Fisheries and Forestry from the region, besides high ranking officials from ICAR HQ, New Delhi participated in the meeting.

Her Excellency Smt. Sheila Dixit, Governor of Kerala, inaugurating the ICAR Regional Committee (VIII) meeting at ICAR-CTCRI on 2nd May 2014

H.H. Sree Visakham Thirunal endowment Lecture–2014

Prof. Keith Tomlins, Professor of Food Science, Natural Resources Institute, University of Greenwich, UK and President, International Society of Tropical Root Crops delivered the H.H. Sree Visakham Thirunal Endowment Lecture, fifth in the series, organized by the Indian Society for Root Crops (ISRC) at ICAR-CTCRI on 17th May 2014. The topic of the lecture was "Let them eat root and tuber crops: Is consumer acceptance important?". Prof. Tomlins highlighted the importance of understanding the food preferences of poor people so as to find ways of offering foods that are both acceptable, affordable and meet cultural preferences. He narrated his experience of conducting sensory testing and consumer acceptability studies on root crops, particularly sweet potato in African countries. He opined that food quality and acceptance involves a wide range of challenges because of diversity of food and drink products and situations in which they are grown, handled and transported, processed, marketed and consumed. Researchers are only just beginning to understand many of these issues, he added. Dr. S. K. Chakrabarti, Director, ICAR-CTCRI presided over the function. Dr. S. Ramanathan, President, ISRC

welcomed the gathering and Dr. G. Byju, Secretary, ISRC proposed the vote of thanks.

H.H Sree Visakham Thirunal endowment lecture-2014

Review Meeting of EU FSTP Funded Project Cassava Gmarkets

The second project review meeting of EU FSTP funded project "Improving the livelihoods of smallholder cassava farmers through better access to growth markets (Cassava Gmarkets) was organized from 14-19 May 2104 in Hotel Mascot, Thiruvananthapuram. The project is led by Natural Resources Institute, University of Greenwich, United Kingdom (http://cassavagmarkets.nri.org/) and ICAR-CTCRI is involved as associate partner. Eleven delegates from UK, Nigeria, Ghana, Tanzania, Malawi and Uganda attended the meeting. Dr. S.K.Chakrabarti, Director ICAR-CTCRI welcomed the delegates. Prof. Keith Tomlins, the project leader introduced the Cassava Gmarkets programmes and Dr. J.T.Sheriff, Country Manager-India gave introductory remarks. Progress of the work during June 2013 to May 2014 in eight work packages were reviewed and a field trip to Tierra Foods, Adoor was also arranged for the delegates.

Review meeting of EU FSTP funded project Cassava Gmarkets

One Day Training on Writing Winning Proposals

A one day training programme on "Writing better research proposals for early career for root and tuber crops scientists" was organized jointly by the Indian Society for Root Crops and the International Society of Tropical Root Crops at ICAR-CTCRI on 20th May 2014. An International panel of experts that included Dr. Keith Tomlins, Professor of Food Science, Natural Resources Institute, University of Greenwich, UK, Dr. Francis Alacho of African Innovations Institute, Uganda, Prof. Lateef Sanni, Federal University of Agriculture, Abeokuta, Nigeria and Dr. J. T. Sheriff, ICAR-CTCRI, India handled classes on various aspects such as writing research proposals, research methods, intellectual property rights, ethics in research etc. Scientists and research scholars from various research institutions numbering 25 attended this programme.

Participants of the one day training on writing winning proposals

Foundation Day Celebration

The ICAR-Central Tuber Crops Research Institute celebrated its 51st foundation day on the 31st July, 2014 at its premises. The foundation day celebration-cum-inauguration of the Techno-Incubation Centre and Tuber Crops Development Programme, Kerala was inaugurated by Sri. Oommen Chandy, Hon'ble Chief Minister, Government of Kerala. Chief Minister in his speech said that Kerala Government

had demarcated funds for promoting small-and medium-scale young entrepreneurs. This fund could be very well utilised by the ICAR research Institutes and other departments. Training could be offered through the techno-incubation centre at ICAR-CTCRI and farmers could utilise these facilities. The Tuber crops development programme could pave way for increasing the production and productivity and thereby the tuber crops can be brought on par with other commercial crops. He stressed the need for up-scaling the technologies developed by the Institute. Sri K. P. Mohanan, Hon'ble Minister for Agriculture, Kerala, in his speech informed that Rs.2.5 crores was given to ICAR-CTCRI by the Kerala Government for the techno-Incubation centre and Tuber crops development programme. He congratulated ICAR-CTCRI for having utilised the fund effectively and on time. He was confident that the incubation centre will fully benefit the farmers and small entrepreneurs. Earlier, Dr. (Mrs.) Padmaja, Head, Division of Crop Utilisation, ICAR-CTCRI welcomed the gathering. Dr. S. K. Chakrabarti, Director, ICAR-CTCRI presided over the function. Sri. M. A. Vaheed, M.L.A., Kazhakuttom and Sri. Ajithkumar, Director of Agriculture, Kerala offered felicitations. Dr. James George, Project Coordinator (AICRP-Tuber Crops) delivered the vote of thanks. Two hundred and fifty farmers/farm women from Kollam, Palakad and Thiruvananthapuram attended the programme. A scientists – farmers interface was also organised. The session was well attended by the farmers and they had informative interaction with the scientists. Field exposure visits were also arranged for the farmers. Wide media coverage was given for the entire programme.

Shri. Oommen Chandy, Hon'ble Chief Minister, Kerala delivering the inaugural address on the occasion of Foundation Day Celebration

Tuber Crops Day 2014

The ISRC and ICAR-CTCRI organized the TUBER CROPS DAY 2014 commemorating THRIKARTHIKA day on 5 December 2014 at ICAR-CTCRI, Thiruvananthapuram. Dr. J. T. Sheriff, Vice President, ISRC delivered the welcome address. Presiding over the function, Dr. S. K. Chakrabarti, Director, ICAR-CTCRI highlighted the importance of tuber crops and its contribution towards food security. He also stated that the ICAR-CTCRI is a premier research institute in the world conducting research exclusively on tuber crops and briefed about the technologies developed by the Institute. He appreciated the tuber crop farmers who are engaged in cultivation of these nutritionally rich crops without much of attention/intervention from the government. Prof. George Varghese, Director, Kerala State Council for Science, Technology and Environment, Thiruvananthapuram, inaugurated the programme. In his inaugural address he appreciated the farmers for cultivating tuber crops and contributing to the food security of the country through their efforts. He also appreciated the research work done by the institute and for celebrating the Thrikartika day as Tuber Crops Day. The key note address was delivered by Dr. M. Chandradathan, Director, VSSC (ISRO), Thiruvananthapuram. He emphasized the importance of Tuber Crops Day and told that the passion towards agriculture needs to be inculcated in the younger generation. He also talked about the advantages and disadvantages of the GM crops. He highlighted the role of communication satellites in disaster management and providing weather reports which is beneficial to the farmers and public. During the occasion, Dr. C.S. Ravindran, Head, Division of Crop Production and Dr. M. Anantharaman, Head, Section of Extension and Social Sciences were felicitated for their contribution to the growth and development of tuber crops. Shri. Balachandran Nair, President, Sangha Mythri and Shri.Ramachandran, from Peyad were felicitated for popularising tuber crops cultivation in Kerala. Dr. V.S. Santhosh Mithra, Secretary, ISRC proposed the vote of thanks.

Dr.M. Chandradathan, Director, VSSC (ISRO) Thiruvananthapuram lighting the lamp before delivering the keynote address

ICAR Zonal Sports Meet

ICAR-CTCRI Basket Ball Team won the first prize in the ICAR-Zonal Sports meet (ZONE IV) held during 13-17 October 2014 at Bangalore.

The victorious ICAR-CTCRI team

National Science Day Celebrations 2015

National Science Day 2015 was celebrated at ICAR-CTCRI during 26-27 February 2015 on the focal theme "Science for Nation Building". Dr. S.K. Chakrabarti, Director, ICAR-CTCRI, inaugurated the celebrations. Along with the entire staff, research fellows, students and apprentices, 58 students representing eight colleges in and around Thiruvananthapuram city attended the meeting and participated in various events. Quiz competition, elocution and poster making competitions were conducted separately for the ICAR-CTCRI members and college students on the focal theme. In the plenary session conducted on 27th February 2015, National Science Day speech was delivered by Padma Vibhushan Dr. G. Madhavan Nair, Former Chairman, ISRO and Secretary to the Department of Space, Govt. of India. Dr. Nair in his speech said that Sir. C.V. Raman proved the world that it is not the sophisticated equipments, but the clear vision and determination to unwind mysteries that makes a great scientist. He was of the opinion that GM crops must be tried for its great advantages. He stressed the need to develop strategies to reduce water consumption and cited example of Israel for its water saving technologies. He gave a detailed account on ways by which satellites and space research would help agriculture sector. He also said knowledge acquisition is a continuous process, there is nothing like ideal solutions, but only practical solutions and invoked the participants to use science for the benefit of mankind. The prizes and cash awards for intercollegiate competitions and inhouse competitions were distributed by Dr. G. Madhavan Nair.

Dr. G. Madhavan Nair distributing prizes on the occasion of National Science Day 2015

ICAR-CTCRI Library

Library continued the information support services to the research activities of the institute. In addition to the routine services, the major activities undertaken were:

1. Purchase of publications for research purpose

The total budget of Rs. 10 lakhs allotted to the library was utilized for the purchase of following publications:

- A total of 21 Journals (International-6 and National-15) worth Rs.750000
- Books (23 numbers) worth Rs. 180000
- E-resources on Database software (Indiastat.com) and NSSO data set (2011-2012) for Rs. 70000

2. User awareness training programme

- Springer online demonstration on 24 July 2014 on e-books

3. Infrastructure development to the library

- Eight book cases and four book racks were procured
- 500 sets of back volumes of journals were bound and kept

In addition, the following services were also made available to the users of the library.

1. **CD-Searches:** NSS Data (Unit Level) on 68th round Sch.1.0 (Type-2) was procured. Facilities were provided to the users to search the CD Databases available in the library. Users were assisted, whenever necessary, in making the searches.
2. **Ready-reference service:** Provided ready assistance and solutions to the user's various queries. These include enquiries in person or over the phone regarding any matters related to information sources, URLS of websites related to our work, downloading of file, common plant names, phone numbers, geographical information etc. About 800 users availed the facility of reference service from the library including 50 users from outside.
3. **Reading and reference facilities to the trainee students:** Services were extended to the students from Colleges and University Departments, who undertook their M.Sc. and Ph. D project works under the guidance of the Institute scientists. Their reference period varied from 1-3 months to 3-4 years. They were given necessary guidance in the use of reference sources and also photocopying facility.
4. **Circulation of books:** About 225 books were issued to the users on loan and it was recorded properly in the books issue register.
5. **Photocopying:** Library continued to provide photocopying service to the institute staff and other library users on official/payment basis. During the period 38904 copies were provided against the work indents, which included 36017 official copies and 2747 private copies.
6. **CeRA:** About 125 DDR requests of outside users of CeRA were fulfilled by sending hard copy of library materials.
7. **Services to the regional centre**: Seven books were procured for the library of Regional Centre, ICAR-CTCRI, Bhubaneswar.

ICAR Entrance Examination

ICAR's 19th All India Entrance Examination for admission to U.G. and P.G. degree programmes (AIEEA-UG/PG–2014) in agriculture and allied science subjects was held on 12th April 2014 and 13th April 2014, respectively at St. Mary's School, Pattom, Thiruvananthapuram and Loyola School, Thiruvananthapuram by ICAR-CTCRI. A total of 5973 candidates appeared for the UG Examination and 393 candidates appeared for the PG Examination. ICAR-CTCRI conducted the above examinations in a smooth and fair manner.

Participation in Exhibitions

ICAR-CTCRI participated in the following exhibitions:

1. Agri Intex 2014, Coimbatore, Tamil Nadu, 18-21 July 2014.
2. Karshakashri Farm Fair 2014, Thiruvananthapuram, 24–28 September 2014.
3. Swasraya Bharat-2014**,** Kerala Agricultural University, College of Agriculture, Padanakad, Kasaragod, 14-19 October 2014.
4. INTERNATIONAL HORTI INTEX 2014, Coimbatore, Tamil Nadu, 7-9 November 2014.
5. Global Agro Meet 2014, Adulex International Convention Centre, Angamali, Kochi, 6-8 November 2014.
6. PLACROSYM XXI, Calicut, 10-12 December 2014.

7. Karshika Mela 2015, Thodupuzha, 26 December 2014 to 4 January 2015.
8. 27th Kerala Science Congress Expo, Alappuzha, 27-30 January2015.
9. Agricultural Science Congress, India Expo 2015, National Dairy Research Institute, Karnal, 3-7 February 2015.
10. Regional Agricultural Fair, Central Potato Research Station, Patna, 19-21 February 2015.
11. Research–Industry Inderface, 2015, ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka, 10 February 2015.
12. Farm Show 2015**,** Kerala Agricultural University, Regional Agricultural Research Station (N.Z), Pilicode, Kasaragod, 12-17 February 2015.
13. National Farmers Meet 2015, Payyur, Krishnagiri District, 14 March 2015.

ICAR-CTCRI exhibition stall in the Agricultural Science Congress, India Expo 2015 at National Dairy Research Institute, Karnal

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014

Name of Division: Horticultural Science
Name of the Institution: Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram 695 017
RFD Nodal Officer of the RSC: Dr. V. Ravi, Principal Scientist (Plant Physiology)

Sl. No.	Objectives	Weight %	Actions	Success Indicators	Unit	Weight %	Target/Criteria Value					Achievements	Performance		Per cent achievements against Target values of 90% Col.	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%		Raw Score	Weighted Score		
	Production management, value addition and technology dissemination	54	Development of production / protection and value addition technologies	Production / protection technologies developed	Number	15	6	5	4	2	1	6	100%	15	120	The excess is because of achieving target value of 100% Col.
				Value addition technologies developed	Number	13	9	8	7	6	5	9	100%	13	112.50	The excess is because of achieving target value of 100% Col.
			Production of quality planting materials	Quality planting materials produced (cassava setts)	Number (in lakhs	6	2.4	2.2	2.0	1.7	1.5	2.66	100%	6	120.91	The excess is because of Good rainfall.
				Quality planting materials produced (yams and aroids tubers)	Weight (Tonnes)	6	39.0	37.0	35.0	32.0	30.0	42.33	100%	6	114.41	The excess is because of Good rainfall.
			Transfer of technologies	Trainings, demonstrations and exhibitions organized	Number	14	55	50	45	40	35	56	100%	14	112	The excess is because of achieving target value of 100% Col.

2.	Enhancing productivity and quality of tropical tuber crops through varietal improvement and germplasm conservation	35	Management of genetic resources	Accessions added to germplasm repository	Number	15	60	50	40	30	20	68	100%	15	136	The excess is because of achieving target value of 100% Col.
			Development of elite breeding lines	Elite breeding lines developed	Number	20	6	5	4	3	2	6	100%	20	120	The excess is because of achieving target value of 100% Col.
	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/ 2013	16/05/ 2013	17/05/ 2013	20/05/ 2013	21/05/ 2013	03/05/2013	100%	2	-	-
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/ 2013	02/05/ 2013	05/05/ 2013	06/05/ 2013	07/05/ 2013	23/04/2013	100%	1	-	-
	Administrative Reforms	4	Implement ISO 9001 as per the approved Action Plan	% Implementation	%	2	100	95	90	85	80	0	0	0	-	-
			Prepare an Action Plan for Innovation	On-time submission	Date	2	30/07/ 2013	10/08/ 2013	20/08/ 2013	30/08/ 2013	10/09/ 2013	24/07/2013	100%	2	-	-
	Improving internal efficiency / responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80	100	100%	2	-	-
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	100	100%	2	-	-

Total Composite Score: 98.00

Rating: Excellent

Achievements Objectives-wise (April 1, 2013 to March 31, 2014)

Objective 1: Production management, value addition and technology dissemination

Action: 1. Development of production / protection and value addition technologies

Success Indicator: 1. Production / protection technologies developed

1. Control method developed for the control of Dynastid beetle grubs attacking Amorphophallus tubers.
2. Developed weed control method for cassava field by the use of oxyflurfen (@ 0.2 kg ai ha^{-1}).
3. One production technology (liming of soil with application of Dolomite @ 1 tonne /ha) developed for acidic Ca and Mg deficient soils of Kerala.
4. Developed two protection technologies (1) production of virus free *Amorphophallus* under *in vitro* conditions and (2) management of greater yam anthracnose caused by *Colletotrichum gloeosporioides* and one production technology (2) Use of weed control ground cover in cassava for complete suppression of weeds and enhance tuber yield.

Success Indicator: 2. Value addition technologies developed

1. A low glycaemic cassava spaghetti with a glycaemic index of < 55 was developed through fortification of cassava flour with a high dietary fiber source viz., NUTRIOSE ®.
2. A modified cassava starch was prepared using stearic acid, sunflower oil and CTAB and was found to have high resistant starch content compared to native starch. Sago prepared out of it also had high resistant starch content.
3. Protein enriched sweet potato starch noodles was prepared using 20% whey protein concentrate as protein additive. The product had a resistant starch content of 24% and cooking loss of only 4.12% and smooth exterior finish.
4. Developed (1) betanin fortified sago with appealing colour (2) calcium enriched sago incorporating calcium carbonate and the product had ca content of 0.226%.
5. Value added products: 1. Functional starch noodles with high protein content and low starch digestibility were developed from sweet potato starch using NUTRIOSE fortification 2. Cassava starch complexes with sun flower oil, stearic acid in ethanol and NUTRIOSE (10%) gave modified starch products with high resistant starch content such as 73.61%, 69.87% and 67.56% respectively and the sago made from these also had high RS content.

Action 2. Production of quality planting materials

Success Indicator: 1. Quality planting materials produced (cassava setts)

1. Planting materials were produced in 4 released varieties viz., Sree Jaya, Sree Vijaya, M-4 Quintal Kappa, Aniyoor, Ullichawala and Vellayani Hraswa, CMR line of cassava.

Success Indicator: 2. Quality planting materials produced (yams and aroids tubers)

1. Planting materials were produced in yams (*Dioscorea esculenta*, (var. Sree Latha), *D. Alata* (var. Sree Rupa, Sree Keerthi) and *D. Rotundata*) (vars.

Sree Priya, Sree Subra), *Amorphophallus* (vars. Gajendra, Sree Padma , Sree Athira and Peerumedu) and *Colocasia* (var. *Sree Reshmi*)

2. Planting materials were produced in *Colocasia* (var. Sree Reshmi , Mukthakesi and Telia).
3. Planting materials were produced in yams (Dioscorea esculenta, (var. Odisha Elite), Amorphophallus (vars. Gajendra).

Action 2: Transfer of technologies

Success Indicator: 1. Trainings, demonstrations and exhibitions organized

1. Four exposure training of one day duration conducted for 120 farmers on improved tuber crops technologies.
2. About 10 FLDs on tuber crops were laid out in Meghalaya, Manipur, Nagaland and Tripura.
3. Four exposure training of one day duration conducted for 95 farmers on improved tuber crops technologies
4. About 8 FLDs on tuber crops were laid out in Meghalaya, Manipur, Nagaland and Tripura.
5. The Institute took part in NIRAVU exhibition in Kerala.
6. Eight exposure trainings were and about 280 farmers/ students from Kerala Tamil Nadu and Punjab participated.
7. Ten exposure trainings were organised and about 300 farmers/ students from Kerala and Tamil Nadu participated.
8. Four exposure trainings were organized at CTCRI for farmers on Production and processing of tuber crops. Training imparted on beta carotene rich sweet potato cultivation and nutritional aspect in Koraput, Mulkhangiri and Jeypure, Odisha in June.
9. Conducted two exhibitions one in Bharat Nirman Public Information Campaign at Alappuzha, Kerala and the other in Utkal-Banga Utsav, Balasore, Odissa 14-21, August 2013.
10. Two one day training programmes organized on Production technology and value addition were conducted at CTCRI, Trivandrum for farmers of Tamil Nadu and Kerala.
11. Conducted advanced training on Production and processing of Tuber crops for 17 male Assam officials and progressive farmers during 15-21, February.
12. Training on value addition in tuber crops for 8 officials from ICAR KVK, private KVK, NGO, OTLP under HRD programme of the Institute.

Objective 2: Enhancing productivity and quality of tropical tuber crops through varietal improvement and germplasm conservation

Action: 1. Management of genetic resources

Success indicator: 1. Accessions added to germplasm repository

1. Three accessions of aroids were collected from Jorhat, Assam.
2. One accession of taro from Assam and one accession of tannia from Wayanadu, Kerala were collected.
3. Five accessions of cassava comprising of two from Adoor, Pathnamthitta and three from Salem, Tamil Nadu were collected.

4. Sixteen new accessions were added to the germplasm. It includes one taro accession from Aeram, Anchal, Kerala; two elephant foot yam accessions and one greater yam accession from Malkhangiri, Odisha ; two sweet potato accessions from Dhenkanal, Odisha ; two taro accessions from Chandaneswar, Balasore, Odisha; five cassava accessions, one sweet potato accession and two *Dioscorea* sp collected from Assam.
5. Twelve accessions of taro and two accessions of sweet potato were collected from Manipur (Ukrul, and Imphal) and West Bengal (Nadia).
6. Six landraces of cassava were collected from Kollam and Pathanamthitta districts of Kerala.
7. Five landraces of cassava were collected from Palghat, Malappuram and Pathanamthitta districts of Kerala.
8. Collected 10 accessions comprising of taro, Chinese potato, greater yam, arrow root, elephant foot yam and *Curcuma* sp. From Kanyakumari district of Tamil Nadu.
9. Collected 7 accessions comprising of taro, Chinese potato, greater yam, arrow root, elephant foot yam and *Curcuma* sp. from Kanyakumari district of Tamil Nadu.

Action: 2. Development of elite breeding lines

Success indicator: 1. Elite breeding lines developed

1. The varietal release proposals of two sweet potato varieties *viz.* CIPSWA2, ST-13 (purple fleshed with high anthocyanin 85-90 mg/100g) and one greater yam variety, Da25 recommended by AICRP(TC) were submitted to Director of Horticulture, Odisha for varietal release in Odisha state.
2. Two triploid cassava hybrids 4-2 (Sree Athulya) & 5-3 (Sree Apoorva) with high yield (38 t ha^{-1}) and starch (30%) content were identified for central release.
3. Identified one CMD resistant clone viz. CR20A-2 with good fried chip quality in terms of frying tolerance and bite feel.

Annual Performance Evaluation Report of Central Tuber Crops Research Institute for the year 2013-2014 is hereby approved by the RFD Committee of the Institute

-sd-	On-deputaion to USA	-sd-	-sd-
(Dr. V. Ravi)	**(Shri. P. Sethuraman)**	**(Smt. R. Saribai)**	**(Smt. K.S. Sudhadevi)**
Principal Scientist	(Scientist (SG))	Finance & Accounts Officer	Technical Officer (PME Cell)
Nodal Officer	Co-Nodal Officer	Member	Member Secretary

-sd-

DIRECTOR

Chairman of RFD Committee

वर्ष 2014-2015 के दौरान इस संस्थान में की गयी राजभाषा कार्यान्वयन से सम्बन्धित कार्यक्रम

राजभाषा कार्यान्वयन समिति की बैठक का आयोजन

ता 28.06.2014, 27.09.2014, 27.12.2014 और 28.03.2015 को राजभाषा कार्यान्वयन समिति की चार बैठकों का आयोजन किया गया। इस अवसर पर राजभाषा कार्यान्वयन से संबधित विभिन्न मुद्दों पर विचार - विमर्श किया गया और उसके आधार पर उक्त मुद्दों के अनुपालन किया जा रहा हैं।

हिन्दी कार्यशाला का आयोजन

संघ सरकार की राजभाषा नीति के अनुपालन में इस संस्थान के सभी कर्मचारियों के लिए 30.05.2014 को हिन्दी टिप्पण और आलेखन पर एक दिन की हिन्दी कार्यशाला आयोजित किया गया। डॉ. एस.के. चक्रवर्ती, निदेशक और अध्यक्ष (राजभाषा), हिन्दी के महत्व पर प्रकाश डालते हुए समारोह का उद्घाटन किया। डॉ. वी. एस संतोष मित्र, वरिष्ठ वैज्ञानिक और संपर्क अधिकारी (राजभाषा) ने सभा का स्वागत किया, विशेष रूप से श्री. मोहन चौधरी सहायक निदेशक (राजभाषा) एवं सदस्य सचिव, न.रा.का.स, चीफ पोस्ट मास्टर जनरल कार्यालय, तिरुवनंतपुरम का स्वागत किया और कार्यशाला में अच्छी उपस्थिति पर संतोष प्रकट किया। श्री. मोहन चौधरी ने हिन्दी टिप्पण और आलेखन पर क्लास लिया। कुल 49 प्रतिभागियों ने कार्यशाला में उत्साहपूर्व भाग लिया। प्रतिभागियों की राय थे कि इस तरह के कार्यशालाओं की बारंबारी बढाई जानी चाहिए क्योंकि उन्हें यह बहुत फायदेमंद लगा। श्रीमती. टी. के सुधालता, तकनीकी अधिकारी (हिंन्दी) ने धन्यवाद प्रस्ताव पेश किया और श्री. मोहन चौधरी की क्लास की सराहना की और सभी प्रतिभागियों को, कार्यशाला से प्राप्त ज्ञान उपयोग करने के लिए अनुरोध किया।

हिन्दी टिप्पण और आलेखन की प्रतियोगिता

हिन्दी पखवाड़ा समारोह का आयोजन

ता. 14-28 सितम्बर 2014 को हिन्दी पखवाड़ा मनाया गया. विविध हिंदी प्रतियोगिताएं, स्टाफ और बच्चों के लिए आयोजित की गई। (निबंध 1. लेखन 2. अनुवाद 3. भाषण 4. कविता पाठ 5. सुलेख 6. खुला मंच 7. अंतासरी आदि प्रतियोगिताएं आयोजित की गई.)।

हिन्दी पखवाड़ा समारोह

ता. 09.01.2015 को हिन्दी पखवाड़ा का समापन समारोह आयोजित किया गया हिन्दी प्रतियोगिताओं में पुरस्कार प्राप्त अधिकारी/कर्मचारी/बच्चों और भाग लिए सभी प्रतिभागियों को मुख्य अतिथि, श्रीमती विशालाक्षी, सेवानिवृत्त सहायक निदेशक (राजभाषा) और सदस्य सचिव (न.रा.का.स.), मुख्य पोस्टमास्टर जनरल कार्यालय, केरल सर्किल, तिरुवनंतपुरम द्वारा उस दिन में पुरस्कार /प्रमाण पत्र वितरित किया गया। डॉ. एस. के. चक्रवर्ती, निदेशक महोदय ने समारोह की अध्यक्षता की।

इसके अलावा केरल हिन्दी प्रचार सभा में राज्यस्तरीय हिन्दी पखवाडा के अवसर पर आयोजित हिन्दी प्रतियोगिताओं में और तिरुवनंतपुरम नगर राजभाषा कार्यान्वयन समिति के तत्वावधान में आयोजित हिन्दी प्रतियोगिताओं में, इस संस्थान के प्रतिभागियों ने भाग ले करके पुरस्कार प्राप्त किया।

तिरुवनंतपुरम नगर राजभाषा कार्यान्वयन समिति के बैठकों में, इस संस्थान के निदेशक महोदय और राजभाषा कार्यान्वयन समिति के सदस्यों ने भाग लिया।

वार्षिक रिपोर्ट के कार्यकारी सारांश का अनुवाद किया गया और मुद्रित किया गया।

हिन्दी प्रशिक्षण

हिन्दी पखवाड़ा मे अंतासरी की प्रतियोगिता

हिन्दी प्रशिक्षण

इस संस्थान की एस एस ग्रेड कर्मचारी जो कुशल समर्थन कर्मचारियों को पदोन्नत किया गया और इनके अलावा जो अधिकारियों/ कर्मचारियों को हिन्दी ज्ञान प्राप्त नहीं उन्को हिन्दी प्रशिक्षण दिया गया। (19 कुशल समर्थन स्टाफ 2 प्रधान वैज्ञानिक और 1 वरिष्ठ वैज्ञानिक को हिंदी प्रबोध प्रशिक्षण कार्यक्रम दिया गया)।

परीक्षा में पास किये गए सदस्यों को नकद पुरस्कार एवं प्रमाण पत्र हिन्दी पखवाड़ा का समापन समारोह-2014 के अवसर पर डॉ. एस.के. चक्रवर्ती, निदेशक महोदय द्वारा वितरित किया गया।

प्रोत्साहन योजना 2014

हिन्दी में काम करनेवालों को (प्रोत्साहन योजना में भाग लिए/ प्रोत्साहन के पात्र कर्मचारियों को) नकद पुरस्कार रु. 800/- प्रति व्यक्ति को दिया गया।

इस संस्थान की सभी रबड़ की मोहरें, पत्र शीर्ष, नाम पट्ट, साइन बोर्ड आदि द्विभाषी रूप में बनाया था।

प्रशासनिक कामकाज में उपयोग द्विभाषी प्रपत्र arisnetshare पर शामिल किया था।

अधिक से अधिक पत्राचार हिंदी में किया था।

सभी परिपत्र, धारा 3(3), के सभी कागजात 100% द्विभाषी रूप में किया था।

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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