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CENTRAL TUBER CROPS RESEARCH INSTITUTE

An ISO 9001-2008 Certified Institute

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Cover Illustration
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Sweet potato weevil

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27 June 2014

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PREFACE

It is indeed my pleasure to present the Annual Report of Central Tuber Crops Research Institute (CTCRI). The year 2013-14 was a unique occasion in the voyage of this premier institute which completed 50 years of its existence in July 2013. The institute was established in the year 1963 to intensify research and development on tropical tuber crops like cassava, sweet potato, yams, taro, elephant foot yam, yam bean, arrow root, Chinese potato etc. It emerged as a premier research centre on tropical tuber crops not only in India but also in the world as a consequence of sustained efforts of our predecessors as well as fruitful linkages with international organizations like CIAT, Cali, Colombia; IITA, Ibadan, Nigeria; CIP, Lima, Peru; NRI, Greenwich, UK; CIRAD, Montpellier, France; DDPSC, St. Louis, USA; DSMZ, Germany etc. During last fifty years, the institute developed 49 high yielding cultivars of different crops and perfected technologies for their production, protection, and utilization. Productivity of cassava increased from 7.1 t ha^{-1} in 1963 to 36.5 t ha^{-1} in 2011 which is three times more than that of world average; in fact, India tops the world in cassava productivity.

During the year 2013-14, two cassava triploid varieties, *viz*., Sree Athulya and Sree Apoorva were recommended for release and cultivation in the states of Tamil Nadu and Andhra Pradesh by Central Sub-Committee on Crop Standards. The greater yam elite line Da 293 performed very well in the on-farm trials in Odisha. Salt tolerant genotypes of both white fleshed (Samrat, Pusa Safed, Kishan, Sree Bhadra, Kanchangad) and orange fleshed (ST-14, Gouri, CIP-440127, CIP-SWA-2) sweet potato were transferred to the farmers and K efficient cassava genotypes *viz*., Aniyoor and 7 III E3-5 have been identified for edible and industrial uses, respectively. Several production technologies, *viz*., eco-friendly weed management using weed control ground cover, organic farming technology for dwarf white yam, soil test based INM strategy for cassava comprising FYM, N, P, K, Mg and Zn, integrated nutrient management (INM) and SSNM strategy in major growing environments of India for sweet potato and elephant foot yam, technology for soil moisture conservation and weed control for rainfed hill, nutrient rich organic manure from cassava starch factory solid waste (thippi) through composting, current and future climate suitability maps of cassava and elephant foot yam in India have been developed. Similarly, management of pseudo-stem weevil of banana using cassava bio-pesticide was a major field success in different regions of Kerala.

Technologies for production of resistant starch enriched cassava starch for possible applications in the development of low glycaemic foods, low glycaemic spaghetti from sweet potato flour, low glycaemic noodles from sweet potato starch, low calorie sago from cassava have been developed. Similarly, effective technologies have been developed for the production of starch based superabsorbent polymers, superporous hydrogels and injection moulded product using poly lactic acid-oxidized starch composites for expanding industrial application of tuber crops. A web based interactive tool for tuber crops statistics has been developed using R environment for statistical computing. Elephant Foot Yam Growth Simulation Model (EFYSIM), Sree Visakham Cassava Expert System, and Tamil version of Tuber Information Cafe (TIC) were developed. Four hundred and fifty

farmers were adopted under CTCRI NEH programme in four states namely Manipur, Meghalaya, Nagaland and Tripura through 10 partner implementing centres. CTCRI Tribal Sub Plan programme was implemented in three states namely Odisha, Chhattisgarh and Jharkhand.

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, ADG (HS II), Dr. Vikramaditya Pandey, PS (HS) and Dr. Manish Das, PS (HS) for their suggestions and encouragement. I appreciate the time and sincere efforts devoted by the editorial committee in compiling the report and all the scientists, officers and staff members for their hard work and contributions for the progress of the institute.

27/ 06/ 2014

S. K. Ckakrabarti
Director

EXECUTIVE SUMMARY

Based on discussions in Institute Research Council and advice of Research Advisory Committee, projects were formulated and activities were framed. There were 57 institute projects during 2012-2013. The projects were reduced to 17 with multidisciplinary approach during this reporting period. The salient achievements of the ongoing institute research projects and 25 externally aided projects during 2013- 2014 are highlighted here. The scientific staff strength was 39 including the Director during the reporting period.

A total of 5832 germplasm of tropical tuber crops comprising of cassava (1383), sweet potato (1483), yams (1151), aroids (1348) and minor tuber crops (390) are being conserved as field gene bank, along with seventy seven new accessions of tuber crops, comprising of cassava (20), sweet potato (10), *Ipomoea* sp. (1), greater yam (5), lesser yam (1), wild yams (2), taro (17), tannia (4), elephant foot yam (8), chinese potato (1), arrowroot (3), *Curcuma* sp. (3), *Canna* sp. (1) and giant taro (1) which were collected during the reporting period. The accessions were collected from Assam, Kerala, Manipur, Tamil Nadu, West Bengal, Jharkhand and Odisha. Data recording on ten above ground qualitative characteristics has been done for 425 accessions of cassava germplasm. Screening of cassava germplasm for CMD was done under field epiphytic conditions and 77 accessions were identified as free from any symptoms. Collected 2450 seeds by hybridizing 3750 flowers of cassava mosaic disease resistant clones with susceptible varieties/landraces having high starch content, earliness and culinary quality.

Two triploid cassava hybrids *viz.,*Sree Athulya (4-2) and Sree Apoorva (5-3) were recommended for central release in the 21st meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops held on 7th October, 2013. Sree Athulya is high yielding (39.00 t ha^{-1}) with high starch content (34.80%) and has been recommended for release and cultivation in the States of Tamil Nadu and Andhra Pradesh. It is suitable for starch extraction as well as cattle feed. Sree Apoorva is also high yielding (37.60 t ha^{-1}) with non top branching plant habit and high starch content (33.30%) and has been recommended for cultivation in Tamil Nadu and Kerala.

Elite clones of cassava with novel traits *viz.,*cassava mosaic disease resistance (9S127,CR 20 A2, CR21-10) with high starch content on fresh weight basis (31.9, 31.6 and 30.8% respectively); good fried chip quality (CR 21-10, CR 20A-2, CMR 100); high dry matter (>45%), CMD resistance (11S20, 11S28, 11S33, IH5/15) and keeping quality (CR 20 A2, CI-800, BR-105) were identified. Morphological characterization in taro was done for 25 accessions mostly from NEH regions for 27 above ground characters as per NBPGR/IPGRI descriptors. Twenty one taro accessions having good cooking quality with no acridity and three with leaf blight resistance (U-64, TCR 125 and IC 204065) were identified. The high yielding greater yam variety Da 293 with good culinary quality and compact tuber is widely adopted in Odisha, particularly in Ganjam district. Promising white yam genotypes with high yield (Dr 246), early bulking (Dr 169), compact tuber (Dr 29), and good cooking quality (Dr 128, Dr 130, Dr 140, Dr 147, Dr 21, Dr 281, Dr 29, Dr 324, Dr 7) were identified for further evaluation.

In the process of developing high starch cassava through transgenic approach, the *glgC* gene construct was mobilized to *Agrobacterium* EHA105 and the

colonies were confirmed as *Agrobacterium*. The *gbssI* gene fragments were amplified and cloned to pGEMT vector and the sequence was confirmed. The targets for cassava miRNAs in the genes of cassava mosaic virus were identified. AmiRNA target prediction tool for the given mRNA sequence has been developed in R package, incorporating sequence similarity score and energy prediction and utilized to identify plant miRNA targets in RNA seq data of elephant foot yam. A web based interactive tool for construction of gene networks using gene expression data was developed using R statistical environment.

Rice-black gram-short duration cassava was profitable and generated added return of Rs.1.5-1.8 lakhs ha^{-1} over sole cassava. Rice-green gram-short duration cassava and rice-soybean-short duration cassava were also feasible as added profit of Rs. 1 lakh ha^{-1} over sole crop could be realized. There was a possibility to reduce full P, half FYM and N to cassava in these systems. Organic farming produced 31% higher yield over conventional practice in dwarf white yam by the third year, though production systems did not vary significantly. Organic farming was equally stable as that of conventional practice in yield stability index analysis of the long term performance of organic Vs conventional management in yams and aroids over a five year period. Among the different organic manures tested to substitute FYM, green manuring *in situ* with cowpea was the best, recording a tuber yield of 31.90 t ha^{-1}; significantly superior to FYM @12.5 t ha^{-1} (24.90 t ha^{-1}). The sustainability of cassava was established through continuous cultivation without any manures and fertilizers from the same field for 23 years with an average yield of 12.14 t ha^{-1}.

The K use efficient cassava genotypes, Aniyoor and 7 III E3-5 recorded better root distribution pattern and root dimensions (white roots/root hairs) among the six genotypes under the root studies conducted in pot, lysimeter and field, conditions. Cassava genotypes, W-19 and CR 43-8 showed highest N use efficiency potential among the six identified K efficient genotypes. The low input management strategy comprised of the NUE genotype (Ac. No. 906) with low cost soil fertility management involving soil test based application of fertilizers (NPK@106:0:83 kg ha^{-1}), green manuring *in situ* with cowpea as organic source and use of nutrient efficient biofertilizers resulted in a significantly higher tuber yield of 36.46 t ha^{-1} with a saving of 10-20% in cost of cultivation

Thippi enriched with cow dung, cassava leaves, *Glyricidia* leaves, Mussooriphos and rock powder composted with earthworm resulted in a good organic manure having low bulk density, with mean N, P, K, Ca, Mg, Fe, Cu and Mn content to the tune of 1.32, 3.82, 0.4, 2.18, 0.96, 1.11, 0.08%, 11.23 and 89.93 ppm respectively which is 3.5, 49, 7, 3.25, 8.1, 185, 100, 2.5 and 12 times higher than that in thippi, in addition to a reduction in C: N ratio to 8:1. The nutrient mineralization pattern of the compost in soil indicated maximum availability of all nutrients in soil during 4 to 6th month. Soil test based (STBF) INM strategy in cassava (FYM @ 5 t ha^{-1} + NPK @ 60:0:54 kg ha^{-1}) could save FYM and NPK to the tune of 60, 40,100 and 46% respectively with statistically equivalent yields for STBF based INM (22.871 t ha^{-1}) and POP (24.901 t ha^{-1}). Highest sweet potato tuber yield (28.729 t ha^{-1}) was produced under combined application of Mg and Zn than POP (21.623 t ha^{-1}) based on soil test. Significantly higher tuber yield of yam bean (35.9 t ha^{-1}) was obtained due to integrated application of lime + FYM + NPK + $ZnSO_4$ on par with 150% NPK (34.9 t ha^{-1}).

Enhancement of 90, 198 and 259% of tuber yield of yam bean was obtained in the acid Alfisol due to application of 50, 100 and 150% NPK over control. Highest tuber yield (28.24 t ha^{-1}) was observed with vermicompost application than the organic manures. Highest starch content was recorded due to application of 150% NPK, however, the total sugars varied from 4.98-5.91%. Highest increase of soil pH and organic C was observed due to combined use of lime + FYM + NPK + $MgSO_4$ from the initial level.

Significantly higher available N & K were recorded due to application of 150% NPK, while the available P was found highest due to integrated use of VAM + lime + FYM + NPK. The recommended doses of fertilizer (RDF) in elephant foot yam applied through fertigation in 40 numbers of splits at 4 days interval produced maximum corm yield of 38.3 t ha^{-1}. Maximum fertilizer use efficiency of 81.7% was observed with the above interaction as compared to application of RDF in soil (37.8%). Drip irrigation in elephant foot yam at 100% CPE (cumulative pan evaporation) during 13-24 weeks after planting resulted in maximum corm yield of 41.9 t ha^{-1} which is on par with flood irrigation given during the entire period of 1-24 weeks.

Weed control ground cover (WCGC) completely suppressed the weeds during the entire crop period of cassava with highest tuber yield (21.22 t ha^{-1}) and net income of Rs.1,60,450 ha^{-1}. The yield was on par with the chemical method using pre-emergence application of oxyfluorfen @ 0.2 kg ha^{-1} (21 t ha^{-1}) and hand weeding twice as per POP (21 t ha^{-1}). Eco-friendly weed management like mulching with crop residues and green manuring proved to be equally effective as that of chemical method and hand weeding twice in cassava.

Elephant foot yam plants var.Gajendra enclosed in poly chamber of 2 m^3 for 3 months and irrigated regularly experienced high temperature stress of 37-40°C during day time (10 am to 4 pm) and showed senescence at 75 days after enclosure in poly chamber.

Current and future climate suitability maps of cassava and elephant foot yam (EFY) in India were developed using geoinformatics tool. Elephant foot yam is positively impacted in many areas of Andhra Pradesh, Gujarat, Bihar and Jharkhand with -3.2 to +19.6 % changes in climate suitability (average % change in all pixels). The predicted increase in temperature by 2030 is between 1.3 and 2.4°C. The predicted changes in rainfall ranged between -135 to +35 mm/year. Most elephant foot yam growing regions showed decrease in rainfall of 65-85 mm.

Highest average soil moisture of 16.7 to 17.9 (v/v) was observed during the month of June and August, 2013 respectively, under integrated application of organic materials in the long term manurial trial of cassava at CTCRI Farm.

Association of soil variables indicated that bulk density was significantly and positively correlated with soil porosity (r=0.99**) and water holding capacity (r=0.71**). Soil moisture was the highest under porous ground cover sheets (GC) and significant (34-65%) over control at Pachamalai hills, Eastern Ghats of Tamil Nadu. The soil temperature varied from 23.5 to 30.9°C in different treatments and was significantly lower in GC treatments to an extent of 3-6% over control. Under two different soil moisture levels *viz.,* air dry (AD) and field moisture (FM), the available soil P decreased with increased soil moisture content whereas soil available K content increased at high soil moisture content.

Virus free planting material of cassava (SreeVijaya) and elephant foot yam (Gajendra) were produced through micropropagation followed by indexing and distributed to the farmers.

There was no incidence of corm borer *Aplosonyx chalybaeus* in any of the coastal districts of Odisha (Puri, Cuttack, Jajpur, Bhadrak, Balasore) and Poorva Midnapore district in West Bengal, despite the presence of several species of wild hosts. Aphids and grasshoppers caused 3-5% foliar damage in taro. Sweet potato weevil infestation in the farmers' fields in different places of Odisha ranged from 5-10%. Sweet potato weevil populations were monitored using sex pheromone traps in different districts of Odisha and Andhra Pradesh.

Foliar spray of the CTCRI developed biopesticide *Nanma* @ 1% at 45 & 60 days after planting (DAP) was effectively manage weevil in sweet potato field. Validated the efficacy of *Menma* against banana pseudostem weevil (BPSW) (over 30,000 plants) in the farmers' fields in three districts (Thiruvananthapuram,

Malappuram and Kasaragod) of Kerala. Fabricated an injection needle with multiple discharge points for the application of cassava biopesticide (*Menma*) against BPSW in banana. Standardized a technique to detect cyanogen in the cassava biopesticide by using gas chromatography.

Out of the three pesticides *viz.,* chlorpyrifos, malathion, and dimethoate treated on sweet potato plants, the residue of dimethoate exhibited maximum retention, up to four weeks, whereas, the concentration of malathion decreased gradually and reached zero in seven days after treatment. Six proline containing cyclic dipeptides were isolated from cell free culture filtrate of *Bacillus* sp. strain N which is associated with the nematode *Rhabditis* sp. The metabolites showed potent inhibitory action against *Fusarium oxysporum* (MTCC 284), *Rhizoctonia solani* (MTCC 4634) and *Penicillium expansum* (MTCC 2006).

Volatiles extracted from leaf and flower of sweet potato varieties have shown differential EAG responses. The chemicals extracted from weevil resistant varieties of sweet potato were identified as alpha-gurjunene and alpha-humulene, repelled the weevil upto 65-75% in Y-tube olfactometer bioassays.

Twenty *Phytophthora colocasiae* isolates were added to the existing collection from farms of CTCRI for studying yearly variation and grouped according to morphology based on culture characteristics of the isolates. Confirmed all isolates to the species level using specific PCR. Performed genetic diversity analysis using Start Codon Targeted (SCoT) Markers. Standardized a reliable method for pathogen quantification using real-time PCR and RNA isolation methods from pathogen and the host to get high quality RNA.

Tuber treatment with *Trichoderma* @ 5g kg^{-1}, soil application of neem cake @ 200g/pit + two foliar sprays with CTCRI bioformulation at 60 and 90 days after planting recorded less than 1% and 5% of collar rot and leaf blight incidence in elephant foot yam respectively, and gave highest tuber yield of 37.5 t ha^{-1} in field. In taro, tuber treatment with *Trichoderma* @ 5 g kg^{-1}, use of tolerant variety Muktakeshi and two foliar sprays with CTCRI bioformulation gave highest yield of 24.5 t ha^{-1} and minimum incidence of taro leaf blight (less than 5%). In field experiments on utilizing organic amendments for disease management, seed treatment with vermiwash + soil application of vermicompost + soil drenching with vermiwash at 90 and 120 days showed least collar rot incidence (22.2%) and highest yield (27.1 t ha^{-1}) in elephant foot yam. In taro tuber treatment with vermiwash + soil application of vermicompost + drenching and spraying with vermiwash at 60 and 90 days showed least taro blight incidence (PDI of 16.6) and highest yield (21.1 t ha^{-1}). On comparison of the best treatment obtained with vermicompost and vermiwash with chemicals, metalaxyl showed least taro leaf blight incidence (PDI of 2.2) and highest yield (11.2 t ha^{-1}) followed by vermicompost with PDI of 4.84 and yield of 9.7 t ha^{-1}. Priming of taro cormels with the bacterial isolate 13-9 showed significantly higher growth rate and tolerance to taro blight. Combination of zinc, silicon and humic acid showed the potential to reduce the incidence in a preliminary study.

Soil samples were collected from the rhizospheres of tuber crops of Kerala, Andhra Pradesh, West Bengal, Manipur and Odisha states. Out of 349 bacterial isolates obtained, 52 isolates showed good inhibition to *Phytophthora colocasiae* and *Sclerotium rolfsii*. Based on IAA production, selected five isolates for further study.

Spraying of carbendazim (0.05 %) alone showed the lowest disease intensity (PDI, 33%) and highest yield (15.16 t ha^{-1}) for greater yam anthracnose management. Even though the PDI was significantly lower, the yield was on par with soil and tuber treatment with *Trichoderma asperellum* @50 g cfu per plant and 5g kg^{-1} of tuber in cow dung slurry respectively along with spraying carbendazim (9.8 t

ha^{-1}) and soil and tuber treatment with *Trichoderma* (9.04 t ha^{-1}) alone without sparying. Dolomite ($CaCO_3$ $MgCO_3$) was the good carrier material (~Rs.3 kg^{-1}) for the biocontrol agent (*Trichoderma* spp.) as they maintained the viability and efficiency in the formulation. *Colletotrichum gloeosporioides* causing greater yam anthracnose was present in the fresh tuber skin of infected plants, plant debris and soil. Pathogen inoculated in sterile field soil (Dry) could not survive beyond three months *in vitro* at room temperature whereas with 20% moisture it could survive beyond five months. Extracted crude toxin of *C. gloeosporioides* and purified by TLC. GCMS of the diethyl ether extract showed the presence of three phenols, two esters and two other compounds. Screened 95 germplasm accessions *in vitro* with crude toxin which showed significant difference in lesion development. Callus induction was tried with different combinations of hormones to select resistant calli through screening with toxin. Good callus induction was observed in greater yam using MS media with a combination of NAA:BA @ 1.5 : 1.5 mg l^{-1}. Liquid MS media supported good callus proliferation compared to agar media.

Nicotiana benthamiana plants mechanically inoculated with *Dasheen mosaic virus (DsMV),* showed leaf deformities within 45 days of mechanical inoculation and the infection was confirmed through RT-PCR. Mechanical as well as aphid transmission, tried to transmit both *Yam mild mosaic virus* (*YMMV*) and *Macluravirus* to propagation hosts, *viz., Nicotiana benthamiana, N. tabaccum* and cowpea with different positive samples were unsuccessful. However, RNA isolation followed by RT-PCR showed the presence of yam *Macluravirus* in the virus acquired *Aphis craccivora.* The presence of partial genome of various viruses like *Dasheen mosaic virus* (*DsMV*), *Bean common mosaic necrosis virus*, *Cowpea aphid-borne mosaic virus*, *Calla lily latent virus*, *Soybean mosaic virus*, *Sunflower chlorotic mottle virus*, *Watermelon mosaic virus*, *Yam bean mosaic virus*, *Zucchini yellow mosaic virus* etc. was established in the transcriptome anlaysis of elephant foot yam leaf samples with mixed infection of virus. The complete nucleotide sequence of *DsMV* infecting *A. paeoniifolius* was assembled from transcripts which showed 81% identity with the *DsMV* reference sequence available at NCBI. Reverse Transcription Loop Mediated Isothermal Amplification (RT- LAMP) was developed for rapid detection of *DsMV* in less time. The reaction conditions were optimised for clear gel based detection. The sensitivity and accuracy of the LAMP assay was higher than that of RT-PCR. Dipsticks were prepared manually based on *DsMV* specific IgG-gold conjugate. The test was found to be highly sensitive and was capable of detecting virus with very low titre.

Taro leaf samples were collected with various symptoms *viz.,* whitish feathery symptom along the veins, mosaic, feathery mosaic, crinkled and distorted leaves, chlorosis and chlorotic patches etc. Around 50% of the samples were positive to *DsMV*. PCR and RT-PCR analysis showed the presence of viruses like *DsMV* and *Taro bacilliform* virus in the infected samples.

DAS- ELISA performed with 46 virus infected greater yam leaves using *YMMV* and Yam Maclura virus specific antibodies showed 7 and 16% positive to the viruses respectively. RNA was isolated from 58 leaf and 31 tuber samples of greater yam. Lithium chloride method was found to be good to extract RNA from tubers compared to other manual and kit methods. Twenty and 50% leaf and tuber samples respectively, showed positive reaction to *Macluravirus* in RT-PCR with specific primers. Two step RT- PCR was found to be reliable than single step protocol. IC-RT PCR was standardised to diagnose Yam Maclura virus. NASH technique with non-radio labelled probe prepared from 200 bp product of *YMMV* showed good specificity and sensitivity.

Molecular characterisation of symptom recovery in cassava showed that CMD symptoms in susceptible lines were severe and expressed throughout six

months monitoring period. Symptoms as well as virus titre of recovery types decreased over the growth period; while resistant types had low concentration of viral DNA, even though there were no symptoms. There was no significant difference in viral load and symptom expression in resistant varieties or susceptible varieties over the last three years. The recovery types planted during the summer season in field showed less symptom and virus titre than those planted during the rainy season.

Two types of protein enriched sago were prepared from cassava starch using whey protein concentrate (WPC) (10%) alone as additive and WPC (10%) + guar gum (1%) as additives. The protein content could be significantly enhanced to 8% when compared to 0.7-0.9% in commercial sago made exclusively from cassava starch. The glycaemic indices of the protein fortified sago were 61, while the commercial sago had Estimated Glycaemic index (EGI) of 64. Calcium content in the sago could be elevated to 226 mg per 100 g dry sago through $CaCO_3$ alone and 273 mg per 100 g through ($CaCO_3$ + WPC) fortification, while the commercial sago had only 78 mg per 100g. Cassava starch noodles enriched with resistant starch rich cassava starch (annealed starch) as additive was prepared and its nutritional and digestibility characteristics were compared with a commercial product *viz.,* Foodles. The test samples (cooked) had significantly higher starch content (76-80%), compared to 66% in the market sample.

Cereal grain shaped pastas were made from cassava-maida blends as well as cassava-rice blends and their starch digestibility characteristics were studied. Starch digestibility increased with increase in the percentage incorporation of maida, while reverse was observed in the case of rice flour. Accordingly, rapidly digested starch (RDS) was the lowest in cassava-maida (70:30) based grain type pasta and highest in cassava-maida (50:50) based blend. Legume flour fortification at 15% level was highly beneficial in lowering the starch digestibility and EGI and the lowest EGI of 56.76 was obtained for black gram flour based sweet potato spaghetti. Pre-treatment of the black gram-sweet potato starch dough by exposing to low temperature to facilitate retrogradation could further reduce the starch digestibility and EGI. Truly low glycaemic spaghetti with EGI of 53.13 could be obtained likewise.

Technique was perfected for making protein enhanced starch noodles from sweet potato. The control sweet potato starch noodle had a bland taste and very low protein content of 0.70% and was highly digestible. The protein content could be raised to 19.43% through fortification with whey protein concentrate. Blending with RS enhanced cassava starch (annealed cassava starch) is an alternative method to produce sweet potato starch/flour noodles, with low starch digestibility and low EGI. NUTRIOSE®, a commercial RS source with a high dietary fiber content 85% was found to be an excellent additive to sweet potato flour and starch, to produce truly low glycaemic flour spaghetti and starch noodles.

Anthocyanin content in tubers of sweet potato genotype ST-13 was greater (106.13 mg per 100 g fresh tuber) than that in leaves of Acc No. 1468. Anthocyanin content was greater in water deficit stressed leaves (37.86 mg/100g fresh leaf; 174.89 mg/100g dry leaf) than that in the leaves of irrigated plants.

Biodegradable films were prepared by using various waxes *viz.,* paraffin wax, microcrystalline wax, bees wax, candelilla wax, carnauba wax and rice bran wax and proteins (whey protein concentrate and casein). Among the different films, minimum water transmission rate (9.59×10^{-3}g mm/cm^2) was obtained for carnauba wax composite based films. Solutions of starch with wax/protein indicate the properties of dilute solutions, which is suitable for film making by casting method.

Cassava starch was modified with propylene oxide and composite were prepared using this starch with carnauba wax, microcrystalline and candelilla wax

by adding glycerol. Maximum thickness (0.223 mm), minimum moisture content (8.16%) and solubility (16.97%) were obtained for the film containing microcrystalline wax. Compounding of polylactic acid/starch blends was done by the twin screw extruder for both injection grade and film grade PLA with native and modified starches. Compression moulding of virgin PLA and PLA with 10-40% oxidised starch were prepared and 20% modified starch was found to be optimum for injection moulded products. PLA blends with 10% starch and 10% glycerol was found to be optimum for blown film extrusion.

Two types of corrugating adhesive formulations were prepared based on chemically modified cassava starch *viz.,* normal corrugating adhesive, which consists of a native carrier starch, and a cold corrugating adhesive which does not require the carrier component. Higher solid content, which is a desirable property for corrugating adhesives, could be obtained in both cases, whereas tack was significantly higher for the cold corrugating adhesives. The moisture retention of the starch based superabsorbent polymer (SAP) in the sandy loam soil in pots increased with increase in concentration of SAP and even after 30 days of initial watering, there was about 20% of moisture retention in the soil amended with 0.5% of SAP. Porosity and water holding capacity also increased in the treated soil.

The demonstrations of the high pressure low volume (water) starch washing system and vibro sieving system were carried out at M/s T.A. Perumal Sago Industry, Salem. The performance evaluation showed that the capacity of the machine was about 2400 litres per hour. The starch content, sugar content and total cyanide content of the samples collected from feed and two outlets of the machine ranged from 87.2-90.0%, 0.43-0.845% and 0.35-1.00 µg g^{-1} respectively.

The starch, sugar and total cyanide content of the starch samples collected from the two outlet of the existing final sieve shakers ranged from 88.2-89.7%, 0.62-0.84% and 0.35-0.41 µg g^{-1}, respectively. In the trials of addition of chemicals for whitening of cassava starch, fresh starch slurry was treated with inorganic (hydrochloric acid and sulphuric acid) and organic (acetic acid and citric acid) acids. The pH of the starch slurry increased with increase in number of washes. The HCl treated starch recorded maximum whiteness index (96.05%) among the treatments and it was on par with the industrial starch (97.91%).

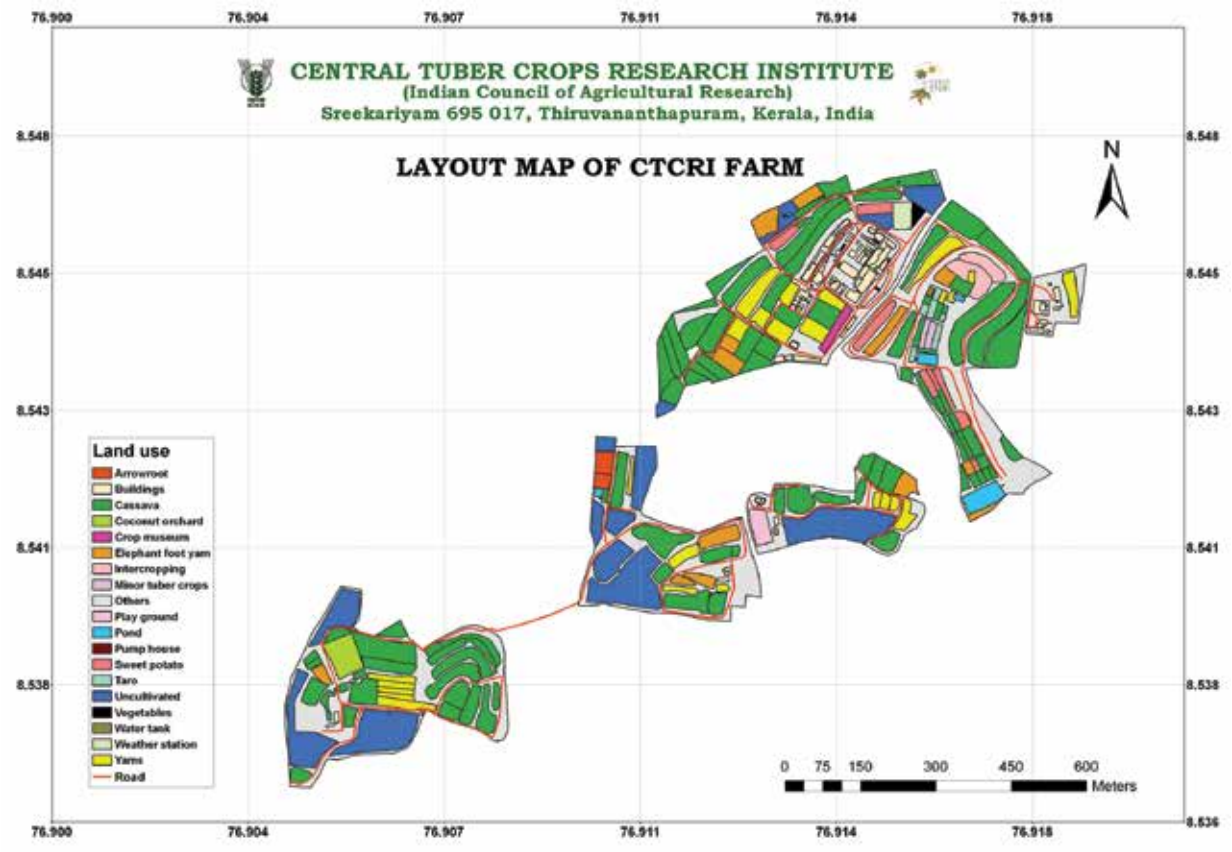
Survey was carried out on adoption of recommended practices of elephant foot yam in two districts *viz.,* Nadia and 24 North Parganas in West Bengal where the crop is very popular. Elephant foot yam is cultivated in an average area of 0.15 ha in farmers' holding. Gajendra variety is dominant. Planting was done during June-July and harvested after 6-7 months. Farmers tend to adopt larger sized seed tubers ranging from 1000 to 1500 g. High dose of fertilizer application was observed. Plant protection for pests and diseases were adopted. However, indiscriminate use of plant protection chemicals was observed in farmers' fields. Non-monetary practices *viz.,* land preparation, planting method etc were adopted as per the recommendations.

High yielding, mosaic resistant/tolerant cassava clones suited to Maharashtra were identified for both industrial and consumption purpose through initial on-farm trials carried out in Maharashtra. The identified clones were Sree Athulya, CR 20 A 2, 9 S 127, 2-18, CR 35-8, M 4, Ci 800 and Ci 888. Using these clones, three participatory on-farm trials have been laid out with three replications during August , one each in Beed, Lolithgaon (Beed district) and Gadegaon (Sangli district).

A web based interactive tool for tuber crops statistics has been developed using R environment for statistical computing. Elephant Foot Yam Growth Simulation Model (EFYSIM), Sree Visakham Cassava Expert System, (SVCES, http://www.ctcritools.in/cassavaexpert) and Tamil version of Tuber Information Cafe (TIC) were developed.

CTCRI NEH programme was implemented in four states namely Manipur, Meghalaya, Nagaland and Tripura through 10 partner implementing centres. Ten villages were covered one each by the implementing centre and there were 250 participating farmers under the programme. The major technologies transferred were, high yielding varieties of cassava (Sree Jaya, Sree Vijaya and H 165), improved variety of taro (Muktakeshi), improved yam variety (Orissa Elite), elephant foot yam variety (Gajendra), cassava chipping machines and cassava slicers. Planting material of cassava (15000 stems), taro (12000 kg), yams (3000 kg) and elephant foot yam (4500 kg) were supplied from RC, CTCRI, Bhubaneswar for Front line demonstrations (FLDs) in adopted villages. FLDs were organized in all the 10 villages. Capacity building programmes were arranged in all these villages. Livelihood surveys conducted have indicated that low productivity, lack of quality seed/planting material, locational disadvantages, vulnerability to natural calamities etc. were some of the major constraints. Assessment on the performance of introduced technologies revealed that the improved varieties of tuber crops were well accepted by the farmers of NEH for their yield and quality.

CTCRI Tribal Sub Plan programme was implemented in three states namely Odisha, Chhattisgarh and Jharkhand. Four hundred and fifty farmers were adopted under the programme. Quality planting materials of improved varieties of Elephant Foot yam (Gajendra variety 8000 kg), taro (Muktakeshi 8000 kg), Sweet potato (2 lakh cuttings) were distributed to the tribal farmers of Jharkhand, Chhattisgarh and Odisha and FLDs were organized in farmers' fields. Four training programmes were organized in the adopted villages and in RC, CTCRI, Bhubaneswar. Kisan Gosthi and demonstration on mobile starch extraction were conducted at Narayanpur at Chattisgarh state during 17-18 January, 2014.



INTRODUCTION

CTCRI (1963-2014)

The Central Tuber Crops Research Institute (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 21.5 ha . Later, an area of 26.69 ha has been added. The Head quarters has completed it's golden jubilee during 2012-2013 and become the **ISO (ISO 9001:2008) certified Institute since 31 March, 2014.** 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 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 17 centres including 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 CTCRI is conducting basic and applied research on various edible tropical tuber crops.

Research Mandate

- To undertake basic, strategic and applied research for generating technologies to enhance productivity and utilization potential of tuber crops (other than potato).
- To act as a national repository of scientific information on tuber crops.
- To coordinate network research with state agricultural universities for generating location specific technologies

- To act as a centre of human resources development for various clientele systems involved in tuber crops research and development
- To undertake transfer of tuber crops technology through consultancy, outreach programmes and linkage with developmental agencies

General Achievements

The CTCRI is the 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 nearly 49 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.

CTCRI has a wealth of germplasm of tuber crops, totalling 5832. 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. Pioneering role of CTCRI in tropical tuber crops breeding attracts international collaboration in the breeding and genetic improvement of those crops. Now, work on molecular based improvement has also been initiated.

CTCRI has released 49 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 depend on two major industrial varieties of cassava released from CTCRI, viz., H 165 and H 226. Two Triploid cassava varieties, viz., Sree Athulya and Sree Apoorva have been released which are found to be promising and acceptable to farmers as well as industries. Beta carotene rich ST-14 sweet potato developed by CTCRI was included in LANSA and FSN programme to alleviate malnutrition. Thus apart from the table varieties, the industrial varieties of cassava have made a major impact in adoption and utilization by the farmers.

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 cassava mosaic disease and to enhance the starch content and waxy starch.

A host of tuber crops production technologies are available for mono crop, intercrop and multicrop 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 taro elephant foot yam and greater yam; cropping system with rice-black gram-short duration cassava was 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 CTCRI giving the leadership and 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.

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 award carries a cash prize of Rs. 5 lakhs, besides a plaque, certificate and citation.

The Institute has 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 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, 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 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 imported equipments like the food extruder, texture analyzer, differential

Museum

Crop museum

scanning calorimeter, FTIR, HPLC, HPTLC, atomic absorption spectrophotometer, auto analyser, gel documentation system, real time quantative PCR, nitrogen analysers, 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, Ministry of Environment and Forest, DoA, Kerala, 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 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 provisional 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 (under implementation) and new touch screen information kiosk (to be installed soon).

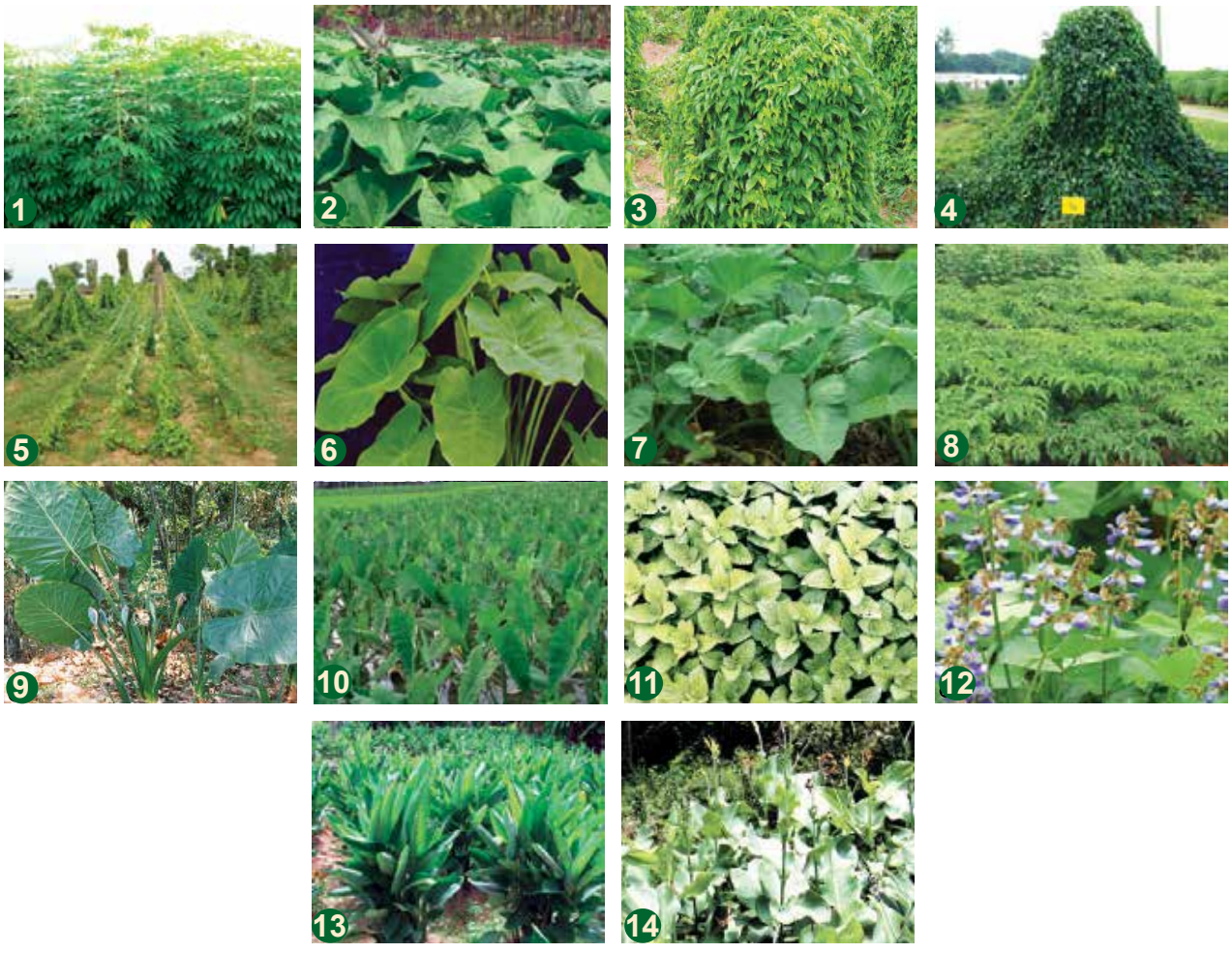
Established a full fledged local area network connecting the various divisions and administration wing. The network consists of windows nt server, internet proxy server, intranet file server and email server, computers, laser printers, inkjet printers,

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.

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.

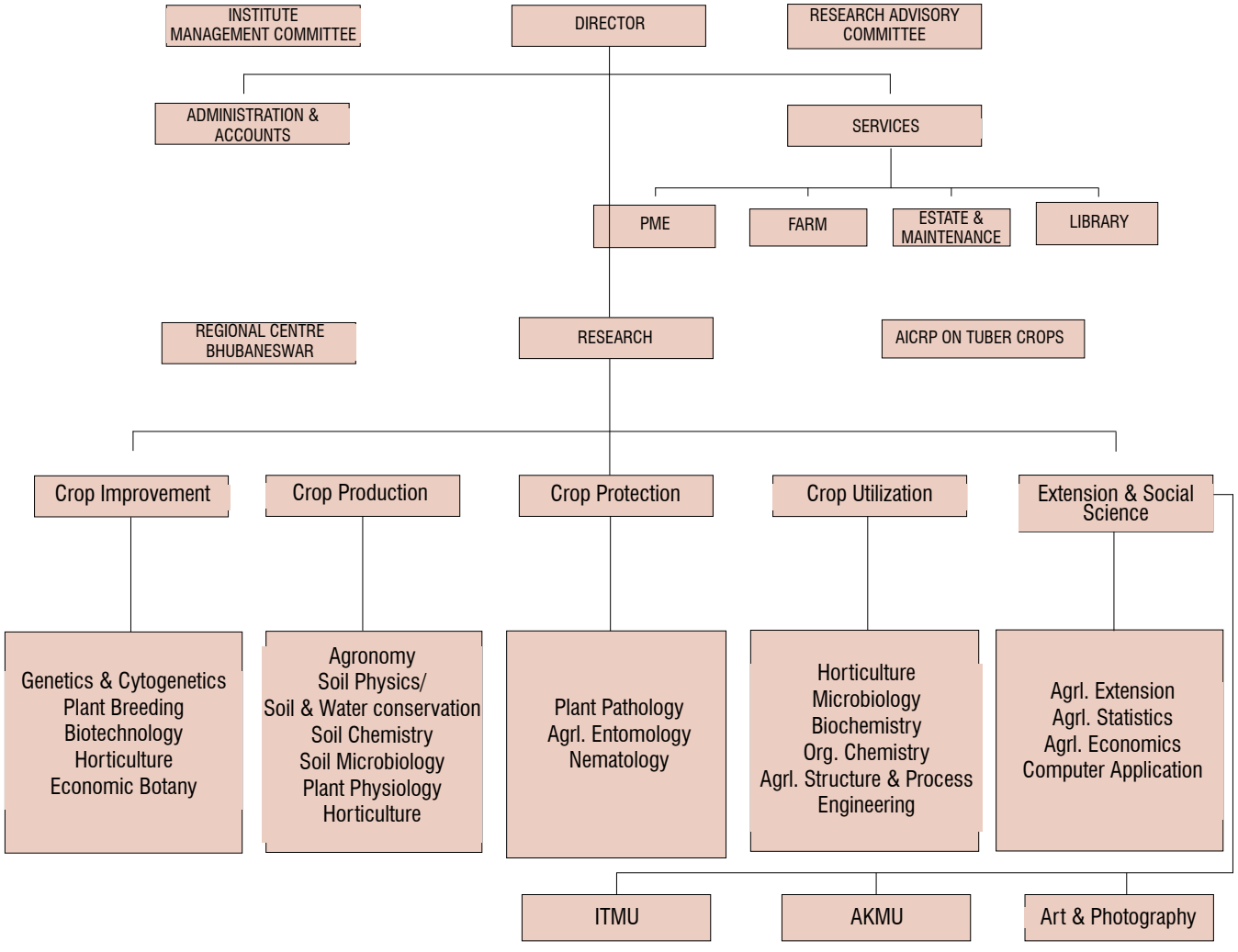
Regional Centre, CTCRI, Bhubaneswar

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 arrow root *Canna edulis* (Ker-Gawler) Cannaceae.

Organisational set-up



Staff position (2013-14)

	Sanctioned	Filled	Vacant
RMP	1	1	0
Scientists	49	38	11
Technical	47	41	06
Administration	31	26	05
Skilled Support Staff	55	33	22
TOTAL	183	139	44

Progressive Expenditure (2013-14)

Sl.No	Head of Accounts	RE 2013-14 (In Lakhs)	Progressive Expenditure 2013-14
1	Works		
	A.Land		
	B.Building		
	i. Office Building	13.00	13.00
	ii. Residential Building		
	iii. Minor Works		
2	Equipments	102.31	102.31
3	Information Technology	12.41	12.41
4	Library Books & Journals	9.95	9.95
5	Vehicles & Vessels		
6	Livestock		
7	Furniture & Fixtures	23.33	23.33
8	Establishment Charges	-	-
9	Travelling Allowances	40.00	40.00
10	Research & Operational Expenses (Instt+TSP)	182.02	182.02
11	Administrative Expenses	131.01	131.04
12	Miscellaneous (Instt+TSP+NEH)	13.97	13.94
	TOTAL	**528.00**	**528.00**
14	AICRP on TC	315.00	315.00
15	AICRP on PHT	6.05	3.20
16	Plan Schemes	49.04	49.57

Non - Plan

Sl.No	Head of Accounts	RE 2013-14 (In Lakhs)	Progressive Expenditure 2013-14
1	Works		
	A.Land		
	B.Building		
	i. Office Building		
	ii. Residential Building		
	iii. Minor Works		
2	Equipments	9.73	9.73
3	Information Technology		
4	Library Books & Journals		
5	Vehicles & Vessels	13.43	13.43
6	Livestock		
7	Furniture & Fixtures	4.87	4.87
8	A. Establishment Charges	1024.99	1024.99
	B. Pension & Other Retirement Benefits	138.38	138.38
	C. Loans & Advances	7.39	7.39
9	Travelling Allowances	6.50	6.50
10	Research & Operational Expenses	32.98	32.93
11	Administrative Expenses	99.00	99.05
12	Miscellaneous	3.99	4.0
	TOTAL	**1341.26**	**1341.27**

RESEARCH ACHIEVEMENTS

INSTITUTE PROJECTS

CROP IMPROVEMENT

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

The project aims at exploration and targeted collection of germplasm of tropical tuber crops from unexplored regions, conservation, cataloguing, identification of duplicates and development of core collection. In addition to field gene bank, the project also aims at *in vitro* conservation of the core collection.

Field gene bank of genetic resources of tropical root and tuber crops

A total of 5832 germplasm of tropical tuber crops comprising of cassava, sweet potato, yams, aroids and minor tuber crops were conserved as field gene bank.

Cassava

Cassava germplasm was augmented with 20 accessions from different parts of the country which included 5 from Assam including the zigzag and pink stem type and 15 landraces from different districts of Kerala *viz.,* Pullad kappa, Arumasakkappa, Block kappa, Karuthathandan kappa and narrow leaved one from Pathanamthitta (5), Ethakka kappa and Salahuddin kappa from Kollam (2), Diwan kappa from Malappurram (1), Ullichuvala, Kochangamuttan, Kantharippadappan, Pachamalayan, Ariyan and Kochangamuttan from Trivandrum (7). After the field establishment of the new collections, passport data will be sent to NBPGR for the allotment of IC numbers. A total of 1208 accessions of cassava germplasm comprising of the indigenous, exotic, landraces and breeding lines were maintained in the field genebank. Preliminary characterization of 425 cassava accessions for 10 qualitative morphological characteristics was completed and the data analyzed using the hierarchical and ward method of clustering and a cluster with 8 groups was identified. Screening of the cassava germplasm for CMD under field epiphytic conditions identified 77 accessions as free of any symptoms.

Sweet potato

Seven accessions which include one wild accession from Alleppey, Kerala; one from Dimapur, Assam; two from Imphal, Manipur and three from other districts of Assam were added to germplasm (Fig. 1) The wild accession is a tuber-forming genus similar to sweet potato and it has to be identified after flowering. IC numbers will be obtained from NBPGR once the new collections are established in the field. At present a total of 1110 accessions are being maintained in the field gene bank with complete drip irrigation system and weed control ground cover and regular pruning. Ten accessions were evaluated for yield and cooking quality and S-1584 (0.59g/plant) and S-1588 (0.25g/plant) were found to be good yielders. The accessions S-1581 and S-1586 showed good cooking quality with starchy, sweet tubers. At the Regional Centre, 373 accessions of sweet potato including 76 wild lines are being maintained.

Fig. 1. Sweet potato germplasm at CTCRI

Yams

At CTCRI, Thiruvananthapuram, a total of 1110 yam accessions are being maintained which includes 591 greater yam, 158 white yam (Fig. 2), 220 lesser yam and 131 wild yam accessions. Fifty one yam accessions are being maintained at the Regional Centre.The wild yams maintained in the biodiversity shed of CTCRI, Thiruvanathapuram were replanted and labelled. Two accessions of greater yam and one accession of lesser yam were collected from Nagercoil, Tamil Nadu and

two accessions of wild yams from Assam. After the field establishment of the new collections, passport data will be sent to NBPGR for the allotment of IC numbers. Four hundred accessions of greater yam were characterized for 10 descriptors including 6 quantitative traits. The tuber characters of greater yam accessions were recorded and grouping of the accessions based on similarity in tuber traits was done to identify the morphological duplicates in germplasm. In greater yam maximum number (84) of accessions had oval oblong tuber shape. White flesh colour was predominant among the accessions. Eight accessions recorded purple flesh colour while 15 had yellow flesh colour. three hundred and fifty accessions of greater yam germplasm were screened for anthracnose resistance and 11 accessions were found to be resistant. In white yam, cooking quality of 116 accessions was undertaken and 39 accessions recorded excellent cooking quality with white flesh colour, mealiness and taste. Tuber and leaf samples of *Dioscorea floribunda* and *D. vexans* were prepared for diosgenin screening.

Fig. 2. White Yam germplasm field view

Aroids

Edible aroid germplasm was augmented with 24 accessions collected from different parts of the country which included 14 accessions of taro, four accessions of tannia, three accessions of elephant foot yam and three accessions of karunakizhangu (Fig. 3 and Fig. 4). The taro accessions were collected from Ukhrul and Imphal Districts of Manipur (10); Nadia District, West Bengal (2); Anchal, Kollam District, Kerala (1) and Vadassery, Kanyakumari District, Tamil Nadu (1); The tannia accessions were from Kerala (3) and Tamil Nadu (1); elephant foot yam accessions from Ranchi (1) and Tamil Nadu (2) and karunaikizhangu, from Tamil Nadu. Once the new collections are established in the field, the passport data will be sent to NBPGR for IC number allotment. A total of 587 accessions of edible aroid germplasm including 306 of taro 203 of elephant foot yam, 28 of tannia are being maintained at Thiruvananthapuram whereas, the Regional Centre maintains 506 taro accessions, 39 elephant foot yam accessions, 1 tannia and 3 *Alocasia* accessions.

Fig. 3. Cormels of elephant foot yam cv. Karunaikizhangu

Fig. 4. Cormels of taro

Cooking quality of 21 taro accessions were recorded and six (IC 089624, U-29, IC 310104, SM8, SM12 and SM18) showed good to very good cooking quality having no acridity. In tannia, seven accessions were tested and three (E-14; CARI 5 and Xa15) showed very good cooking quality. Data on yield characters viz., corm/cormel number, weight and shape of corm/cormel and cormel flesh colour was recorded for 152 taro accessions. TCR 479 recorded the maximum average corm weight (92 g), whereas, IC033093 recorded the maximum average cormel weight (10

g). The average corm and cormel weight ranged from 3.6 - 9.0 g and 0.4 - 10 g, respectively.

Morphological characterization in taro was done for 25 accessions mostly from NEH regions for 27 above ground characters as per NBPGR/IPGRI descriptors. Shannon-Weaver's diversity index (H) was determined based on percentage distribution of the characters and a diversity index of 0.62 was obtained. Screening of taro against TLB in the field (108 accessions) and pots (206 accessions) was done. In field, no tolerance was noted, whereas, in the pots, 3 showed resistance (U-64, TCR 125 and IC204065).

Aroid germplasm database was updated with photographs of 12 Manipur accessions of taro, three *Amorphophallus* varieties and 6 aroid accessions including 3 karunaikizhangu, 1 elephant foot yam, 1 tannia and 1 taro from Tamil Nadu. Photographs of morphological traits viz., stem and leaf characters in taro and elephant foot yam were also included.

Among the 17 accessions of wild forms/wild relatives of elephant foot yam screened for morphological characters, seven morphotypes could be identified. Cultivated elephant foot yam was different from cv. karunaikizhangu based on morphological descriptors and both showed different pattern of evolution in the dendrogram which has to be confirmed by advanced studies.

For molecular characterization in taro, DNA was isolated from 25 accessions collected from the North Eastern region of India. A total of 18 SSR primers were screened of which, 10 primers viz., Ces1 A06, Ce1 BO3, Ces1 C03, Ces1 C06, Ce1 F04, Ce1 H12, Uq 73 164, Uq 84 207, Uq 97 256 and Uq 201 302 showing polymorphism in 2% agarose was selected for further screening.

Minor tuber crops

Under minor tuber crops, one accession of *Canna* and 2 of *Curcuma* species collected from Assam and one each of Chinese potato and *Curcuma* species and 3 of arrowroot collections (Fig. 5) from Nagercoil, Tamil Nadu were also added to the germplasm. A total of 220 accessions of minor tuber crops comprising Chinese potato (127), yam bean (75), *Curcuma* spp. (9), *Maranta arundinacea* (7), *Coleus aromaticus* (1) and *Vigna* sp. (1) were also conserved in the field gene bank. Regional centre maintains 145 yam bean, five chinese potato and two arrowroot accessions.

Fig. 5. Arrowroot :New collection from Tamil Nadu

***In vitro* conservation of tuber crops germplasm**

Four hundred accessions of cassava, sweet potato, yams and taro are being maintained under *in vitro* conditions. Two new media – half MS media with sucrose (1.5%) and without hormones and half MS with sucrose (1.5%), NAA (0.1µM) + BA (0.1µM) + GA_3 (0.3µM), were used for initial establishment in sweet potato. For slow growth conservation, MS media with above concentration of plant growth regulators and mannitol (2%) and sucrose (2%) were used. Half MS media with 1.5% sucrose was as good as the slow growth media for short term conservation. In tannia the accessions, E-14 and MTS-local showed multiple shoot induction in 50% of the explants in MS media containing TDZ (0.1mg l^{-1}). Preliminary studies showed that in basal MS medium, tannia cultures could be maintained for 6-8 months with slow growth rate.

In vitro cultures of 125 accessions of tuber crops comprising sweet potato (84) and yams (41) received from NBPGR were also added to the *in vitro* gene bank. Released varieties and pre-breeding lines of cassava (28) and sweet potato (27) were brought under *in vitro* condition. The response of accessions in the different slow growth media is being studied. At the Regional Centre, 38 sweet potato, 21 taro, 12 cassava, five yam, five chinese potato and two elephant foot yam varieties and pre released varieties as well as elite lines are maintained under *in vitro* status.

VARIETAL IMPROVEMENT IN TROPICAL TUBER CROPS

Varietal development in tuber crops *viz.* sweet potato, cassava, taro, elephant foot yam and yams is being continued since inception of CTCRI. However, in the context of climate change and the prevailing issues of food insecurity, malnutrition and low productivity of food crops owing to diseases and pests, climate resilient tuber crops with valued traits are the need of the hour. Thus the present programme was proposed to develop disease and pest resistant tuber crops with early maturity, longer keeping quality, high dry matter, starch, beta carotene, anthocyanin and low sugar contents.

Cassava

One hundred and sixty eight crosses involving seven resistant parents (9S127, CR 54A3, IMS2-8, CR 54A-4, CI-273, 9S132, 11S40) and fourteen susceptible varieties/landraces with high starch content, earliness and culinary quality (Sree Vijaya, Sree Jaya,Vellayani Hrazwa, Sree Visakham, 99/14/S17, Sree Prabha, 8CTM5, IVD7-1,7W10, IPS2-1, 9S98, 7IIIC-8, C15, C144) were made. A total of 3750 flowers were hybridized and 2450 hybrid seeds were collected. This includes 572 hybrid seeds produced by crossing early bulking clones *viz*. Vellayani Hraswa, 9S127, CI-889, 9S132 and CR54A-3. Cassava mosaic disease resistant clones were evaluated for starch content and 9S127 recorded the highest starch content on fresh weight basis (31.9%) followed by CR20A2 (31.6%) and CR21-10 (30.8%). In a preliminary agronomic evaluation to identify early bulking genotypes, CR52A41 proved to be an early bulking line of cassava with an yield of 5.21 kg /plant (62.46 t ha^{-1}) followed by CI-273 (3.57 kg per plant, 42.9 t ha^{-1}) at six months after harvest.

Elite clones with desirable traits *viz.,* good fried chip quality (CR21-10, CR20A-2) and high dry matter with CMD resistance *ie*., >45% (11S20, 11S28, 11S33, IH5/15) were identified for advanced yield trial. In addition to CMD resistance, 11S33 recorded good culinary quality also. In an evaluation of clones with low cyanogen content and good cooking quality, CI-859 recorded the highest yield (37 t ha^{-1}). The cassava clone BR-105 has showed PPD resistance more than a month.

The CMD resistant hybrids were screened for PPD tolerance along with highly susceptible released varieties. The change in dry matter and starch content of the clones were studied. The CMD resistant clone, CR20A-2, was found to be tolerant to PPD. The pre-release clone C-800 with yellow flesh colour also recorded tolerance to PPD. The clone CMR- 100 having long cylindrical tuber good for chips quality and consumption purpose.

Two triploid cassava hybrids *viz*., Sree Athulya (4-2) (Fig. 6) and Sree Apoorva (5-3) were recommended for Central release in the 21st meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops held on 7th October, 2013. Sree Athulya is a high yielding (39.00 t ha^{-1}) variety with high starch content (34.80%) and has been recommended for release and cultivation in the States of Tamil Nadu and Andhra Pradesh. The cultivar is suitable for starch extraction as well as cattle feed. Sree Apoorva is also a high yielding (37.60 t ha^{-1}) triploid variety with non/top branching plant habit and high starch content (33.30%) and has been recommended for cultivation in Tamil Nadu and Kerala.

Fig. 6. Sree Athulya, a triploid cassava variety

Sweet potato

Sweet potato germplasm was evaluated for desirable traits and 16 lines were identified with high starch (>22%) and low infestation of weevil (5-10%). Of these 16, 13 were selected for early maturity (70-90 days). Among them 10 were white fleshed and 3 were orange fleshed. Existing OP seed raised progenies were evaluated which resulted in the identification of 12 white / cream

fleshed lines, 14 orange fleshed lines rich in β-carotene and 9 purple fleshed ones rich in anthocyanin, apart from other targeted traits. Based on yield and flowering frequency along with other targeted traits, 10 lines each were selected for white, orange and purple flesh for hybridization. Selected lines were planted in a pollination block. Hybridization though initiated, flowering and seed setting was affected due to cyclone Phailin.

Yams

In greater yam eighth clonal progenies developed by crossing 36 elite female clones and 41 male clones during 2005-2008 were evaluated in replicated yield trials and elite hybrid clones viz. Das 417, Das 9-173, Das 22-2, Das 9-1, Das 10-149, Das 493, Das 255 and Das 272 with high yield, good tuber shape and culinary quality were identified for further evaluation. In white yam, among the dwarf hybrids evaluated, Drd 1095 recorded highest yield (5.5 kg/plant). Crossing of dwarf and tall clones of white yam was undertaken and hybrid seeds were collected.

The planting material of pre-release white yam hybrid DRH 657 and purple fleshed greater yam Da 331 were multiplied. Planting materials of four white yam hybrids were provided to Regional centre for multiplication and evaluation in Odisha.

Da 293, the pre-release grater yam variety is replacing the ruling variety in Odisha by virtue of its good tuber shape and culinary quality (Fig. 7). The adoption of Da 293 was assessed and is currently cultivated as monocrop under non-trailing conditions in over 250 acres in the most backward villages of Ganjam district in Odisha.

Fig. 7. Field view of Da 293 under nontrailing condition in Ganjam district,Odisha

Edible aroids

Elephant foot yam breeding was initiated. Flowering was observed in three accessions of elephant foot yam, Appakudal local and Puttur local I and II. The crossing between Puttur local II (female parent) x Puttur local I (male parent) was successful resulting in the formation of two hundred seeds. These were sown in polythene covers for further germination studies. Pollen of five accessions of elephant foot yam was conserved as flowering is not synchronous and rare in elephant foot yam as part of the breeding programme.

BIOTECHNOLOGICAL APPROACHES FOR IMPROVEMENT OF TROPICAL TUBER CROPS

Most of the characters in tuber crops can be improved by conventional breeding methods. To further improve some of the stress/ tolerant characters, biotechnological approaches like marker assisted breeding and transgenic technology will be useful. There is a need to develop end use specific varieties suitable to various processing industries by altering the starch quality using transgenic technology. Similarly, genome sequence information of crops would facilitate in- depth analysis of complex traits. This project aims at harnessing biotechnological tools like genomics and transgenic technology for improvement of root and tuber crops.

Marker assisted selection for gene pyramiding

The cassava genotypes of the Tropical *Manihot* Selection (TMS) series and African landraces, the Tropical *Manihot esculenta* series (TME) are the major sources of resistant to CMD at present and are being used to increase the genetic base of resistance to the disease. The objective of the present work is to combine these two sources of resistance which can lead to durable resistance to CMD. The presence of resistant genes in TMS (*cmd*-1) and TME lines

(*CMD*-2) were confirmed by CMD associated marker SSRY28 & SSRY40, respectively. A crossing block was laid out in the CTCRI farm with five parents of TMS lines *viz.,* TMS-30001, TMS-30572, TMS-96/1089A, TMS-96/0304, TMS-96/0160 and two TME lines *viz.,* TME-3, TME-4.

Development of gene constructs for modification of starch metabolism in cassava

This project was initiated with an objective to develop transgenic cassava *via Agrobacterium* mediated transformation with a bacterial *glgC* gene and to develop waxy cassava by silencing *gbssI* gene using RNAi. The *glgC* gene construct was mobilized to *Agrobacterium* EHA105 through tri-parental mating method and the transformed colonies were confirmed as *Agrobacterium* colonies through PCR and through biochemical test (3-ketolactose test). Further, sequencing confirmed the presence of *glgC* gene in transformed colonies. The *gbssI* gene fragments were amplified, cloned to pGEMT vector and sequence confirmed.

Development of mosaic resistant transgenic cassava

Unopened leaf lobes, embryogenic structures of H 226, H 165, Sre eVijaya and Sree Sahya were used as starting material for the development of friable embryogenic callus (FEC). Organized embryogenic structures (OES) produced in MSPC medium were transferred to GDP medium and sub-cultured every two weeks. The time required for production of FEC initials from H 165 was found to be 3-4 months for H 226 and 4-5 months for H 226 (Fig. 8). The calli were able to regenerate when placed in regeneration medium which confirm that these FEC are highly potent to develop into a complete plant. The proliferation rate of FEC was very low in H 226 when compared to H 165 and very high in TMS 60444 which was kept as control for all studies. Six week old FECs were used for transformation study. It was also observed that in H 226, even 5 month old embryogenic callus was able to regenerate into complete plant, hence can be used for transformation studies.

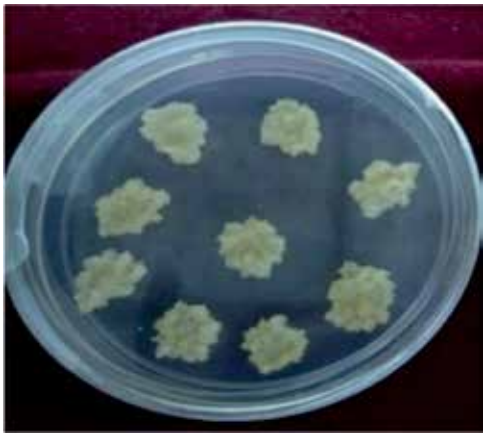


Fig. 8. FEC of cassava

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

The callus was mass multiplied by frequent sub-culture (20 days) in callus induction medium (3B modified MS medium provided with hormone BA (0.5mg l^{-1}), NAA (0.5 mg/l), 2,4- D (0.5 mg/l) for obtaining sufficient explants for the transformation studies. Sensitivity of calli was evaluated to utilize it as a marker system for selection during transformation. The calli were tested for their sensitivity to antibiotics Geneticin and Ticarcilline at varying concentrations ranging from 5 to 25 mg/l. In Geneticin sensitivity study, the control plate gave 100% survival rate, and the survival rate decreases with increase in concentration. Similarly in Ticarcilline sensitivity study, callus was tested at 0-750 mg l^{-1} concentration. The callus was healthy and no change was observed in one week interval. Three strains of *Agrobacterium* (LBA 4404, AGL0 and GV 3103) harbouring different binary vectors were used for transformation. Transformation was performed with 10 replicates for each strain and the experiment was repeated 3 times. Adequate rate of survival was observed and regeneration in selection medium and its molecular analysis is under progress.

***In silico* analysis of transcriptome data in elephant foot yam**

Two samples (1A & 2A) having virus infection and two healthy samples (3A and 3B) were subjected to tracnscriptome analysis using paired end sequencing with an Illumina GAII analyszer platform. The quality control of the sequences was carried out using

SeqQc v2.2. The mean read length were 99 and the total number reads ranged from 24.83 million to 37.22 million among the samples. The percentage of high quality reads ranged from 96.60 to 97.92. The assembly of the reads were carried out using the SOAP-denovo-trans software. The N50 value ranged from 650 to 1511 and 65-85% of the reads were used in developing the contigs. 7338, 21853, 20300 and 25152 contigs were generated respectively in samples 1A, 2A, 3A and 3B.

Differential analysis of the expression of transcripts were carried out using the DE Seq package in R and the online venny tools was used for drawing the venn diagrams. A total of 40549 consensus transcripts were generated and differential analysis was carried out between samples. While comparing 1A with 3A, 1A with 3B, 2A with 3A and 2A with 3B respectively, 222, 208, 275 and 264 transcripts were found up regulated (Fig. 9). Similarly 104, 97, 255 and 220 genes were found down regulated in the respective comparisons.

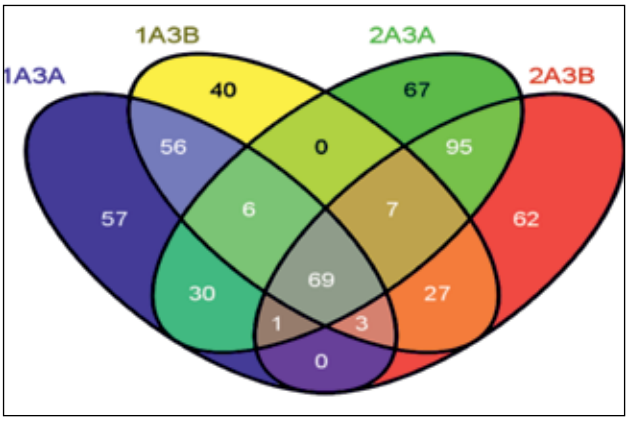


Fig. 9. Graphical representation of the up regulated transcripts in different comparison filtered by q value less than equal to 0.05.

Analysis of gene expression profile during abiotic stresses in sweet potato

Microarray experiment was carried out to explore the global gene expression pattern and to identify the differentially expressed genes in tuber forming roots in comparison to non-tuber forming roots. A total of 8 expression data obtained by microarray analysis were exported to GeneSpring GX (Agilent Technologies) and percentile shift normalization, which is a global normalization, where the locations of all the spot intensities in an array are adjusted, were carried out. Data were transformed into the log 2 ratio for analysis. The changes in gene expression were statistically analysed by the unpaired t-test (threshold was set at $p < 0.01$) for two groups. The false discovery rate (q-value) was calculated for each p value according to the method of Benjamini and Hochberg. Differential analysis and functional annotation of gene involved in tuber formation were carried out and the results showed that 14680 genes in different functions were up regulated while 14726 genes were down regulated in tuber forming roots of sweet potato.

The functional classification of gene found up regulated (Fig. 10) and down regulated (Fig. 11) in tuber formation in sweet potato in caparison to fibrous root.

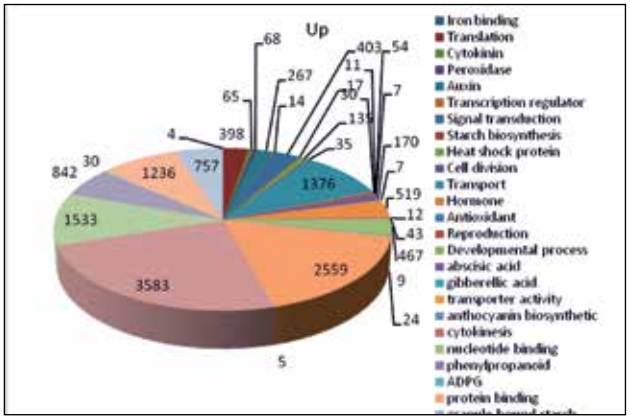


Fig. 10. Upregulated genes

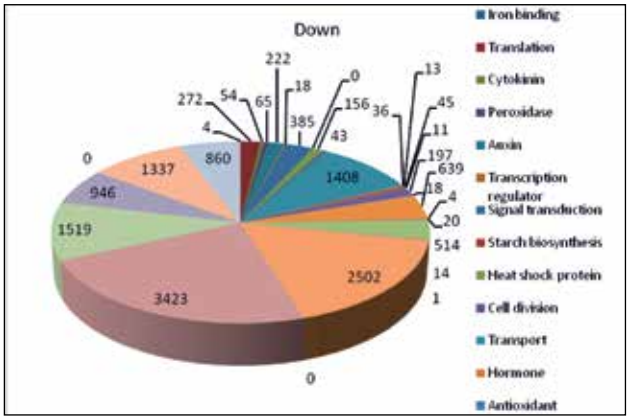


Fig. 11. Down regulated genes

Computational prediction and annotation of miRNAs in cassava

Six thousand six hundred and eighty nine plant miRNA sequences were downloaded from miRBase and the repeated sequences from the same miRNA families

were removed using Jalview (v.2.8) bioinformatics software and after redundancy removal there were 3513 miRNA sequences. Phytozome Blast search, BLAST N 2.2.26+ was performed with the selected miRNA sequences and cassava genome with criteria of E value <0.01, having less than three mismatches when compared with query miRNA sequence and with not less than 18 nucleotides (nt) in length were selected. Two hundred and ninety six miRNA sequences gave outputs that matched the criteria. Precursor sequences of 400 nt were extracted (200 nt upstream and downstream from the blast hits). Protein coding sequences were removed by BLASTX program in Phytozome and the application software mFOLD was used for secondary structure prediction and 148 sequences that fit the following criteria were designated as potential miRNAs in cassava:

- Mature miRNA should be 18–25 nt in length.
- The predicted pre-miRNA folded into a perfect or near perfect stem-loop hairpin secondary structure.
- The potential mature miRNA sequence located on one arm of hairpin structure
- No loops or breaks were allowed in the miRNA/miRNA* duplex.
- 6 nt mismatches were allowed between miRNA/miRNA* duplex.
- (A + U) % content should be 30–75%.

The pre-miRNA which had high negative minimal free folding energy (MFE) were selected and psRNA target was used for target identification and out of the 29 miRNA (156,159, 2111, 171 etc.) 24 had targets and 5 yielded no results. Target prediction via miRANDA identified approximately 39 targets for various cassava miRNA within the nucleotide sequences of 9 different strains of the cassava mosaic virus.

CROP AND WATER MANAGEMENT IN TROPICAL TUBER CROPS

The great challenge in the production of tuber crops for the coming decades lies on maximum production with minimum costs invested on basic resources such as water and nutrients. In order to achieve the above goal, the nutrient and water use efficiency needs to be maximized that will help to minimize the harm to environment. This could be achieved by suppression of weeds through suitable techniques that will reduces the exploitation of water and nutrients during the crop stand, developing location specific cropping systems involving tuber crops, site specific water and nutrient package through established techniques such as drip irrigation and fertigation, with an aim of improving the crop water productivity under irrigated and rainfed conditions.

Sequential cropping system involving short-duration cassava and pulses in rice based cropping system

Field experiment to confirm the feasibility of sequential cropping system involving short-duration cassava and pulses in rice based cropping system was taken up for the second season. First crop of rice was raised; growth and yield attributes were recorded. Grain yield of 3.593 t ha^{-1} and straw yield of 10.75 t ha^{-1} was obtained from rice. Short-duration pulses, green gram (Co Gg-7), black gram (Co-6) and soybean (JS 95-60) were raised after rice. Yields obtained from green gram, black gram and soybean were 843.05, 1385.6 and 659.01 kg ha^{-1} respectively. Short-duration cassava was planted in the rice-pulse sequence. Chemical analysis of soil samples of the previous season indicated that growing pulses before short-duration cassava helped to maintain the soil fertility, especially available K and the impact was more pronounced with black gram, which may be due to its greater biomass production. Rice-black gram-short duration cassava was profitable and generated added return of Rs.1.5-1.8 lakhs ha^{-1} over sole cassava (Fig. 12). Rice-green gram-short duration cassava and rice-soybean-short duration cassava were also feasible as additional profit of Rs. 1 lakh ha^{-1} over sole crop could be realized (Fig. 13 &14). There was a possibility to reduce full P, half FYM and N to cassava in these system.

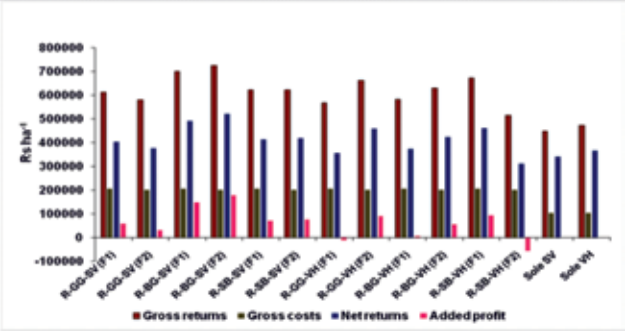


Fig. 12. Profitability of rice-pulse-short-duration cassava cropping system
R: rice; GG: Green gram; BG: Black gram; SB: Soybean; VH: Vellayani Hraswa; SV: SreeVijaya; F1: Full dose of FYM,N and K; F2: Half FYM and N, full K

Fig. 13. Harvest of first crop of rice

Fig. 14. Field view of second crop of pulse

Weed management in cassava

To identify the best weed management practice in cassava, a field experiment was conducted using different plastic mulch materials at CTCRI farm with eight treatments and three replications in Randomized Block Design under rainfed conditions using the cassava variety Sree Jaya. Among the different plastic mulch materials used, complete suppression of weeds of all kinds was observed in plots from planting till harvest where weed control ground cover was used. Highest tuber yield of 21.22 t ha^{-1} was obtained from the plots where weed control ground cover was used from planting till harvest. Highest net income of Rs. 1,60,450 ha^{-1} was obtained from the plots where weed control ground cover was used as mulch (Fig.15) Soil temperature, soil moisture, soil micro flora were not affected significantly by the use of weed control ground cover. Starch and HCN content of tubers were not affected by the use of weed control ground cover.

Fig. 15. Weed control ground cover in cassava

Water management in tropical tuber crops

Field experiment on elephant foot yam to assess the water requirement and scheduling of irrigation was conducted in split plot design with two main plots, eight sub-plots and three replications.Two methods of irrigation *viz*., drip irrigation and flood irrigation were included in the main plots. Subplots comprised of 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 & 100% CPE for 13-24 weeks and irrigation at 100 % CPE for 1-12 weeks & 75% CPE for 13-24 weeks. A rainfed crop was also included as control.

Drip irrigation was given daily and flood irrigation was given at weekly intervals. Quantity of water was calculated based on the daily evaporation rate and the crop factor. Time taken for first sprouting, 50% germination and full germination under drip irrigation and flood irrigation were recorded. Under drip irrigation, the crop took 28 days for initiating germination. Fifty percent germination was achieved within 48-54 days and full germination within 86-92

days. Under flood irrigation, the crop took 30 days for initiating germination. Fifty percent germination was achieved within 58-70 days and full germination within 105 days. In treatments where irrigation was not given during initial periods, the crop took 66-86 days for 50% germination and 108-110 days for full germination.

Morphological characters recorded at monthly intervals were more or less similar, once the canopy was established. However, during grand growth stage of the crop after 5 months, maximum number of leaves and leaf area were recorded under flood irrigation at 100 % level. Drip irrigation during 13-24 weeks at 100% level recorded growth characters comparable with irrigation given for 1-24 weeks.

Soil samples were collected from two depths, 0-15 cm and 15-30 cm at monthly intervals and assessed the moisture content over a period of six months from planting. Drip irrigation maintained 30-40% moisture content in top soil (Fig.16) compared to 20-30% soil moisture under flood irrigation (Fig.17) and less than 20 % moisture under no irrigation. Soil in the second depth, (15-30 cm) held more moisture under both the methods of irrigation compared to top soil.

There was significant difference in corm yield at harvest among the methods of irrigation. Drip irrigation recorded significantly higher yield than flood method. Among the sub plots, irrigation at 75% level during initial 12 weeks followed by irrigation at 100% level for 13-24 weeks resulted in maximum yield (36. 67 tha^{-1}). However, it was on par with 100% irrigation during 13-24 weeks (36.34 tha^{-1}).When the interaction effects were compared, drip irrigation at 100% during 13-24 weeks resulted in maximum yield (41.9 t ha^{-1}) followed by flood irrigation given during the entire period of 1-24 weeks.Total quantity of water used and water use efficiency were calculated for various treatments. Under drip irrigation , there was a saving of 137mm of water compared to flood irrigation to get comparable yields. Maximum water use efficiency was also recorded under drip irrigation at 100% level during 13-24 weeks (42.3 kg ha^{-1} mm^{-1}).

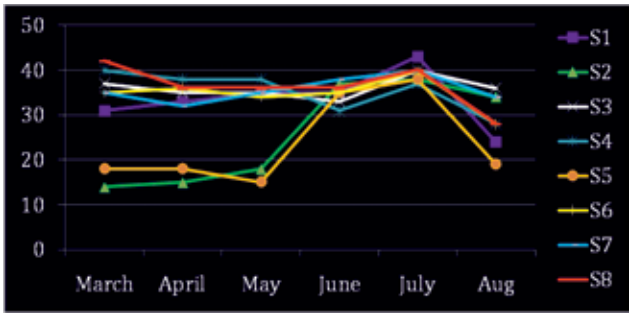


Fig 16. Moisture Distribution pattern in Soil (0-15 cm) under Drip Irrigation

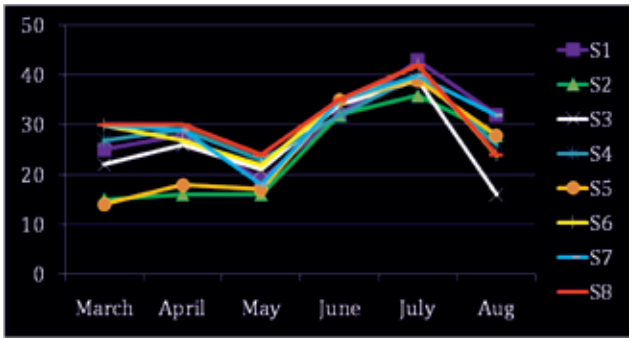


Fig 17. Moisture Distribution pattern in Soil (15-30 cm) under Flood irrigation

Management of fertigation in elephant foot yam

A field experiment was conducted during 2013-14 at the Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar to study the effect of frequency, dose and duration of fertigation on growth and yield of elephant foot yam. The experiment was laid out in split plot design with fertigation interval (2, 3 and 4 days) in main plots and in sub-plots the recommended fertilizer (Soluble fertilizer N- P_2O_5-K_2O 120-60-120 kg/ha) was split into 30 (N- P_2O_5-K_2O 4-2-4 kg/ha/dose), 40 (N- P_2O_5-K_2O 3-1.5-3 kg/ha/dose) and 50 (N- P_2O_5-K_2O 2.4-1.2-2.4 kg/ha/dose) doses and applied through drip irrigation. A Check (IW/CPE: 1.0; P_2O_5 60 kg/ha basal application; N-K_2O 120-120 kg/ha soil application at 1 (40%), 2 (30%) and 3 (30%) months after planting (MAP)) and a control (no fertilizer application) treatments 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 in the last plough in all the treatments. The crop was drip irrigated 80% CPE. The irrigation was withheld 10 days before harvesting. The crop was harvested 8 MAP.

The results revealed that maximum plant height and

plant spread at three and five MAP was recorded in treatments that received higher fertigation. The treatment fertigation at two days interval with 40 split doses recorded higher plant height and plant spread at three MAP whereas fertigation at three days interval with 50 split doses registered taller and wider plants at five MAP. The check recorded plant height of 72 and 93 cm, and plant spread of 84 and 123 cm at three and five MAP, respectively. The control with no fertilizer recorded lower plant height and spread at thre eand five MAP.

Corm yield increased with increasing fertigation interval from two to three days (Fig. 18). The maximum corm yield was observed in fertigation at four days interval (35.4 t ha^{-1}). Fertigation at two days interval was recorded with lower corm yield. This may be due to non-utilization of nutrients by the crop, if supplied in quick successions. The recommended fertilizer applied in more number of splits has recorded higher corm yield (Fig 19). However, maximum corm yield was noticed with 40 numbers of split of recommended fertilizer. The interaction effect was found significant between fertigation interval and number of splits of recommended fertilizer dose. Maximum corm yield of 38.3 t ha^{-1} was observed with fertigation at four days interval and 40 numbers of split of recommended dose of fertilizer. The treatment fertigation at four days interval with 50 numbers of split of recommended dose of fertilizer recorded lesser corm yield (34.8 t ha^{-1}). Interpolation of fertigation duration indicated that the crop responded up to 180 days after planting. Maximum fertilizer use efficiency of 81.7% was noticed in case of fertigation at four days interval and 40 numbers of split of recommended dose of fertilizer. This was 43.9% higher fertilizer use efficiency than soil application. Application of recommended dose of fertilizer in soil recorded just 37.8% fertilizer use efficiency.

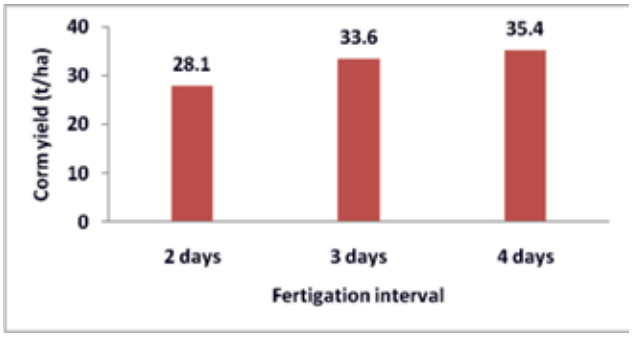


Fig 18. Effect of fertigation interval on corm yield (CD @ 5%: 1.1)

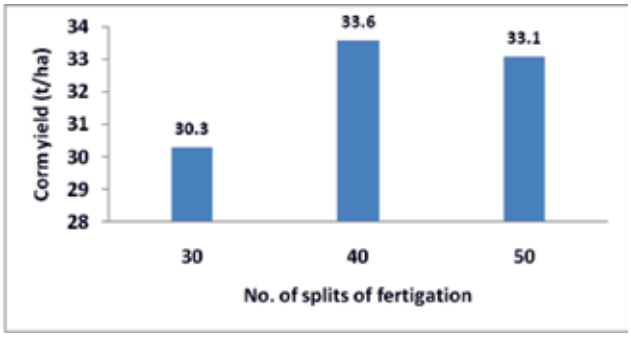


Fig 19. Effect of number of splits of recommended fertilizer dose (CD @ 5%: 1.1)

SOIL HEALTH AND PLANT NUTRITION IN TROPICAL TUBER CROPS

Sustainable and eco-friendly soil management strategies need to be developed in tuber crops to produce safe food, maintain crop growth, yield and quality besides keeping the soil and environment healthy. These include precise fertilizer use, organic farming, use of nutrient efficient genotypes and soil and water conservation practices. In order to develop above strategies that gives higher yield and income besides maintaining soil health and environmental quality, it is essential to develop fertilizer best management practices (FBMP) and integrated nutrient management and organic farming practices, to test the sustainability of different soil fertility management practices using long term fertilizer experiments, identification of genotypes that have better nutrient use efficiencies besides developing ideal soil and water conservation practices for the rainfed hilly tracts. This will eventually result in the sustainable production of tropical tuber crops catering to the needs of different stake holders such as farmers, industrialists and health conscious sections of the society. The proposed project will help to evolve technologies that will address all the issues

Fertilizer best management practices by SSNM for sustainable tuber crops production and soil health

Two field experiments on site specific nutrient management (SSNM) of elephant foot yam and cassava were conducted in the farm of CTCRI with six treatments (N-omission, P-omission, K-omission, NPK-omission, present recommendation (PR) and SSNM plots) and four replications in a randomized complete block design (RCBD). 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 38.5 t ha^{-1}, whereas in PR plot it was 28.5 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 six seasons showed the superiority of the treatment over present recommendation. The yield in SSNM treatment (38.5 t ha^{-1}) was significantly higher compared to the present recommendation (31.25 t ha^{-1}).

The current and future climate suitability of elephant foot yam in India was studied using geoinformatics tools. The results of the study showed that elephant foot yam is positively impacted in many areas of AP, Gujarat, Bihar and Jharkhand with -3.2 to +19.6 % changes in climate suitability (average % change in all pixels). The predicted increase in temperature by 2030 is between 1.3 and 2.4 °C. The predicted changes in rainfall ranged between -135 to +35 mm/year. Most elephant foot yam growing regions showed decrease in rainfall of 65-85 mm/year (Fig. 20 & 21).

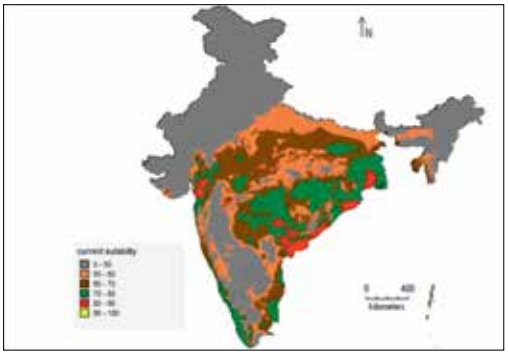


Fig. 20. Current climate suitability of elephant foot yam in India

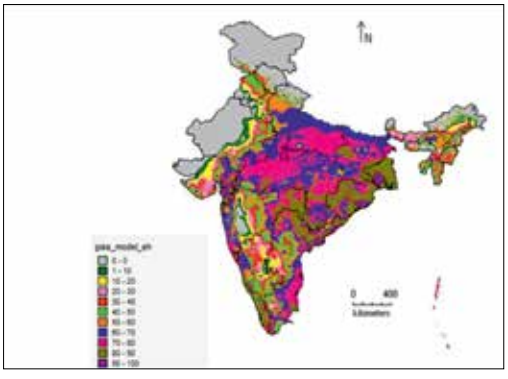


Fig. 21. Future climate suitability of elephant foot yam in India predicted by giss_model_eh

Long term fertilizer cum manurial trial in cassava

The overall objective of this trial was to evaluate the response of cassava to plant nutrients (major, secondary and micronutrients) and to study the effect of sustainable long term nutrient management on soil physico-chemical, biological, biochemical properties, carbon sequestration potential, soil quality, soil health and nutrient budget. The activities envisaged included, long term fertility experiment to develop nutrient management practice involving organic and inorganic sources of plant nutrients, study the response of cassava to application of Mg, Zn and B, standardization of B recommendation for cassava and to study the response of cassava to soil test based application of plant nutrients.

The salient findings from the 9th season crop included, among the different levels of fertilizers, except absolute control, all levels viz., NPK@ 125:50:125 (25.098 t ha^{-1}), 100:50:100 (21.623 t ha^{-1}), 50:25:50 (20.280 t ha^{-1}), 50:25:100 (20.402 t ha^{-1}) and 60:0:54 kg ha^{-1} based on soil test data (22.871 t ha^{-1}) were on par with respect to cassava tuber yield. Even without any manures and fertilizers, the yield of cassava was maintained to the tune of 12.14 t ha^{-1} even after 24 years of continuous cultivation in the same field. Among the different organic manures, green manuring *in situ* with cowpea resulted in significantly higher tuber yield of 31. 902 t ha^{-1} as the green biomass of cowpea incorporated was 28.33 t ha^{-1} having 3.326% N and all other organic sources viz., FYM (24.901 t ha^{-1}), vermicompost (19.531 t ha^{-1}), coir pith compost (21.145 t ha^{-1}) were on par. Soil test based application of different combinations of Mg, B and Zn resulted in significantly higher yield over POP (21.623 t ha^{-1}) except for application of B alone with conjoint application of Mg and Zn resulting in significantly the highest tuber yield (28.729 t ha^{-1}). Levels of fertilizers caused significant increase of soil P and Cu where the highest and recommended levels resulted in the maximum build up. Different organic sources except ash resulted in maintaining the soil nutrient status especially organic carbon and Cu whereas ash resulted in building up the Ca status of the soil. Among the different secondary and micronutrient combinations, treatments having Zn resulted in significant increase in soil Zn status. Stem N,P, K and tuber N were

significantly influenced by levels of fertilizers with the highest NPK @ 125:50:125 kg ha^{-1} registering the maximum content as well the highest total plant uptake of all nutrients.

Stem and tuber nutrient contents were significantly influenced by the different organic sources where ash, FYM and vermicompost resulted in significantly higher N, P and K in stem and tuber. Different combinations of Mg and Zn did not result in any significant increase in the leaf, stem ant tuber Zn or Mg contents. Though no significant effect of levels of fertilizers on starch and cyanogenic glucoside content was noticed, the highest NPK and soil test based NPK resulted in highest and lowest cyanogen and lowest and highest starch content respectively. Crop residue and vermicompost caused the lowest cyanogen and highest starch in cassava tubers.

Field observations and laboratory estimations of soil physical properties were carried out in 9th season crop of cassava in six selected treatments with different organic manure applications. The soil is of sandy loam in texture and NPK and vermicompost treated plots had significantly low bulk density (1.44 Mg m^{-3}) and high maximum water holding capacity (43.6 %) as compared to other five treatments. Field estimations of volumetric soil moisture were made 12 times during the period to study the pattern of soil moisture variation and depletion in different treatments. Among the stages, highest soil moisture of more than 10% (v/v) was observed during the month of June and August, 2013 under integrated application of all the four organic manures. Association of soil variables indicated that bulk density was significantly and positively correlated with soil porosity (r=0.99**) and water holding capacity (r=0.71**).

Screening nutrient efficient genotypes of cassava for low input management

The activity envisaged was to ascertain the N efficiency potential of the K efficient genotypes and to take up field validation, molecular level studies, root biomass and distribution studies and to develop low input management strategy for cassava using nutrient use efficient genotypes. The salient results of the season I experiment revealed that agronomic efficiency, N utilization for biomass, physiological efficiency, tuber bulking rate, leaf area index, tuber yield, stem N and total plant N uptake were significantly influenced by the genotypes. The interaction effect of cassava genotypes (edible: Aniyoor, W-19, H-1687, industrial: 6-6, CR 43-8, 7 III E3-5) and levels of N (0, 50,100, 150 kg ha^{-1}) were significant in the case of tuber bulking rate only. N levels significantly influenced the agronomic efficiency, apparent recovery efficiency, N efficiency ratio, tuber yield, tuber bulking rate and total plant N uptake. Though W-19 produced the highest tuber yield (30.522 t ha^{-1}), it was on par with the tuber yield of the other two edible genotypes. Among the industrial genotypes, CR 43-8 recorded the highest tuber yield of 31.105 t $ha^{-1.}$ Significant increase in tuber yield with increase in N level was seen with the super optimal level of N @ 150 kg ha^{-1} resulting in the maximum tuber yield of 31.105 t $ha^{-1.}$ Agronomic efficiency was highest (77) with CR43-8 and physiological efficiency with W-19 (101). LAI was higher with W-19 (9.54) and CR 43-8 (10.11) among edible and industrial genotypes. Aniyoor gave the lowest cyanogenic glucoside content of 40.4 µg g^{-1} which was on par with all other genotypes except 6-6 which recorded the highest cyanogen content of 233.8µg g^{-1}. CR 43-8 at N @ 50 kg ha^{-1} recorded the maximum TBR of 5.945 g day^{-1}.

The demonstration cum validation trials for the 6 selected Kefficient genotypes were laid out in 3 locations viz., KVK, Mithranikethan, Thiruvananthapuram; KVK, CARD, Pathanamthitta and a farmer field at Chullimanoor, Thiruvananthapuram. The crop is yet to be harvested.

The root distribution studies were undertaken in 3 situations viz., field, lysimeter and pots with the 6 identified genotypes at 3,6 MAP (field), 2,4,6,10 MAP (lysimeter) and 1,2,3,4,5 MAP (pots). Observation on the fresh weight of fibrous roots including white roots having root hairs (responsible for water and nutrient absorption) recorded at these intervals indicated maximum in the case of Aniyoor and 7 III E3-5 among edible and industrial genotypes respectively (Fig. 22). Studies on root anatomy of the K- efficient genotypes revealed more white roots with root hair protrusions in the case of Aniyoor and 7 III E3-5 respectively.

Low input management strategy using the PK

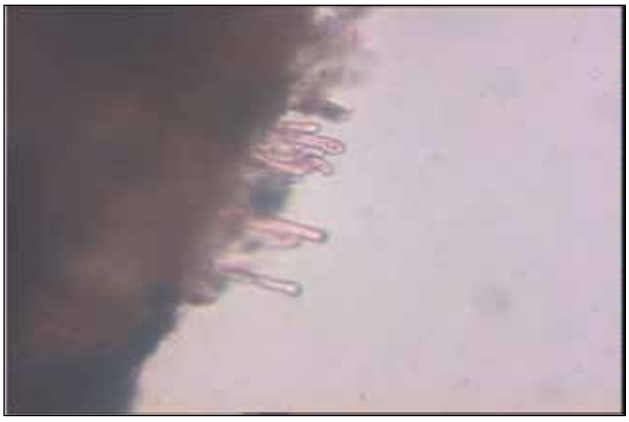


Fig. 22. Root hairs in K efficient genotype 'Aniyoor'

efficient genotype (AC. No. 906) coupled with low cost nutrient management strategy involving green manuring *in situ* with cowpea as source of organic manure, soil test based application of NPK (106:0:83 kg ha^{-1}), secondary ($MgSO_4$ @2.5 kg ha^{-1}) and micronutrient ($ZnSO_4$ @12.5 kg ha^{-1}) and nutrient efficient bio-fertilizers (N fixers, P solubilizers and K solubilizers) resulted in the significantly highest tuber yield of 36.457 t ha^{-1} which in turn caused about 10% yield increase and 10-15% reduction in cost of production over the existing POP recommendation.

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

A field experiment was initiated at Vengamudi, Pachamalai hills, Eastern Ghats to study the interaction of soil moisture and nutrients (P and K) in rainfed cassava. A total of seven treatments taken up in the study that consisted of black porous ground cover sheet (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. Cassava was planted on 11th October, 2013.

Volumetric surface soil moisture and soil temperature were measured in field on 12th November, 05th December, 2013, 28th January and 01st March, 2014 after four varying rainfall events/stages. Results have shown that soil moisture under AC varied from 2.9 to 19.6 % (v/v) during the studied period whereas ground cover (GC) (Fig. 23) was found to be highly beneficial over IC and C especially at the time of low rainfall intensity events that occurred on 26th January and 25th February, 2014. The soil moisture under GC was found to be highest and significant (34-65%) over control in third and fourth stages of observation. No significant soil moisture differences were observed among intercrop and control treatments where as SP was found to have highest and significant soil moisture over FP to an extent of 11-18% during 12th November and 28th January. Soil temperature varied from 23.5 to 30.9°C in different treatments and significantly lowest in GC treatments to an extent of 3-6% over control. Sorption studies showed that the soils had a very high soil P fixation capacity (84%) and medium soil K fixation capacity (43%). Soil available P and K content was estimated at air dry (AD) and field moisture (FM) levels at 54 DAP (days after planting) and 140 DAP. Results showed that at a mean field soil moisture content of 12.6%,v/v on 140 DAP, the available P at FM was 46% higher than AD conditions whereas at a mean soil moisture content of 21.4% at 54 DAP, it was only 20%, showing that the available soil P decrease with increased soil moisture content. However, the available K content showed a positive response with increased soil moisture, unlike available P.

Fig. 23. GC sheet treatment in cassava field at Pachamalai hills, Tamil Nadu

Organic farming of yams and aroids

Dwarf white yam var. Sree Dhanya was tested under four production systems viz., conventional, traditional, organic and integrated farming for the third season. Production systems did not vary significantly and organic farming (14.79 t ha^{-1}) was on par with conventional practice (11.30 t ha^{-1}). However, organic management produced 31% higher yield over conventional practice. No significant micro-environment (soil temperature, soil moisture, soil CO_2 and PAR) changes were observed under organic farming, but favorable effects were discernible. The major chemical properties of the soil remained

unaffected by the third year, though pH increased by 0.412 unit, soil organic matter by 22%, available N by 44% and K by 7% under organic management. Soil microbial population and biochemical constituents of tubers were unaffected.

The long term performance of organic vs conventional management in yams and aroids was analyzed through the stability index calculated over a five year period and it was found that organic farming was equally stable as that of conventional practice (Fig. 24).

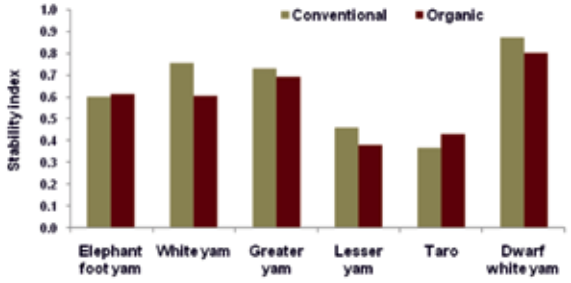


Fig. 24 Yield stability index in organic vs conventional management in yams and aroids

Effect of organic sources, secondary and micro nutrients on soil quality, yield and proximate composition of minor tuber crops

A field experiment was conducted during Kharif season of 2013-14 at Regional Centre of CTCRI, Bhubaneswar to study the effect of integrated use of lime, mycorrhiza, inorganic and organic manures on soil quality, yield and bio-chemical constituents of yam bean (Fig. 25). The trial was laid out with 16 treatments replicated thrice in a randomized block design. The soil (sandy loam) was having a pH of 4.67, non saline (0.24 dS m^{-1}), 0.26% organic C and 226, 24.64, and 189 kg of available N, P_2O_5, and K_2O ha^{-1}. Yam bean (cv RM-1) seeds were dibbled at a spacing of 50x30 cm. All the cultural practices were followed as per schedule and the crop was harvested at 5 months after sowing and yield parameters were recorded.Tuber samples were analyzed for starch, total sugars and dry matter contents. Vine and tuber samples were processed for estimation of nutrient contents. Significantly highest tuber yield (35.87 t ha^{-1}) was recorded due to integrated application of lime + FYM + NPK + $ZnSO_4$ with highest yield response of 270 per cent over that of control at par with 150% NPK (34.86 t ha^{-1}). The increase in tuber yields was

Fig. 25. Lay out of the experiment and tubers obtained from highest yielded treatment

90, 198, and 259 % over control due to application of 50, 100 and 150% NPK based on soil test values.

Among the organic sources, vermicompost application showed higher tuber yield (28.24 t ha^{-1}) followed by *in situ* incorporation of green manure (27.75 t ha^{-1}). Integrated use of FYM + NPK + VAM recorded a tuber yield of 31.68 t ha^{-1}, whereas lime addition further enhanced the tuber yields by 6 % over that of FYM + NPK + VAM (33.62 t ha^{-1}). The harvest index was highest (80.4%) due to *in situ* incorporation of green manure followed by 100% NPK STBF (79.2%). Highest starch content was recorded due to application of 150% NPK, however, the total sugars varied from 4.98-5.91% with highest being due to integrated use of lime + FYM + NPK + B.

The results showed that the soil pH progressively improved due to integrated application of lime, inorganic fertilizers and organic manures. Addition of lime in combination with NPK improved the soil pH by 0.3 units over the initial level. Highest increase of soil pH and organic C was observed due to combined use of lime + FYM + NPK + $MgSO_4$ from the initial

levels followed by lime + FYM + NPK + $ZnSO_4$. Total N content in the soils increased in all the treatments and significantly highest available N (292 kg ha^{-1}) and available K (272 kg ha^{-1}) were recorded due to application of 150% NPK. Integrated use of VAM along with lime + FYM + NPK recorded significantly highest available P (105.4 kg ha^{-1}).

ABIOTIC STRESS MANAGEMENT IN TROPICAL TUBER CROPS

Abiotic stress includes contingent drought (prolonged dry spell during normal monsoon season), high temperature stress (daily mean temperature > 30°C), salinity (Chloride and Sulphate of Sodium Calcium and Magnesium) and heavy metal in soil in mining areas. The aforementioned three abiotic stresses affect productivity whereas heavy metals affect quality of produce in tuber crops. In order to sustain productivity under abiotic stresses and quality the present project aims to address these issues in tropical tuber crops.

Drought and heat stress management in tropical tuber crops

To induce high temperature stress tolerance in elephant foot yam, variety Gajendra was planted in the farm of CTCRI during May 2013 in Block IV in RBD with three replications. Elephant foot yam plants were enclosed in poly chamber of 2 m^3 for 3 months and plants were irrigated regularly. Inside the poly chamber these plants experienced high temperature stress of 37-40°C during day time (10 AM to 4 PM) and showed senescence at 75 days after enclosure in poly chamber. Outside plants experienced 30-32°C during day time. This information will be utilized for taking inducing heat tolerance through chemical treatments during the next year.

Studies on salt tolerance in sweet potato

Field experiments were laid out in natural saline soils in farmers' fields at two locations (Lalpahar (L1) and Chouldari villages (L2) of Chouldari Gram Panchayat of South Andaman district, Andaman & Nicobar Islands in collaboration with Central Island Agricultural Research Institute, Port Blair, Andaman (Fig. 26). The experimental soil at L1 is slightly acidic (pH 6.2), saline (1.78 dS m^{-1}), and having 0.56 % organic C, 280, 12.5, and 160 kg N, P, and K ha^{-1}. The experimental soil from L-2 is almost neutral (pH 6.5), saline (1.53 dS m^{-1}), and having 0.48 % organic C, 260, 16.0, and 175 kg N, P, and K ha^{-1}. The trials were laid out with 4 white fleshed genotypes (Samrat, Kishan, Sree Bhadra and Pusa Safed) and 2 orange fleshed genotypes (ST-14 and CIP-440127) of sweet potato in RBD. Well rotten farmyard manure @ 5.0 t ha^{-1} was applied well in advance of planting of the vines. A uniform dose of 50-25-50 kg N, P_2O_5 and K_2O ha^{-1} was followed. Planting of sweet potato vines at both the locations was done at a spacing of 60x20 cm during 1st week of December, 2014 and all the cultural practices were followed as per schedule. The crop was harvested in April, 2014 and the yield parameters were recorded. Plant (tuber & vines) samples were collected at harvest, washed thoroughly, processed and used for estimation of biochemical constituents and nutrient concentration. Among the sweet potato genotypes, Samrat was found superior with a tuber yield of 18.32 t ha^{-1} followed by CIP-440127 (16.23 t ha^{-1}) and Sree Bhadra (15.83 t ha^{-1}) at L 1, while it was highest with Samrat (19.04 t ha^{-1}) at L 2 followed

Fig. 26 Field experiments at Lalpahar and Chouldari villages, South Andaman district, A & N Islands

by CIP-440127 (16.46 t ha^{-1}) and Sree Bhadra (16.08 t ha^{-1}).

PRODUCTION OF DISEASE FREE PLANTING MATERIALS

Most of the tuber crops are prone to various viral, fungal and bacterial diseases, which cause enormous economical losses. Since these crops are invariably vegetatively propagated and characterized with low multiplication rate as compared to cereals and pulses, healthy and disease free planting materials of released varieties by the research institutes needs to be produced in large quantities so as to reach the end user in short period without quality deterioration. In order to achieve total production of disease free planting materials, techniques such as minisett multiplication is linked with indexing and *in vitro* propagation. In cassava, the procedure has been designed in four stages for effective monitoring and selection of disease free planting materials of which he first three stages are under controlled condition and the final stage is in the open field.

Planting material production

Virus free planting materials were produced through procedures involving indexing, micro propagation, hardening and minisett multiplication under protected environment followed by multiplication of disease free planting materials in selected areas of Kerala, Tamil Nadu, Odisha and the North East India in a farmers participatory mode. Accordingly, 40 numbers of Sree Vijaya, 240 numbers of H 226 were indexed in cassava *in vitro* cultures whereas in elephant foot yam, 400 numbers of Gajendra were indexed. The micro propagation (indexed) includes 265 numbers of Sree Vijaya and 442 numbers of H 226. Hardening was done on 15 numbers of Sree Vijaya and 61 numbers of H 226. A total of 20,000 cassava stems and 8 tons of elephant foot yam were produced and distributed (Table 1).

Table 1. Quantity of planting materials produced (01-04-2013 to 31-03-2014)

Crop	Quantity produced (Kg)
Elephant foot yam	35000
Greater yam	25000
White yam	1500
Lesser yam	850
Tapioca stems (nos)	60,000
Sweet potato vines (nos)	5,00,00
Arrowroot	1000
Taro	6000
Chinese potato cuttings (nos)	2,500
Yam bean	100

CROP PROTECTION

ECOFRIENDLY STRATEGY FOR THE MANAGEMENT OF INSECT PESTS IN TUBER CROPS

Tropical tuber crops are generally less vulnerable to insect pests. However, few insects like sweet potato weevil, mealy bugs and scale insects affecting cassava, elephant foot yam and yams cause considerable damage to the tubers which affects the marketability. Apart from damage, some of them *viz*., whiteflies and aphids act as vectors of different viral diseases. For managing the pests indiscriminate use of synthetic pesticides created uncountable miseries to man and environment. This necessitates identifying suitable bio pesticides and development of an IPM package for the management of insect pests of tuber crops. Hence, a project with the objective of identification of suitable biopesticides for the management of pests of tuber crops, standardisation of doses for the management tuber crop pests, management of vectors of the cassava mosaic disease, residue analysis in various tuber crop and further developing IPM package for the management of insect pests of tuber crops has been formulated.

Survey

A survey during August, October, November, December, January and March was conducted for monitoring the pests. There was no evidence of presence of taro corm borer *Aplosonyx chalybeaus* in the coastal districts of Odisha (Puri, Cuttack, Jajpur, Bhadrak, Balasore; and Poorva, Midnapore district in West Bengal, inspite of presence of several species of wild hosts. In Odisha, *Spodoptera litura* was found as a major pest of taro. Infestation of aphids and grasshoppers was also observed in taro (3-5% foliar damage) in Odisha and Kerala. Sweet potato weevil populations were monitored using sex pheromone traps in different districts of Odisha and Andhra Pradesh (Fig. 27)

Fig. 27. Monitoring sweet potato weevil population

Management of sweet potato weevil

The two biopesticides developed at CTCRI viz. *Nanma* and *Menma* were tested against sweet potato weevil (SPW) *Cylas formicarius*. The treatments were given as soil drenching by *Menma* in three doses (1:0; 1:1 and 1:5) and foliar spray by *Nanma* (1, 3 & 5%). Treatments were given at three intervals (i) 30, 60 and 75days after planting (DAP); (ii) 60 and 75 DAP; (iii) 75 DAP. The biopesticide *Nanma* at the dose of 1, 3 and 5% was also sprayed in the same interval. Untreated plants were kept as control and imidacloprid and chlorpyrifos at 0.01% served as positive checks. On harvest, the weevil infestation was noticed in the tuber as well as the vines. In the case of treatment with *Menma,* the weevil infestation was not observed in all the 3 doses applied continuously for 30, 60 & 75 DAP. When the treatment was restricted to 60 & 75 DAP, 25.5% tubers were found unmarketable due to infestation in the plants treated with the dose of 1:5, whereas no unmarketable tubers from the plots were obtained when treated with doses of 1:0 and 1:3. When *Menma* drenched only on 75 DAT, high infestation was observed in all the tree treatments (1:0, 1:3 & 1:5), however the infestation level was less in treatments with the dose of 1:0 (25.0%) and at 1:3 (40.4%). In the case of control the infestation was as high as 50.0%. This indicates that *Menma*, the

biopesticide prepared exclusively from cassava leaf, is effective when treated frequently.

Treatments with *Nanma* were on par with the treatments with chemical insecticides. In all the three doses and also the intervals of application, no unmarketable tuber was noticed in any of the treated plots. Plots treated with chemical insecticides were also found effective in controlling the pest. However treatment with imidacloprid at 0.1% when treated at 75 DAP alone caused 25% unmarketable tubers.

Pesticide residue analysis in sweet potato

The sweet potato field was treated with dimethoate, chlorpyriphos and malathion at a concentration of 0.01% and the residue on the leaf was analysed at weekly interval using gas chromatograph. In the leaf collected from dimethoate treated plants, the residue was 5.710, 1.499, 0.274 and 0.170 ppm at 0 to 4 week intervals, and in chlorpyriphos and malathion these were 0.67, 0.575 and 0.102 and 4.211 and 0.124 ppm respectively.

Kairamones and repellents of sweet potato weevil

Sweet potato weevil (SPW) is an important pest of sweet potato in Odisha. In farmers' fields, 30-50% were found damaged before harvest. The harvested tubers, once stored for 2 months, resulted in emergence of 300 weevils/kg tubers, indicating that though weevil damage is not seen in field, its risk is imminent in later periods, as tuber inherently have developing insects within them. In order to identify kairamones emitted by sweet potato, electro antennagram (EAG) technique was tried with volatile compounds.

Leaf, flower volatile extracts from sweet potato varieties showed differential EAG responses, in terms of the length and time of the excitation of the antennal receptors, opening and closing of olfactory receptors. Thirteen plant volatile compounds were evaluated in Electroantennogram Detector (EAG). Antenna of female *Cylas formicarius* showed highest depolarization and duration (5.29 mV) to Geraniol, followed by Humulene (2.91 mV, 6.52 Sec), citrial (2.82 mv, 4.82 Sec), ylanglang oil (2.71 mV) and trans-caryophyllene (2.30 mv). The slope for these compounds was highest for Geraniol (15.78 mV/Sec) followed by Humulene (11.03 mV/Sec) and Citral (3.49 mV/Sec) indicating that Geraniol and Humulene makes the antennal olfactory receptors to excite for a longer time, thus opening their Na+/K+ ion gates for longer duration, to facilitate maximum absorption of the odour in case of female insects. Alcohols (cis-3-hexeneol) excited male antenna (4.03 mV) more than female antenna (2.86 mV). Their corresponding aldehydes and acetates have shown lesser response or depolarization of olfactory receptors on insect antenna. This indicates, the alcohols have great influence on insect behavior in diversified ways.

Alpha-Gurjunene and Alpha-humulene identified from sweet potato weevil resistant lines, have shown feeding deterrents in the first contact, and as repellents at higher concentrations. These two compounds repelled the weevil upto 65-75% in Y-tube olfactometer bioassays.

INTEGRATED MANAGEMENT OF FUNGAL DISEASES OF TROPICAL TUBER CROPS

Among the fungal diseases of tropical tuber crops, taro leaf blight, collar rot of elephant foot yam and greater yam anthracnose are the most destructive which cause substantial loss to the crops. The diseases cause severe damage to the crops and little information is available regarding the management of the disease using chemicals, organic amendments and biological agents. This necessitates formulation of effective integrated approach to reduce the yield loss caused by the pathogen. Hence to develop eco-friendly and bio-intensive management strategies the project has been formulated. Apart from chemicals, no other control method has been successfully established in field to tackle these target pathogens. There are attempts to tap the potential of various aspects of disease management to combat fungal diseases of tuber crops individually. But, no concrete effort has been made to integrate these strategies for an effective, cost effective and eco-friendly management package. Added to this, many attempts were confined to laboratory or glass house studies. For the acceptance of any technology as an alternative to chemicals, establishment of suppressive potential in field condition is a must. The present project aims to address the above mentioned gaps and to develop integrated management strategies for the above diseases which can successfully adopted in field conditions.

Bio-intensive management of taro leaf blight and collar rot of elephant foot yam

Soil samples were collected from rhizosphere region of tuber crops of Kerala, Andhra Pradesh, West Bengal, Manipur and Odisha states. Three hundred and forty nine bacterial isolates were obtained from these samples and crop wise distribution of the isolates is given in Fig. 28. All the isolates were screened against *P.colocasiae* and *S.rolfsii* which cause taro leaf blight and EFY collar rot respectively by adopting direct confrontation, production of diffusible metabolites and volatiles. Fifty-two isolates showed good inhibition to both the organisms.Twenty isolates from potential antagonists were screened for growth promotion potential by using Indole Acetic Acid (IAA) production and found that five isolates has growth promotion potential also.

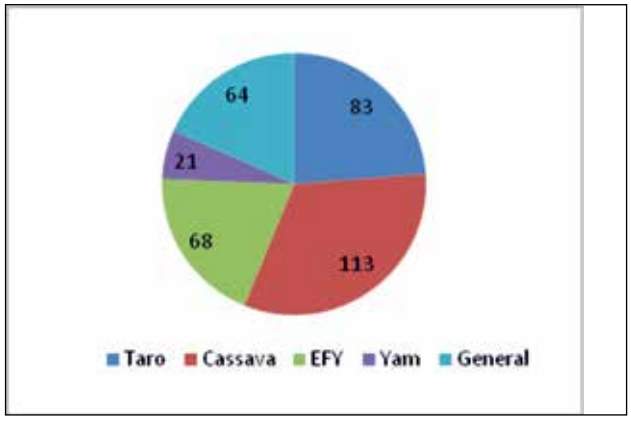


Fig. 28. Bacterial isolates obtained from different crops

In another experiment, cormels of taro were primed with four *Trichoderma asperellum* isolates and a bacterium and raised the plants in pots. The height of the plant and number of leaves produced were recorded. After two months of planting, the plants were challenge inoculated with *P. colocasiae* and kept in fabricated moist chamber to simulate the conditions required for disease development. The lesions developed were measured and compared with lesions developed in control plants. The bacterial isolate 13-9 showed significantly higher growth promotion and least lesion development and the isolate was selected for further study (Fig. 29 and 30).

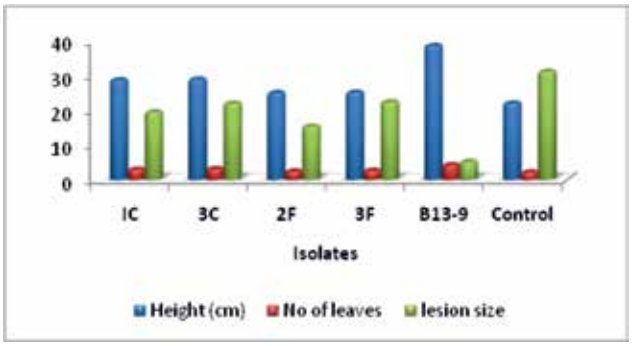


Fig. 29. Growth promotion and disease suppression by 13-9

Fig. 30. Growth promotion of taro by 13-9

Effect of micronutrients in disease suppression

Humic acid, ZnSO4, borax and potassium silicate were applied to taro plants separately and in all possible combinations to study their effect on taro leaf blight incidence. The variety used was Sree Kiran, a known susceptible variety. The plants were challenge inoculated with target pathogen after 2 months of planting and observed for lesion development if any. Lesion development was noted in all treatments. The plants that received NPK alone showed an average lesion size of 72 cm. The least lesion size was noted with the treatments where combination of ZnSO4, potassium silicate and humic acid were applied together (38 cm) followed by combination of ZnSO4, borax, potassium silicate and humic acid (40 cm).

Effect of vermicompost on taro leaf blight and collar rot of elephant foot yam

The results of pot culture experiments conducted during 2011 and 2012 in taro and elephant foot yam, four treatments with vermicompost application were found good in managing these two diseases. The four treatments were tested in field along with present

recommendation. The experiment was conducted in both taro and elephant foot yam plants.

Taro leaf blight

The experiment was conducted with the variety, Sree Kiran, a known susceptible variety and the statistical design followed was RBD. Growth parameters *viz*., height of the plants, number of leaves, breadth and width of the plants were recorded at bimonthly interval. None of the parameters showed significant difference among treatments. The least PDI was noted with the treatment consisting of seed treatment with vermiwash (10%) + soil application of vermicompost + drenching and spraying with vermiwash at 60 & 90 DAP (16.76). Comparatively, disease incidence was more in present recommendation (PDI of 23.8) and control plots (PDI of 31.0). Similarly, significantly higher cormel yield was also produced by the same treatment (21.1 t/ha).The treatment resulted in 24.1% and 67.7% yield increase over present recommendation and control respectively.

The best treatment, i.e. seed treatment with vermiwash (10%) + soil application of vermicompost + drenching and spraying with vermiwash at 60 & 90 DAP was compared in field with the chemicals which are being recommended for the management of taro leaf blight incidence elsewhere. The least disease incidence was noted with metalaxyl application (PDI of 2.2) followed by vermicompost application (PDI of 4.84). Whereas the plants in present recommendation and control showed PDI of 9.3 and 15.6 respectively. The highest yield was also noted with metalaxyl application with yield increase of 32.7% and 40.9% over present recommendation and control. This was followed by vermicompost application with yield increase of 19.6 % and 29.8% over present recommendation and control. The microbial population was monitored throughout the cropping period. Fungal, bacterial and actinomycete population in different treatment did not show any significant difference due to various treatments.

Collar rot of elephant foot yam

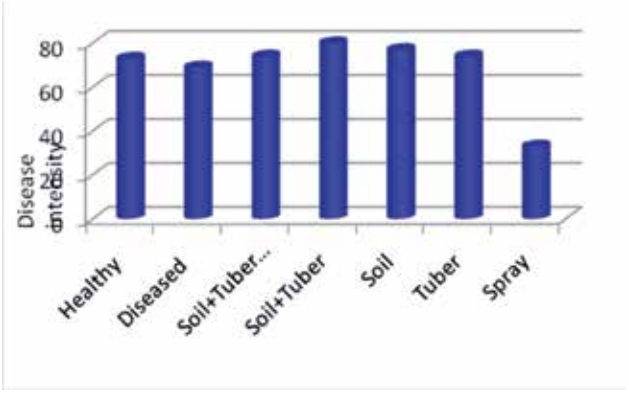
The variety used for the experiment was Gajendra and the design followed was RBD. In elephant foot yam also none of the growth parameters showed significant difference due to the incorporation of vermicompost. However, yield as well as collar rot incidence showed significant difference due to incorporation of vermicompost. The treatment consisting of seed treatment with vermiwash + soil application of vermicompost + drenching with vermiwash at 90 & 120 DAP showed highest yield and least collar rot incidence. Vermicompost application could reduce the collar rot incidence to 22.2% and it showed 68.9% and 14.4% efficiency in controlling the disease over control and present recommendation respectively. The highest yield was also noted with the same treatment. It showed 32.47% and 18.0% yield increase over the plants in control and present recommendation.

Greater yam anthracnose and its management

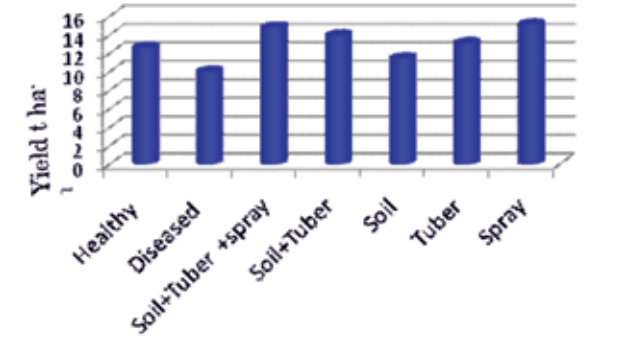
The studies on source of inoculum showed the presence of the pathogen in the fresh tuber skin of infected plants, plant debris and soil but not in the dried tubers. Pathogen inoculated in sterile field soil (Dry) and incubated at room temperature could not survive beyond three months whereas with 20% moisture the pathogen continued to survive beyond four months.

A field trial on the management of greater yam anthracnose (Fig. 31) was conducted with seven treatments by means of soil (@ 50g per plant and tuber treatment (5g per Kg tuber in cowdung slurry) with 10^7 cfu of biocontrol agent (BCA), *Trichoderma asperellum*: CTCRI-Tr 15 and carbendazim spray (@ 0.05% three times at fortnightly intervals. The first spray was done when the symptom initiates. Spraying carbendazim (0.05 %) alone showed lowest disease intensity (33.3%) which is significantly less than other treatments. All other treatments are on par. In the case of yield though there is no significant difference between treatments, spraying alone showed maximum increase in yield (51%) which was followed by soil and tuber treatment with *Trichoderma* along with spraying (49%) and soil and tuber treatment with *Trichoderma* alone (39%) and tuber treatment alone (31%) (Fig. 32). The population of bio control agent was monitored throughout the crop period at monthly intervals. There was drastic reduction in the population. Generally the tuber treatment with BCA recorded increased yield but not soil treatment compared to control .

Fig. 31. Field trial on the management of greater yam anthracnose



a. Anthracnose intensity



b. Yield

Fig. 32. Effect of soil and tuber treatment of BCA and spraying carbendazim on greater yam a. anthracnose intensity and b. Yield

Characterisation of toxic metabolites

Culture filtrate of *Colletotrichum gloeosporioides* causing anthracnose in greater yam has been taken after 30 days of incubation in Richard's broth . Crude toxin was prepared using diethyl ether which was effective on yam leaves in earlier studies. GCMS of the diethyl ether extract showed the presence of three phenol, two esters and two other compounds which has to be confirmed further with more samples. Totally 95 germplasm accessions were screened *in vitro* with crude toxin by detached leaf assay and correlated with field symptoms to standardise a rapid i*n vitro* technique for anthracnose screening. Data analysis showed that the lesion development in different accessions is significantly different.

Callus induction

Standardization of callus induction of the greater yam variety, Orissa Elite, which is highly susceptible to anthracnose was done to screen calli for resistance to anthracnose using toxins

The MS Agar media with 13 different combinations of hormones (NAA, BA and 2,4- D) were tried for callus induction. The nodal cuttings of tissue cultured plants were used as explants. Among all NAA:BA @ 5 : 0.5 and 1.5 : 1.5 mg^{-1} showed good response in inducing the callus. Direct regeneration was observed in both the combinations. Liquid MS media with 1.5: 1.5 mg^{-1} NAA:BA supported considerably good callus proliferation compared to agar media (Fig. 33)

Fig. 33. Callus induction and plant regeneration in greater yam

A: MS Agar media + 1.5:1.5 mg^{-1} NAA:BA; B: MS liquid media + 1.5:1.5 mg^{-1} NAA:BA; C&D: Regeneration from callus

CHARACTERIZATION, DIAGNOSIS AND MANAGEMENT OF VIRUSES OF TUBER CROPS

Viral diseases are most important one in tuber crops, as they are carried through infected planting material from one season to next season and lead to loss in yield. Some of the major virus diseases are cassava mosaic disease, sweet potato feathery mottle virus, sweet potato leaf curl virus, yam mosaic virus, *Amorphophallus* mosaic virus, dasheen mosaic in taro. Primary spread of these causal agents is through infected propagating material and secondary spread in the field occurs through vectors like whitefly or aphids. Occurrence of these diseases leads to a reduction in yield and quality apart from affecting the growth of plants and their physiology. These diseases pose a serious problem in the production and distribution of healthy planting material. Apart from these known diseases, most of the plants showed mixed infection with exhibiting different kinds mixed symptoms and they are yet to be identified. Also the change in climatic pattern also might be influence with the use of new molecular diagnostic techniques. In order to overcome the above hurdles, we need to employ the more sensitive diagnostic techniques to unravel the viruses associated with them and need to be characterized at molecular level. Also several strains/ biodiversity of viruses associated with tuber crops should be identified. More sensitive, quick and cost effective detection techniques need to be developed for reliable diagnosis at faster time. Stress should be given for production of virus free planting material to replace the infested fields and exploring various options to manage these diseases. To fulfill the above requirements, Mining and characterization of viruses present in tropical tuber crops, development of user friendly efficient diagnostic kits for important viruses, molecular investigations of host- virus interactions and devising suitable management strategies for important viral diseases of tropical tuber cropswere undertaken to address the issues:

Transmission studies

In an attempt to mechanically transmit Dasheen mosaic virus (DsMV), *Nicotiana benthamiana* plants inoculated with DsMV showed leaf deformities within 45 days and the infection was confirmed through RT-PCR and this can be used as propagation host.

Mechanical as well as aphid transmission, tried to transmit both *Yam mild mosaic virus* (YMMV) and *Macluravirus* to propagation hosts , *viz*., *Nicotiana benthamiana, N. tabaccum* and cow pea with different positive samples were unsuccessful.

Mining of new viruses

Transcriptome anlaysis of the leaf samples of *Amorphophallus* with mixed virus infection showed the presence of portion of genomes of various viruses like *Dasheen mosaic virus (DsMV), Bean common mosaic necrosis virus, Cowpea aphid-borne mosaic virus, Calla lily latent virus, Soybean mosaic virus, Sunflower chlorotic mottle virus, Watermelon mosaic virus, Yam bean mosaic virus, Zucchini yellow mosaic virus* etc. The complete nucleotide sequence of *DsMV* infecting *A. paeoniifolius* was assembled from transcripts that showed 81% identity with the *DsMV* reference sequence available at NCBI.

Yam samples collected from the farmers' fields of Thiruvananthapuram, Kollam, Alapuzha, Pathanam-thitta and Wayanad districts of Kerala diagnosed for *Maclura virus* and none of the samples was positive .

Diagnosis of viruses infecting tuber crops

DsMVin elephant foot yam

Leaves of elephant foot yam showing typical mosaic, deformation and shoe string symptoms (Fig. 34) were subjected to different diagnostic techniques like ELISA, DIBA, RT-PCR with *DsMV* CP specific primers for confirmation of DsMV infection.

Reverse Transcription Loop Mediated Isothermal Amplification (RT- LAMP) was developed for rapid detection of *DsMV* which is less time consuming. The reaction conditions were optimized for clear gel based detection. The sensitivity and accuracy of the LAMP assay was found higher than that of RT-PCR when 50 leaf samples showing various symptoms were tested. Dipsticks were prepared manually based on *DsMV* specific IgG-gold conjugate. The *DsMV* positive samples gave red colouration in both control and test lines while the negative samples gave colouration in control lines alone. The test was found to be highly sensitive and was capable of detecting virus with very low titre. About 25 samples of elephant foot yam were detected with dipsticks within 10-15 minutes time.

Elephant foot yam

Taro

Fig. 34. DSMV infection

Viruses of taro

Around 70 leaf samples symptomatic and suspected of virus infection were collected from various parts of CTCRI and Bhuvaneshwar. Various symptoms noted are whitish feathery symptom along the veins, mosaic, feathery mosaics, crinkled and distorted leaves, chlorosis and chlorotic patches etc. (Fig. 34) ELISA test with 17 samples showed 8 of them positive for DsMV. Remaining samples are being tested. PCR & RT-PCR analysis showed the presence of viruses like DsMV and Taro bacilliform virus in the infected samples.

Viruses of yam

DAS- ELISA performed with 46 virus infected greater yam leaves (Fig. 35) using YMMV and Yam Maclura virus specific antibodies showed 7 and 16 per cent positive to the viruses respectively. RNA was isolated from 58 leaf and 31 tuber samples of greater yam. Lithium chloride method was found to be good to extract RNA from tubers compared to other manual and kit methods. Twenty and 50 per cent leaf and tuber samples showed positive in RT-PCR with *Macluravirus* specific primers. Two step RT- PCR was found to be reliable than single step. IC -RT PCR was standardised to diagnose Yam Maclura virus. NASH technique with non-radio labelled probe prepared from 200 bp product of YMMV showed good specificity and sensitivity (Fig. 36)

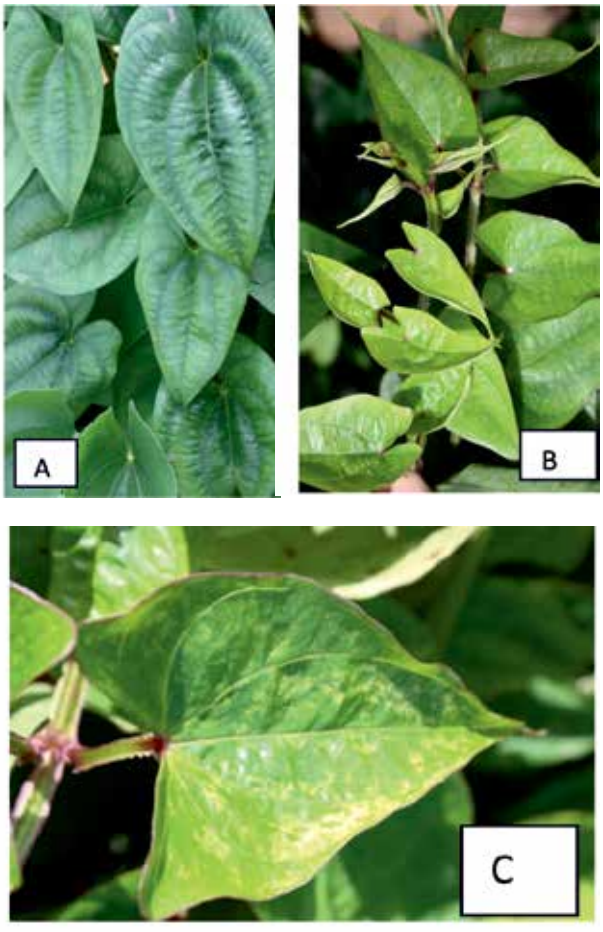


Fig. 35. Virus infected greater yam leaves A: YMMV B: Maclura virus C; YMMV &Maclura virus

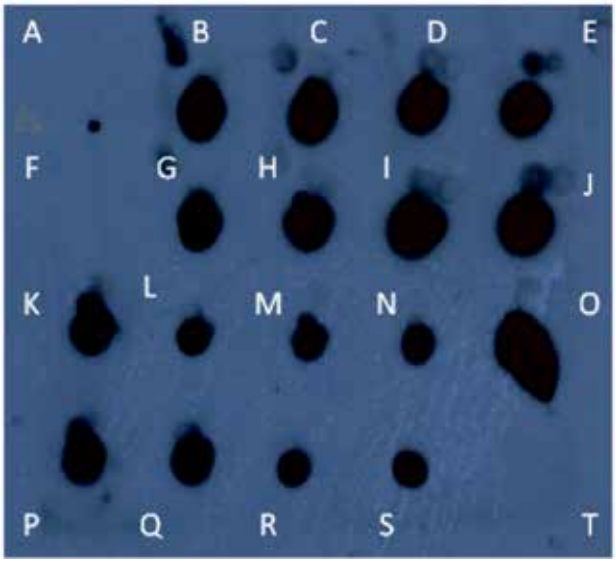


Fig. 36. Detection of YMMV from tuber samples through NASH using non radioactive probes
A: Buffer control; B: Positive; C-S: Tuber samples; T: Blank

Molecular Characterization of Symptom Recovery in Cassava Genotypes during Cassava Mosaic Disease (CMD) Infection

Fifteen selected cassava varieties of Susceptible, Resistant and Recovery types were planted in field and observations were taken at every month based on different grades of symptoms. Symptom development was scored and virus concentration 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. CMD Symptoms in susceptible lines were severe and were expressed throughout the 6 month monitoring. Symptoms as well as virus titre of recovery types were decreased over the growth period; while resistant had low concentration of viral DNA even though there was no symptoms. While comparing three years data, there was no significant differences in viral load and symptom expression in resistant or susceptible varieties. However, in recovery types, out of the five selected CMR varieties, only CMR 123 showed higher viral concentration in the first month of 3rd year than first two years.

Effect of climatic variation on symptom expression

Seven selected varieties (CMR 102, CMR 123, CMR 117, CMR 1, CMR 84, Susceptible variety was H226 and resistant variety was CMR 8) were planted at monthly interval to study the influence of climate change in the symptom expression. The results showed that the recovery types which were planted in the summer season showed less symptom and virus titer than those planted in the rainy season.

CROP UTILIZATION

DEVELOPMENT OF FUNCTIONAL FOODS FROM TUBER CROPS

With the rapidly changing food habits and increased migration to urban area coupled with the projected rise in per capita income, demand for ready-to eat convenience food is on a rise in the recent and coming years. There exists potential to develop various functional foods from tuber crops, as unlike fruits, the starch and flour open large avenues for processing, fortification etc. The project is aimed at developing health foods with prophylactic and therapeutic properties, processed foods like pasta and noodles and other value added food products like lacto-pickles from tuber crops.

Studies on functional and speciality food products from tuber crops

Four experiments *viz.,* development of functional sago with high protein or calcium content, development of cassava starch noodles with resistant starch rich cassava starch, development of cereal gain type pasta from cassava and development of sweet potato based functional spaghetti enriched with bioactive pigments were undertaken and the major findings are delineated below:

Development of functional sago with high protein or calcium content

Sago was prepared from cassava starch using its blend with whey protein concentrate (WPC) (90:10; T1) or with WPC and guar gum (89: 10: 1; T2) for protein enhancement. Nutritional analysis showed that T1 and T2 had 8.58% and 8.23% respectively of crude protein, while the commercial sago (C) had only 0.7-0.8% protein. Quantification of the starch fractions indicated that the resistant starch was not significantly different from commercial sago. Nevertheless, the estimated glycaemic index was only 61.6 for test products compared to 63.9 for commercial sago.

Functional sago with calcium content was obtained through fortification of either cassava starch: WPC blends (87.5:10; T1) or cassava starch (97.5%; T2) with 2.5% calcium carbonate. T1 containing WPC had high protein content of 8.23% compared to 0.88% in T2. Calcium content was significantly enhanced in T1 (273 mg/100 g) and T2 (226 mg/100 g) compared to only 78 mg in commercial sago (Fig. 37). Whilst T2 did not differ significantly from commercial sago in its RS content, T1 had only 40% RS indicating a higher digestibility for the same.

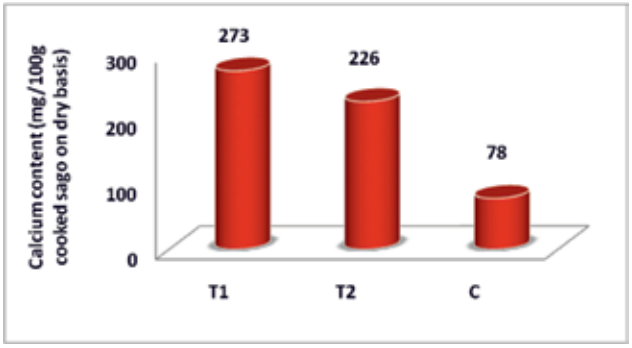


Fig. 37. Calcium content in fortified sago T1: with WPC; T2: without protein source

Development of cassava starch noodles using resistant starch (RS) enhanced cassava starch

Resistant starch rich cassava starch (annealed cassava starch) was added at levels of 50 and 60% respectively to blends of cassava starch: WPC: oil (35: 10: 5; T1) and cassava starch: WPC: oil (25: 10: 5; T2) and the blends were used for making starch noodles. The products (T1 and T2) had significantly higher starch (76.6% in T1 and 80.4% in T2) and protein contents, (9.98% in T1 and 10.16% in T2) when compared to a market sample viz., Foodles (starch 66.17% and protein 8.05%). *In vitro* starch digestion kinetics was monitored from 20 to 120 min and it was found that 60% RS rich starch fortified noodles (T2) had lower digestibility than the other two samples (Fig. 38). The product (T2) exhibited medium glycaemic index (65.2) compared to 68.3 for T1 and 61.8 for Foodles.

Fig. 38. RS enhanced cassava noodles

Development of cereal grain type pasta from cassava

Cereal grain type pasta with significantly low glycaemic index compared to cooked rice was prepared from cassava flour blended with either maida or rice flour. Out of the three formulations tried *viz.,* cassava: maida (70:30, 60:40 and 50:50), the latter only gave reasonably good grain shaped pasta. Cassava: rice based formulations had 9% WPC, 0.5% guar gum and 0.5% common salt in addition to 70:20 (cassava: rice), 60:30 and 50:40 of 50:40 formulation gave good shaped grain pasta (Fig. 39). The *in vitro* starch digestibility of these formulations (cassava: maida 50:50 and cassava: rice 50:40) was lower than cooked rice during 20-120 min digestion period (Fig. 40) and the estimated glycaemic index (EGI) was only 58.69 for cassava: rice pasta compared to 74.17 for cooked (parboiled) rice.

Fig. 39. Cereal grain type pasta from cassava

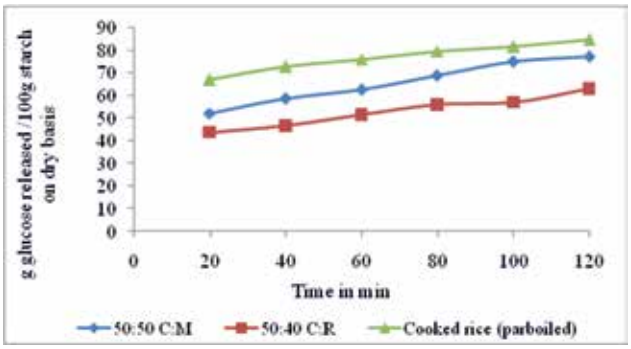


Fig. 40.*In vitro* starch digestibility of grain type cassava: maida and cassava:rice pasta (cooked)

Development of sweet potato flour based functional spaghetti enriched with bioactive pigments

Functional spaghetti was made from blends of sweet potato flour (59%), maida (14%), WPC (10%), NUTRIOSE (15%) and guar gum (1%) along with 1% addition of carotene (T1) (Fig. 41), betanin (T2), anthocyanin (T3) and curcumin (T4).

Blends of pigments *viz.,* carotene + betanin (each at 0.5% levels; T5), betanin + anthocyanin (T6), carotene + curcumin (T7) and betanin + curcumin (T8) were also used for the study. *In vitro* starch digestion kinetics indicated that all the samples exhibited slow and progressive kinetics with only 50-56 g glucose release even after 2 h digestion. Accordingly, all the samples had EGI in the range of 57-59, indicating their medium glycaemic nature.

Fig. 41. Functional spaghetti enriched with carotene

Enhancement of anthocyanin content and recovery in sweet potato and use of bio-colour in functional food product development

Anthocyanin rich sweet potato Acc No. 1468 and S-13 was planted in the field under pot conditions during

December 2013. Three treatments imposed were (1) water deficit stress at 2 months after planting, (2) with N fertilizer (urea), (3) without N fertilizer and (4) control (irrigated). Anthocyanin was extracted by the method of Francis (1989) from the fresh leaves of Accession No. 1468 and fresh tubers of S-13 to study the effect of treatments (Fig. 42).

Anthocyanin content of fresh leaves of plants that did not receive nitrogen was greater (31.83 mg/100g fresh leaf) than that in the leaves of plants which received nitrogen (25.61 mg/ 100g fresh leaf). Anthocyanin content of tuber of ST-13 was greater (106.13 mg/ 100g fresh tuber) than that in leaves of Acc No. 1468 (Fig. 42). Anthocyanin content was greater in water deficit stressed leaves (37.86 mg/100g fresh leaf) than that in the leaves of irrigated plants.

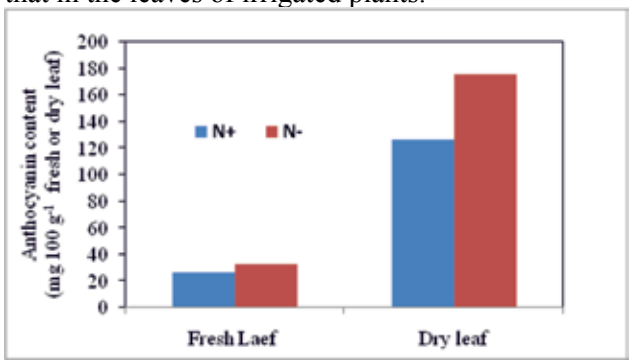


Fig. 42. Anthocyanin content in the leaves of sweet potato Accession No. 1468 which was grown with and without N fertilizer

Probiotics enriched food products from elephant foot yam, yam bean and yams

Preliminary study has shown that a lactic acid bacterium (LAB) *Lactobacillus plantarum* earlier isolated in our laboratory was found to possess amylolytic activity. The α-amylase activity of this strain showed a molecular mass of 75.45 kDa, temperature stability at 35°C, optimum pH 6.0-7.0 for enzyme activity and starch to sugar conversion rate at 56%. This strain was chosen as one of the bacteria in consortium for lacto-pickling.

The other probiotic strains used in the consortium were *L. acidophilus, L. casei and Bifidobacteriun bifidum*. All these strains have desirable attributes such as tolerance to acidic conditions (pH 2.0-6.5), temperature (25-35°C) and salt (5-25%). These four strains were chosen in the consortium for lacto-pickling process. Using the consortium, the protocol/ methodology of lacto-pickling was standardized taking elephant foot yams as the matrix.

INNOVATIVE APPROACHES FOR THE DEVELOPMENT OF TUBER CROPS BASED INDUSTRIAL PRODUCTS

The production and consumption of synthetic polymeric packaging materials are increasing at a phenomenal rate during the last few decades. There is a renewed interest in the development of biodegradable materials made from renewable and natural polymers such as starch. Cassava starch is found to be a suitable candidate for the development of such materials. Cassava starch also has a lot of potential to be used in corrugating adhesives after making suitable modifications of its properties. The development of various starch based industrial products which include biodegradable packaging films and foams, moulded articles and adhesives for paper and corrugating industries are envisaged in this project.

Development of thermoplastic cassava starch composites based biodegradable films and foam type packaging products

Biodegradable films were prepared by using various waxes *viz.,* paraffin wax, microcrystalline wax, bees wax, candelilla wax, carnauba wax and rice bran wax and proteins viz., whey protein concentrate and casein. The wax/protein concentrations were 5, 10 and 15%, whereas starch and glycerol concentrations were 3, 4 and 5% and15, 20 and 25% respectively. The thickness of starch-wax composite films ranged from 0.104 to 0.202 mm, with minimum thickness for candelilla wax based films and maximum for the film containing 5% starch, 10% candelilla wax and 25% glycerol. Among the different waxes, the minimum moisture content (9.68%) was obtained for the composite film containing 4% starch 15% rice bran wax and 15% glycerol and minimum water transmission rate was obtained for carnauba wax composite based films. Among the different films, minimum water transmission rate (9.59×10^{-3}gmm/ cm^2) was obtained for carnauba wax composite based films. In the case of protein based films, thickness of whey protein concentrate (WPC) incorporated film was less than that of casein based film. Rheological characterization of the filmogenic solutions of starch with wax/protein showed low storage modulus, high loss modulus and phase angle indicating dilute solutions, which is suitable for film making by casting method.

Cassava starch was modified with propylene oxide and composite were prepared using the modified starch with carnauba wax, microcrystalline and candelilla wax and glycerol. The films made from starch-candelilla wax-glycerol composites had minimum thickness of 0.117 mm for 3% starch, 5% wax and 20% glycerol and maximum of 0.208 mm for 5% starch, 15% wax and 20% glycerol. There was lot of variation in the moisture content from 9.99% to 20.97%. The whiteness index varied from 33.27 to 39.97 and the solubility values ranged from 20.22 to 32.57%. The low storage modulus and high loss modulus values showed the formation of dilute filmogenic solutions.

Compounding of poly lactic acid/starch was done by a twin screw extruder for both injection grade and film grade polylatic acid (PLA) with native and modified starches by varying the starch concentration up to 40%. Compression moulding of virgin PLA and PLA with 10-30% oxidised starch was performed to obtain preliminary information about the processing characteristics. Injection moulded products were made with 10 and 20% oxidised starch with 5% glycerol composition (Fig. 43). It was difficult to extrude PLA with 10 and 20% native starch, but could be extruded successfully by adding 5% glycerol based on starch content. Modified starch could be added up to 40% for better processability. Twenty percentage modified starch was found to be optimum for injection moulded products and 10% starch with 10% glycerol was optimum for blown film extrusion.

Development of cassava starch based adhesive formulations for corrugation and paper industries

Cassava starch was modified by two chemical methods, viz., oxidization using sodium hypochlorite and acid thinning using sulphuric acid under different conditions to obtain modified starches with suitable pasting properties. The carboxyl content in acid thinned starch was 0.2±0.05 milliequivalents/100g starch. The carboxyl content and carbonyl content of the oxidized starches ranged from 0.6-3.38 milliequivalents/100g of starch and 0.07-0.042% respectively. Based on the preliminary trials and viscosity determination, the oxidized starch with a carboxyl content of 1.4 milliequivalents/100g of starch prepared by treatment of starch with sodium hypochlorite at 5% available chlorine was selected for formulation of various adhesives. Acid treatment was carried out by treating starch with 25% sulphuric acid.

Fig. 43 Injection moulded article (jewellery box) with 20% oxidised starch

Two types of adhesive formulations were prepared from modified starches at different levels of starch solid content, concentrations of sodium hydroxide and disodium tetraborate (borax). Formulation I involved oxidized starch as carrier starch along with a raw cassava starch component. Nine samples were prepared at different level of NaOH and borax and tested for tack, energy and time for fibre tear. The solid content of the formulations varied from 32.4 to 33.1% and the sample with 32% solid content was found to have very good consistency. Higher levels of borax resulted in more solid like consistency, but at higher levels of NaOH, even with high concentrations of borax, flowable consistency could be obtained. Three types of papers were used for testing:VPB Grey Board 340 GSM/17 KG, VPB Grey Board 300 GSM/15KG and WCPM MG PB 300 GSM/17.2KG. The maximum tack and time of fibre tear depended on the type of paper used. The tack of the adhesive formulations ranged from 1.0 to 3.1 kg and it was higher for GB 340 GSM in all cases, followed by PB 300 GSM and GB 300 GSM. The tack, time for fibre tear and energy were higher at medium concentration of borax ie., 1.2%. The tack was higher at lower concentration (1%) and time and energy were higher at medium concentration of NaOH (2%).

Formulation II was a cold corrugating adhesive based on oxidized and acid thinned starches, which do not require a raw starch component. Fifteen different samples were prepared from each modified starch and tested with three types of paper board with 300 and 340 GSM. The solid content of the oxidized starch based formulations ranged from 9.5-17.9%, whereas that based on acid modified starch ranged from 17.4-30.4%. The tack varied from 3.73-10N for various formulations based on oxidized starch and it was in

the range of 3.1-11.1N for the formulations based on acid thinned starch. More solid content with good consistency and high tack could be obtained with acid thinned starch. The tack was significantly higher for the cold corrugating adhesives in comparison to the common adhesive preparations based on carrier starch and raw starch, however, more solid content could be obtained in the latter.

Trials on addition of organic and inorganic chemicals for whitening of starch for industries

Fresh cassava tubers were washed, trimmed, cut into pieces and crushed using mobile starch extraction plant and starch slurry was prepared for treating with chemicals, *viz*., hydrochloric acid, suplhuric acid, acetic acid and citric acid. The pH of the treated starch slurries increased with increase in the number of washings. The starch treated with 15% hydrochloric acid recorded a minimum total colour difference (3.48) with maximum whiteness index (96.05%), whereas those of the industrial starch were 1.8 and 97.91% respectively. The Brookfield viscosity of the starch treated with different acids ranged between 10.63-24.75cP.

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

In India, mostly cassava starch is produced in small and medium sectors using indigenous non-standard equipment. The units are energy intensive and out turn are less with low quality product. The out turn of the starch depends on the efficiency of sieving and settling systems, whereas the colour (whiteness) and appearance of starch depend on the efficiency of starch washing. Therefore, advanced and efficient techniques are required for improving the product quality and quantity. There is also necessity for the development/modification of machineries for pre-harvest operations also. The project envisages the development of machineries for pre and post harvest operations of tuber crops, especially starch processing machineries.

Industrial evaluation of vibro-sieving system in starch industries

The vibro sieving system installed at Ms. T.A.Perumal Sago Industry**,** Salem was evaluated. The machine was operated with 200 litres of starch milk. It was estimated that the capacity of the vibro sieve is about 2400 l h^{-1}. Samples collected from feed and two outlets of the machine were analysed and presented in Fig. 44. The starch content, sugar content and total cyanide content of the samples ranged from 87.2-90.0%, 0.43-0.85% and 0.35-1.00 µg g^{-1} respectively.

In the industry, two final shakers were existing for handling 28,000 litres of starch milk. The frequency of oscillating deck was 250 strokes per minute. Samples were collected from the outlets of the existing final shakers and the results are presented in Fig. 44. The starch content, sugar content and total cyanide content of the samples collected from the two outlet of the sieve shakers ranged from 88.2-89.7%, 0.62-0.84% and 0.35-0.41 µg g^{-1} respectively.

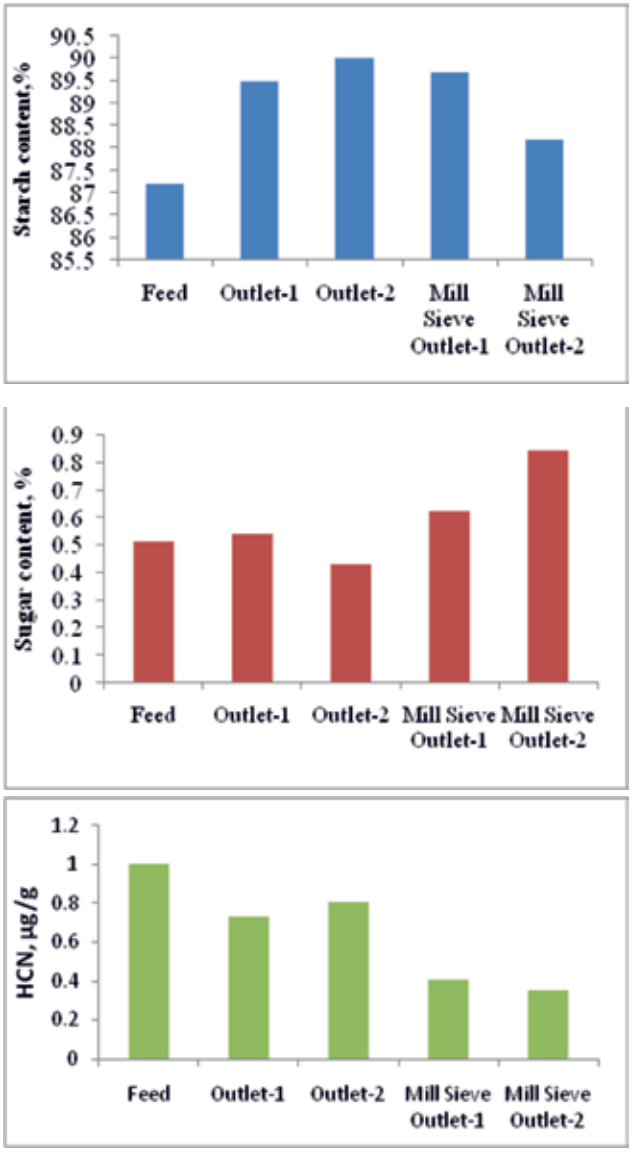


Fig. 44. Starch, sugar and cyanide content of starch slurry collected from the vibro sieve shakers

EXTENSION AND SOCIAL SCIENCES

SECTION OF EXTENSION AND SOCIAL SCIENCES

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

A survey was conducted among the farmers in two districts *viz.,* Nadia and 24 North Parganasof West Bengal on the adoption of recommended cultivation practices of elephant foot yam (EFY) using interview schedule and PRA techniques. The major crops grown in the surveyed districts were rice, banana, vegetables, taro, EFY, mustard, and cauliflower. The EFY was cultivated as a mono crop under irrigated conditions during June-December (Fig. 45). Regarding adoption of improved varieties of EFY, the variety Gajendra has been widely adopted by the framers of both the districts, even though they named the varieties based on the source of seed materials, *viz.,* Bihar and Andhra. The adoption rate of cultivation practices was good in these areas (Table 2). Practices such as selection of seed materials, depth of planting, fertilizer application method and time, intercultural operations were fully adopted by all the farmers. However, land preparation and spacing were adopted by only 60% of farmers and seed size was not adopted as per recommendation. Farmers tend to use bigger size of seed materials of 1-2 kg size.

Fig. 45. Elephant foot yam field in Nadia district

Table 2. Adoption of cultivation practices

Practices	Per cent adoption of recommended practices			
	Full	Partial	Non adoption	Remarks
Land preparation Ridge (height and spacing)	60	40	-	Small pit cum ridge, 90 cm 20-30 cm height
Planting method Selection of seed material Seed size Depth of planting Spacing	100 0 100 60	- - - -	- 100 40	Cautious on diseases 1-2 kgs 20 cm depth 90x90, 90x120, 90x75
Fertilizer application 1. Method 2. Time	100 100	- -	- -	Broadcasting the basal and band application the top
Interculture	100			2-3 times
Seed material production	-	50	-	Traders dependency
Processing	-	-	100	Traders procure all materials
Marketing	100	-	-	Traders procure all materials/ self marketing

It was observed that farmers meet their seed requirement only partially from their produce and depend on traders and other sources for the rest. A major portion of their produce is sold (Fig. 46) and none of the farmers use their produce for any type of processing. In the case of adoption of monetary input recommendations, farmers apply more than the recommended dose of NPK *viz.,*183 kg N, 208 kg P and 225 kg K ha^{-1}. FYM application is partially adopted since the FYM applied in the previous crop was sufficient.

Regarding plant protection also all the farmers adopted plant protection measures, however it was noticed that the quantity of chemicals farmers used was higher than recommended dose.

Fig. 46. Storage of EFY tubers for sales

Strategic popularization of cassava technologies in potential and emerging industrial belts

To identify the most promising cassava clone suited to Maharashtra conditions for industrial and consumption purpose, high yielding, mosaic resistant/tolerant cassava clones were selected for taking up participatory on-farm trials. The selected clones were Sree Athulya, CR 20 A 2, 9 S 127, 2-18, CR 35-8, M 4, Ci 800 and Ci 888. Using these clones, three participatory on-farm trials have been laid out with three replications during August end, one each in Beed, Lolithgaon (Beed district) and Gadegaon (Sangli district) (Fig. 47). The pre-harvest monitoring of the trials were carried out at 5th month stage . The percentage of establishment is given in the Fig. 48.

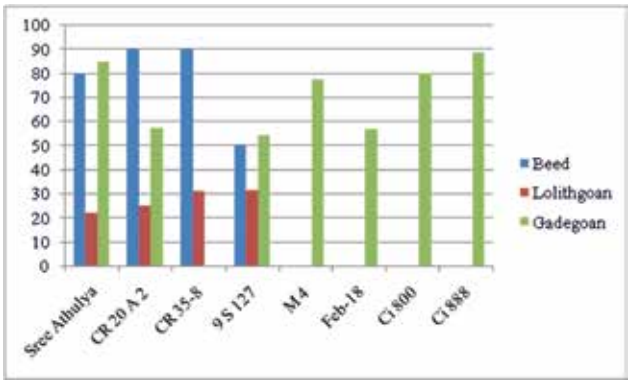


Fig. 47. Establishment of different cassava cultivars/ lines in different places of Maharashtra

Fig. 48. Cassava on-farm trial at Gadegaon (Sangli district)

The CMD incidence was observed only in M4, 2-18, Ci 800 and Ci 888 with less infection (Grade1). There was no pest incidence except scale infestation in Gadegaon in Sree Athulya (Fig. 49). Generally the vigour was good. However, stunted growth was observed in Gadegaon in all the varieties. General observations were, lodging of plants due to thunder shower in Beed; poor establishment, excess irrigation, flowering in CR 20 A 2 line and lodging of some plants in Lolithgaon; stunted growth, but good foliage, flowering in majority of the lines and branching in Sree Athulya.

Fig. 49. Scale infestation in Sree Athulya

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

Tuber crops play a crucial role in the food and nutritional security of the people living in North-Eastern India. Though tuber crops are found in most of the homesteads under multiple cropping systems in this region mainly in Jhum areas, no systematic effort was undertaken to improve the efficiency of these production systems by careful application of improved tuber crops technologies. This project was implemented to enhance the food, nutritional security and livelihood of people in North-Eastern Region by careful application of improved tuber crop production and processing technologies. To start with, the project was implemented in four NEH states namely Manipur, Meghalaya, Tripura and Nagaland (Fig. 50). The project is in operation on partnership mode. The major partner of the project is ICAR Research Complex for NEH region (ICAR NEH) apart from partnership with Agriculture Department, Nagaland and Non-government Organisations which include Ukhrul District Community Resource Management Society, Manipur, Volunteers for Village development, Ukhrui, Manipur, Shiba welfare, Nagaland, Divodhya Krishi Vignan Kendra (Sri Ramkrishna Seva Kendra, Kolkata) . Through the partners the project is executed by 10 implementing centres (Table 3 and Fig. 51- 54).

Fig. 50. Colocasia demonstration in Homestead, Kweng village, Rhiboi district, Meghalaya (Partner : ICAR RC, NEH)

Table 3. Implementing partners-villages adopted by Partners

Sl.No.	States	Partners and Linkages	Adopted villages(main)	No. of farmers participating directly
1	Meghalaya	ICAR RC Umiam	Kweng	10
2.	Meghalaya	ICAR KVK Tura	RongsepKamagre	40
3.	Manipur	ICAR KVK Ukurul	Riha	15
4	Manipur	UDCRMS, Ukhrul(NGO)	Ramva	10
5	Manipur	VVD, Ukhrul (NGO)	Marangphung Lureishimphung	21
6	Nagaland	Agri Department KVK, Mon	Ngangching	12
7.	Nagaland	Agri Department KVK, Mukokchung	Ungma	33
8	Nagaland	Agri Department KVK, Tuensang	Alisopur	15
9.	Nagaland	Shibawelfare , NGO	Jalukie	14
10	Tripura	KVK,DKVK(Ramakrishna) NGO	Boltoli	31

Fig. 51. Taro demo plot under jhum lands in Mukokchung , Nagaland (KVK, Mukokchung)

Fig. 52. Cassava demonstration under jhum lands inUkhrul district, Manipur (VVD, Ukhrul)

Fig. 53. Taro under jhum in Ukhrul(VVDUkhrul)

Fig. 54. Demonstration in Tuensang, Nagaland (KVK, Tuensanag)

Livelihood Surveys

The livelihood surveys on all the adopted villages were completed and a workshop was organized to familarise the partners in the livelihood analysis. Some of the constraints observed during livelihood surveys arelow productivity, lack of quality seed/ planting material, subsistence cultivation, poor pest management, poor post harvest management, marketing, absence of market information, absence of knowledge of technological advances, dissemination of information, lack of proper water management technologies, high rain fall and humidity, inadequate infrastructure, water logging, land erosion and degradation, shifting or Jhum cultivation, tenure system / small operational holdings, lack of authentic up-to-date database, locational disadvantages, absence of risk management system, vulnerability to natural calamities, limited capacity for resource utilization and absence of long term perspective and vision etc

Field demonstration on tuber crops technologies

The main mode of technology dissemination and education on the technology was through field demonstrations in the farmers fields. The technologies included for transfer through field demonstrations are improved varieties of cassava (Sree Vijaya, Sree Jaya and H165), improved variety of greater yam (Orissa Elite), elephant foot yam (Gajendra) and value addition in tuber crops. It was also envisaged to make use of the farmers for production and distribution of planting materials from the seed supplied to them. The seed materials supplied to various states is presented in Table 4.

Table 4. Planting materials supplied under the programme

State	Quantity of planting materials to be sent
Meghalaya	Cassava- 2000 stems, Yams-2500 kgs, Taro- 3150 kgs
Nagaland	Cassava- 4500 stems,Taro- 3150 kgs
Manipur	Cassava- 4500 stems,Taro- 3150 kgs
Tripura	Cassava- 1500 stems,Taro- 1050 kgs Elephant foot yam - 4800 kgs

It was also envisaged to equip farmers with the capacity to adopt value addition technologies of tuber

crops (Fig. 55, 56, 57 and 58). To support the farmers in the area of value addition, stainless cassava chipping machines were supplied one each to all the implementing agencies except KVK of Mukokchung and Tura who received two each as a community input. Similarly, cassava slicers which would help preparation of cassava chips for frying were also distributed two each to all centre. Field demonstrations on the improved varieties were organized with all the participating farmers either in homesteads or jhum area where farmers have demonstrated the varieties on group basis. Likewise, demonstration was arranged on use of chipping machines and cassava slicers to all

Fig. 55. Cassava chipping machine demonstration in Tripura (DKVK, Chebri)

Fig. 56. Cassava slicers demonstration in Pheren district, Jaluki, Nagaland (Shiba welfare, Nagaland)

Fig. 57. Elephant foot yam under homestead in West Tripura District, Tripura (KVK, West Tripura)

Fig. 58. Cassava under jhum in Mon district (KVK, Mon)

Technology support through capacity building programmes.

Various technology support activities like organizing training for farmers, farmer women and field level staff of the partner institutes accompanied by printing, exhibitions, press coverage and distribution of extension publications have been undertaken. Regular field visits were made by the partner staff as well as monitoring of the programme was done by CTCRI scientists. During 2013- 2014, a series of training programmes and workshops were organized which are listed in general section of this report.

Seed materials production by the farmers

Farmers were encouraged to produce seed materials of colocasia, cassava and EFY on buy back arrangements so that the seed materials produced could be distributed to additional participants to be selected in the ensuing seasons. About 5000 kg of seed

materials were made available for the programme. Additional 10 farmers will be included from each of 10 centers by procuring the seed materials produced by the farmers of FLDs.

Performance assessment of demonstrations

The performance of the introduced varieties of cassava, taro, EFY in the demonstration plots were assessed by the partners with the participant farmers through field visits and surveys. In general, it was found that all the varieties could yield better than existing land races. The cooking quality and tolerance to pest and diseases were good. Only in the case of Mukthakesi (Taro), farmers expressed that the yield was slightly less and the tuber size was small. However the variety was liked for its taste, quality and disease tolerance. The information gathered on performance assessment with regard to village adopted in Tripura under the programmes is given in Table. 5.

Table. 5 Performance appraisal of demonstrations in Tripura

Sl. No.	Parameters	Elephant foot yam (Gajendra)	Taro (Muktakesi)	Cassava (Sree Vijaya)
1.	Establishment	> 75%	> 75%	> 75%
2.	Growth	Good	Good	Good
3.	Disease symptoms	Tuber rotting	Nil	Nil
4.	Disease Severity	Very less	0%	0%
5.	Pest incidence	Nil	Nil	Nil
6.	Yield	4kg/ Plant	750 gm/ Plant	3kg/ Plant
7.	Yield comparison	Good	Poor	Good
8.	Shape	Good	Good	Good
9.	Size	Good	Good	Good
10.	Quality	Good	Good	Good
11.	Positiveattributes	Low Acrid, Cooking quality	Low Acrid, Good quality	Best cooking quality
12.	Negativeattributes	-	Poor yield	-
13.	Utilization Food Feed Seed Marketing	 10% Nil 25% 65%	 50% - - 50%	 50% 50% Nil Nil

It could be seen from the table that the introduced varieties established well in spite of the fact that the materials took more than two weeks to reach by trucks to the villages adopted. The growth, disease tolerance, quality and yield were good. The produce was used as food, feed and marketing.

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

Root and tuber crops are indispensable in tribal areas as they play crucial role in food and nutritional security of the tribals. Under Tribal Sub Plan (TSP), systematic efforts were undertaken to improve the productivity of root and tuber crops by careful application of improved technologies.

Three states *viz.,* Chhatisgarh, Jharkhand and Odisha were selected for implementation of Tribal Sub Plan programme (TSP). The primary aim of the programme was to enhance the food security and livelihood through introduction of tuber crops

technologies. All the three states are comprised of hilly and plateau terrain. Ranchi district in Jharkhand, Narayanpur district in Chhattisgarh and Kandhamal and Koraput districts in Odisha, were selected for the present programme. All these districts are dominated by tribals. A total of 205 tribal farmers were selected for conducting 310 demonstrations on tuber crops technologies. High yielding varieties were also introduced as technological interventions. Quality planting materials of greater yam (Orissa Elite) 6000 kg, elephant foot yam 8000 kg, taro (Muktakeshi) 6000 kg, yam bean (RM-1) 100 kg, sweet potato (ST14 and Kishan) 100000 vine cuttings and cassava (Sree Jaya, Sree Vijaya and Vellayani Hraswa) 9000 setts were used for the demonstrations (Table 6). The area covered in all the three states together were 3.0 ha under greater yam, 1.6 ha under elephant foot yam, 3.0 ha under taro, 10 ha under yam bean, 1.25 ha under sweet potato and 0.9 ha under cassava (Table 7).

The cultivation of high yielding varieties of tuber crops like elephant foot yam, greater yam, yam bean, sweet potato, cassava and taro hold promise in the hilly and plateau regions of Odisha, Chhattisgarh and Jharkhand states of India. The study indicated that root and tuber crops play significant role in the improvement of livelihood security and income of tribal farmers.

Capacity building of farmers

Capacities building training programmes were organized for the tribal farmers, three in Ranchi, two in Narayanpur districts and one each in Kandhamal and Koraput districts on root and tuber crops production and value addition (Fig. 59). Two exposure visits for the tribal farmers to the Regional Centre of Central Tuber Crops Research Institute, Bhubaneswar were organized to train the tribal farmers on root and tuber crops production and value addition (Fig. 60). A training programme in "Value addition in tuber crops" was conducted at CTCRI, Trivandrum during March 24 -29, 2014 in which field functionaries of implementing centers were trained.

Table 6. Quantity of planting materials of tuber crops distributed to the tribal farmers

State	Yam (kg)	EFY (kg)	SP (vine cuttings)	Yambean (kg)	Cassava (sett)	Colocasia (kg)
Odisha	4000	2000	100000	50	5000	2000
Jharkhand	1000	3000	-	25	2000	2000
Chhattisgarh	1000	3000	-	25	2000	2000
Total	6000	8000	100000	100	9000	6000

EFY- Elephant foot yam, SP- Sweet potato

Table 7. Area (ha) covered by the tuber crops interventions

State	Yam	EFY	SP	Yam bean	Cassava	Colocasia
Odisha	2.0	0.4	1.25	5.0	0.5	1.0
Jharkhand	0.5	0.6	-	2.5	0.2	1.0
Chhattisgarh	0.5	0.6	-	2.5	0.2	1.0
Total area (ha)	3.0	1.6	1.25	10.0	0.9	3.0

EFY- Elephant foot yam, SP- Sweet potato

Fig. 59. Women farmers with the harvested tubers of greater yam var. Orissa Elite

Fig. 60. Dr. S.K. Chakrabarti, Director, CTCRI distributing certificate to Jharkhand women tribal farmers during their exposure visit to Regional Centre of CTCRI

Generation and applications of statistical and computing technologies for tuber crops resaerch and development

User friendly macros in SAS and R functions for data analysis

A web based interactive tool for tuber crops statistics is being developed using R environment for statistical computing and shiny application (Fig. 61). SAS macros were developed for analysis of variance and path analysis. R programs were developed for creating boxplots, dendrograms and clustering and principal component analysis.

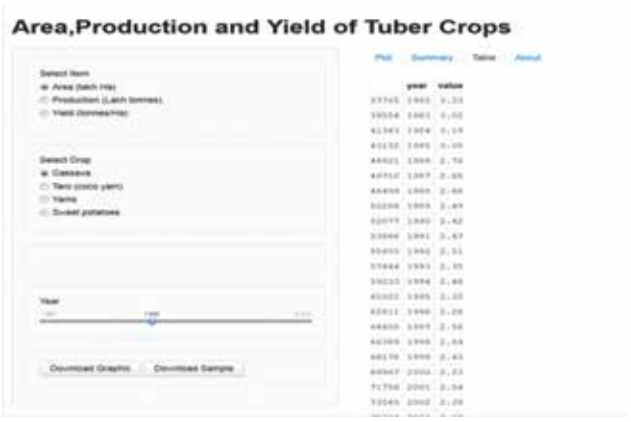


Fig. 61. A web based interactive tool for retrieving tuber crops statistics

Information and Communication Technology (ICT) applications for technology transfer of tuber crops

Tamil version of Tuber Information Café (TIC) was developed and uploaded to CTCRI website http://www.ctcri.org (Fig. 62)

Fig. 62. Tamil version of TIC

An electronic device which will be useful for providing better and realistic agro advisory to the farmers is being developed. Inputs required for the device are different weather and soil parameters. The weather parameters include maximum and minimum temperature, solar radiation/sunshine hours, day length and rainfall. The soil parameters required

for the device are maximum and minimum soil temperature and soil moisture.

Development of online agro advisory system for tuber crops

Elephant foot yam growth simulation model EFYSIM was developed. The model is driven by weather parameters, plant parameters and soil and nutrient parameters (Fig. 63). The software is developed using Visual C++ 6.0. The model is validated with different datasets to compute potential yield and for yield gap analysis

The weather parameters required at daily interval to run the model are:

1. Maximum temperature
2. Minimum temperature
3. Solar radiation and
4. Precipitation

Growth of the crop is calculated in terms of growing degree days (GDD). The temperature specifications of the crop to compute GDD are:

T_{high} - 40^0C

T_{opt}- 25^0C

T_{base} -12.5^0C

Description of the model

Rate of growth of the height of the stem (RHT), girth of the stem (RGIRTH), leaf area index (RLAI) and roots (RRT) are influenced by the weather parameters like temperature (TEMP), solar radiation (SRDN) and precipitation (PPTN). These growth rates under the influence of these weather parameters determine various plant attributes like height of the stem (HT), girth of the stem (GIRTH), leaf area index (LAI) and number of roots (ROOTS) at any point of time. In the initial stages i.e. before sprouting, the dry matter from the planting material/mother corm (MOTHERCORM) only is available for the plant growth. After sprouting when green portions like petiole and leaf area develops, photosynthesis takes place and dry matter will be produced. Dry matter production on each day is calculated as a function of LAI, SRDN as well as some plant attributes like maximum photosynthetic efficiency etc. Dry matter from mother corm will be continued to be used for the growth of the plant as well as the newly produced dry matter. The total dry matter available will be apportioned between leaves (DMLF), petiole (DMHT), roots (DMRT) and new corm (DMNC). For calculating new shoot formation, critical limits in terms of GDD are fixed in the model (Fig. 64).

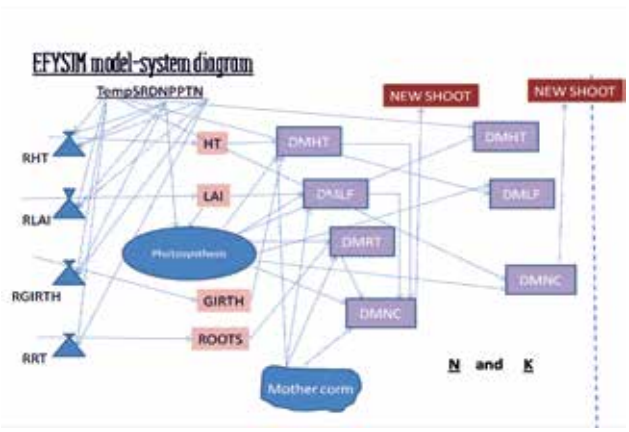


Fig. 63. System diagram of EFYSIM

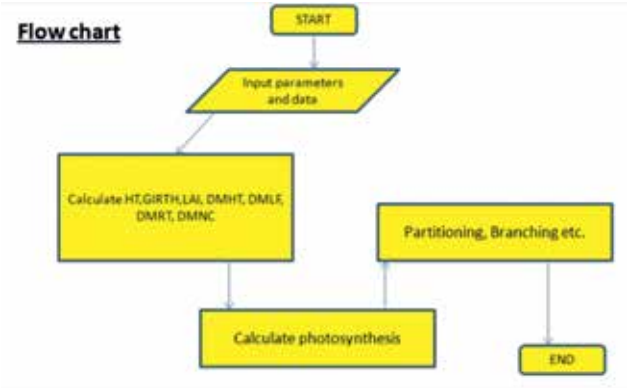


Fig. 64. Flowchart of EFYSIM model

The model was used for computing the potential yield of elephant foot yam at some important growing tracts of India. The results are as follows:

Sl.No.	Location	Potential Yield (t ha^{-1})
1.	Manjali	101 .00
2.	Tirunelveli	97.42
3.	Kakinada	89.70
4.	Elluru	92.06
5.	Howrah	92.06

EXTERNALLY AIDED PROJECTS

1. Adapting clonally propagated crops to climatic and commercial changes : (EU funded International Network for Edible Aroids (INEA), Project on Taro)

A total of 50 exotic lines are being maintained *in vivo* and *in vitro*. The number of lines from different countries is given in Fig. 65. In total 4053 plants were grown and multiplied in field. Among these, 11 lines are stoloniferous, showing slender, elongated, short stolons. Based on tuber types it was found that 10, 35 and 5 lines are of Eddoes, Dasheens-and intermediate types respectively. The lines identified as tolerant and resistant to TLB in 2012 continued to show the same reactions in 2013 confirming the stability of this character. Participatory trials have been conducted in 5 different locations of Odisha with 14 farmers. Tuber yield ranged from 30g/plant to 1000g/plant. Out of the 50 lines, 35 potential lines are identified through evaluation

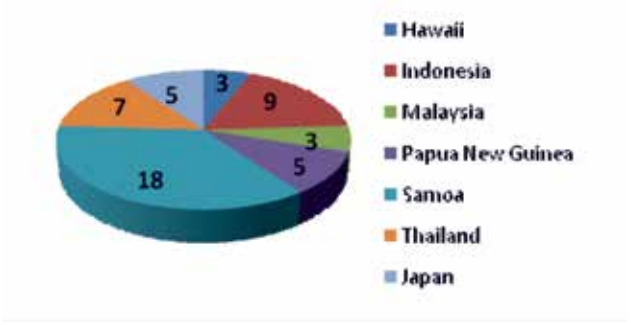


Fig. 65. Exotic lines from different countries

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

The observations of morphological characters of taro and elephant foot yam revealed individual and group distinctness. Such characters are uniform in all replications and briefed crop wise as follows:

Taro

Varietal gene bank was established with 21 varieties. The varieties like BCC-22 & IGCOL-8 showed group distinctness of having 6-10 suckers .The varieties like Jhankri, BCC-35 showed group distinctness of having cup-shaped predominant position of leaves while Panisaru-1, Muktakeshi, Sonajuli having erect apex down position of leaves. Post harvest observations revealed that most of the varieties of eastern region are of eddo types in contrast to dasheen types of eastern, northern, northeastern regions and exotic taro.

Elephant foot yam

In elephant foot yam, gene bank was established with 18 varieties. Sree Athira and Bidhan Kusum showed group distinctness in having smooth pseudo-stem texture. NDA-5 & Gajendra also observed with group distinctness of yellow / yellow green leaflet colour. Gajendra showed individual / unique distinctness of green vein colour, while rest all were having white vein colour. Post harvest tuber morphology showed smooth skin without cormels in Gajendra in contrast to rough skin with varying number of cormels in Sree Padma, Sree Athira and other breeding lines. Draft DUS standards have been prepared for both the crops

3. DUS testing centre for cassava and sweet potato: (PPV & FRA, New Delhi)

Forty varieties (released/reference) in cassava and forty six varieties in sweet potato are being maintained in the field (Fig. 66) and DUS characters were recorded. Supplied the planting materials of released varieties of sweet potato to universities, AICRP centres and to NGOs. Recorded observations on 53 traits for cassava including 9 grouping traits and 34 traits for sweet potato including 7 grouping traits.

In cassava 14 and sweet potato 37 released varieties are being maintained in field and 205 cultures of sweet potato and 35 cultures of cassava are being maintained *in vitro* at Regional Centre. In total, 33 characters of 37 released sweet potato varieties and 26 characters of 14 released cassava varieties have been recorded. Seventeen pre-harvest characters of sweet potato and 11 characters of cassava have been identified and validated for uniformity and stability. The DUS standards have been prepared.

Fig. 66. DUS testing field of cassava and sweet potato

4. Development of eco-friendly technologies for quality cassava production and to safeguard soil health and environment : (Ministry of Environment and Forests, (MOEF) Govt. of India)

A field experiment on eco-friendly weed management in cassava was laid out in split plot design with three varieties viz., H 165, Sree Vijaya and Vellayani Hraswa in main plots and five weed control methods viz., chemical; eco-friendly, mulching using weed control ground cover, hand weeded and unweeded controls in sub plots. Weed flora was dominated by broad leaved weeds viz., *Boerhaavia diffusa*, *Vernonia cineria*, *Emelia sonchifolia*, *Cleome viscosa* and the sedge *Cyperus rotundus*.Varietal effect was not significant. Weed management using weed control ground cover (WCGC) produced the highest yield (25 t ha^{-1}), which was on par with the chemical method using pre-emergence application of oxyfluorfen @ 0.2 kg ha^{-1} (21 t ha^{-1}) and hand weeding (HW) twice as per POP (21 t ha^{-1}). The yield under WCGC was 19% higher than HW. Eco-friendly weed management (18 t ha^{-1}) like mulching with crop residues and green manuring proved to be equally effective as that of chemical method and HW twice. Unweeded plots produced significantly lowest yield (4.1 t ha^{-1}).All the varieties, except Sree Vijaya, responded significantly to WCGC. Sree Vijaya produced significantly higher yield under hand weeding.

5. Soil based plant nutrient management plan for agro-ecosystems of Kerala: (Department of Agriculture, Government of Kerala)

Chemical analysis of 10,348 and 11,605 soil samples respectively of Pathanamthitta and Kottayam districts for pH, organic carbon, available P, K, micronutrients viz., (B, Fe, Cu, Mn and Zn) and 10% samples for Ca, Mg and S were completed and the analytical data were uploaded in the IIITMK website for issuing soil health cards to the concerned farmers. The nutritional status of the soils of Pathanamthitta (PTA) district indicated the soils are strongly to very strongly acidic (4.5-5.5), organic C (>0.75%) and available P (>25 kg ha^{-1}) was very high, exchangeable K medium to high (110-280 kg ha^{-1}), exchangeable Ca sufficient in 77%, Mg deficient in 60% and S sufficient in 90%, B deficient in 56% samples and Fe, Cu, Mn and Zn as sufficient . The nutrient management plan evolved for PTA district indicated the need for application of lime or dolomite, K and B as per POP and skipping or reduction of P (specific to crops). The nutritional status of the soils of Kottayam (KTYM) was extremely acidic to moderately acidic (3.5-6.0), organic carbon (>0.5%) and available K (>110 kg ha^{-1}) as medium to high, available P as very high (>25 kg ha^{-1}), exchangeable Ca as adequate in 61%, Mg deficient in 60%, S adequate in 83% and B deficient in 49% samples and Fe, Cu, Mn and Zn were sufficient. Nutrient management plan prepared for KTYM district indicated the need to apply either lime or dolomite to manage soil acidity and to replenish both Ca and Mg, reduction in the application of P fertilizers and application of B as per POP specific to crops. Preparation and issue of soil health cards to more than 20, 000 farmers, preparation and release of soil based nutrient management plan for 108 panchayats, 17 blocks and 2 districts based on the chemical analytical data provided were undertaken by the Department of Agriculture, Government of Kerala. Field validation trials in selected panchayats on soil test based integrated nutrient management involving organic manures, chemical fertilizers including secondary and micronutrients for selected crops is in progress under the Department of Agriculture, Government of Kerala.

6. Promotion of Sweet potato to increase cropping intensity, livelihood enhancement and nutritional security in coastal saline soils of Erasama block, Jagatsinghpur district of Odisha: (NABARD)

A total of 240 demonstrations were laid out with sweet potato (*cvs* Pusa Safed, Samrat, Kishan, ST-14, CIP-440127 and Sree Bhadra) at farmers' fields under natural saline soils during rabi season of 2010-2013 at 27 villages from 5 Gram Panchayats (Ambiki-71, Japa-3, Gadabishanpur-12, Padmapur-78 and Gadaharishpur-76) of Erasama block, Jagatsinghpur

district, Odisha. The pH in the soils of the demonstration plots (240 Nos.) ranged from 4.08 to 6.83. A total of 123 (51%) soils had < 5.0 pH and only 8 (3%) soils had a pH of > 6.0. Soluble salts (EC) content (1:2.5, soil: water ratio) varied from 1.02 to 4.63 dS m^{-1} with a mean EC of 2.12 dS m^{-1}. Organic C ranged from 0.146 - 1.291% (mean of 0.511%). Out of 240 locations, 55.4, 28.3, and 16.3 per cent soils respectively, were found deficient, medium and high in respect of organic C. Available N varied from 112 to 365 kg ha^{-1} and 226 out of 240 soils were found deficient and only 14 soils had medium status of available N. The available P ranged from 4.24 to 192.64 kg ha^{-1} and majority of soils (65.4%) were found to be high in available P. The available K varied from 56.7-1082.6 kg ha^{-1} (mean 241.0 kg ha^{-1}). Around 45.8, 24.6 and 29.6 per cent soils were found deficient, medium and high status inavailable K, respectively.

A total of 16 Farmers' Clubs have been formed in association with the NGO (SAMADHAN) for implementation of project activities. A Farmers' federation namely 'Janakalyan Farmers' Federation' was formed involving all the farmers clubs to look after the marketing, starch extraction from sweet potato tubers and to maintain the starch extraction unit. Training programmes on 'Sweet potato cultivation for livelihood & food security in saline areas' were organized at Kalabedivill., Padmapur GP on 30.5.2011, at Pimparkanivill., Ambiki GP on 25.5.2012, at Mayurlanjivill., Gadaharishpur GP on 8.6.2012 and at Padmapur, Erasama on 22.6.2013. An average productivity of 8.71 t ha^{-1} was recorded from all the 240 FLDs. Highest tuber yields were observed in Gadaharishpur GP (76 FLDs), that ranged from 2.98 - 23.43 t ha^{-1} with a mean yield of 10.66 t ha^{-1}. Out of 71 FLDs laid out in Ambiki GP, the tuber yields varied from 0.50 - 16.67 t ha^{-1} (mean yield of 6.96 t ha^{-1}). Tuber yields ranged from 1.7 - 23.2 t ha^{-1} (mean 9.52 t ha^{-1}) in Padmapur GP (78 FLDs). Wide variations in tuber yields may be due to variations in salinity build up during crop growth period, nature of salts existing in the soil, native soil fertility, performance of genotype under the saline environment, availability of good quality irrigation water during the tuber initiation, and awareness of the farmers for sweet potato cultivation.

7. Sustainable rural livelihood and food security to rainfed farmers of Odisha (NAIP, ICAR)

The NAIP districts Dhenkanal, Kalahandi and Kandhamal of Odisha comprised of plain, hilly and backward areas. Though agriculture is the main occupation for livelihoods to the large population of this region, the farming has faced serious setbacks due to erratic monsoon, poor irrigation, inadequate supply of inputs and lack of awareness about improved technologies. Tuber crops technologies were introduced in these districts under NAIP project to improve livelihood of the farmers. A total of 208 demonstrations were conducted during the year 2013-14. Elephant foot yam var. Gajendra (25 demo), yam var. Orissa Elite (80 demo), yam bean (50 demo), high yielding sweet potato varieties (30 demo), Orange flesh sweet potato varieties (10 demo) and cassava high yielding varieties (13 demo) were introduced in these districts. Disease free quality planting materials of tuber crops were given for the demonstrations of our proven technologies. Elephant foot yam 1000 kg, greater yam 2000 kg, yam bean 10 kg, sweet potato 2,00,000 vine cuttings and cassava 650 setts were given to the farmers. The crops were harvested and recorded the yield of all the demonstrations. Elephant foot yam (Var. Gajendra) recorded 359 kg tuber per 100 m^2. Greater yam (Var. Orissa elite) registered 420 kg tuber per 200 m^2. The sweet potato tuber yield was in the range of 838-848 kg tubers per 800 m^2. Yam bean recorded tuber yield of 518 kg/300 m^2 and cassava recorded 88 kg/50 m^2.

8. Rehabilitation of existing tissue culture laboratory for micro-propagation of disease free planting materials (State Horticulture Mission, Kerala)

Under the above program, the existing tissue culture lab at CTCRI in block V was renovated and a poly net house for protected raising of planting materials was developed. Over 10,000 stems of cassava, 5 tons of elephant foot yam and 3 tons of yams were produced.

9. Establishment of leaf/ tissue analysis laboratory : (Directorate of Horticulture, Govt. of Odisha under National Horticulture Mission)

Atomic Absorption Spectrophotometer along with cathode lamps for Fe, Mn, Co, Al, Mg, Ni, Cu, Zn, Na, K, Ca, Cd, As, Hg, Ti, Pb, Se, Cr, Mo, V, Bi, Te and indigenous accessories at a cost of 29,803 USD + Rs.

2,35,360/- was procured and installed. Besides this, other equipments like electronic balance, hot plate, refrigerator (300 L) with stabilizer, air conditioner (2.0 T) with 5.0 KVA stabilizer at an amount of Rs. 69950, 18029, 27850 and 36740, respectively.

Extended the analysis facility to the farmers and other agencies/ organizations for analyzing soil and plant samples and generated a revenue of Rs. 34,350/-

10. Tuber crops development scheme: (Department of Agriculture, Government of Kerala)

The objectives of the project are large scale production of clean and disease free planting materials in cassava, yams and elephant foot yam through micropropagation and minisett techniques, demonstration plots of tuber crops for popularization of agrotechniques and new varieties for higher economic returns and to conduct need based and skill oriented training programme to farmers on planting material production, agro techniques and value addition besides exposure visits to research institutes and model farms (Fig. 67 and Fig. 68). Four districts of Kerala state *viz*., Kollam, Palakkad, Malappuram and Kasaragod with a total area of 36 ha and over 600 beneficiaries were covered under the program. The Grama Panchayats covered under the project were Kinanoor (Kasaragod), Mangada (Malappuram), Kootilangadi (Malappuram) and Thazhava (Kollam) with the three tuber crops. The following tribal belt of Attapadi (Palakkad Dist.) *viz.,* Pudur, Agali and Sholayur were also included in the program. Different tuber crop varieties of cassava (Sree Jaya, Sree Vijaya, CTM 806, CTM 815, CTM 818, CTM 820), elephant foot yam (Gajendra) and greater yam (Kovvur-1) were distributed with over 13 training programs and exposure visits of farmers.

Fig. 67. Demonstration on cassava cultivation at Koottilangadipanchayath of Malappuram district

Fig. 68. Training programme on cultivation of Yams at Kinanoor- Karinthalampanchayath of Kasaragod

11. Popularisation of cassava biopesticide against pseudostem weevil, Odoiporus longicollis Olivier (Coleoptera: Curculionidae) in three districts of Kerala: Rashtriya Krishi Vikas Yojana (RKVY).

CTCRI developed biopesticides (*Nanma* & *Menma*) (Fig. 69) were used for treating over 30,000 banana plants in the farmers' fields in three districts of Kerala (Kasaragod, Malappuram and Thiruvananthapuram) against pseudostem weevil (Fig. 70). The data pertaining to growth and yield was recorded. *Nanma* was sprayed at the doses @ 1, 3 and 5% and found no infestation at 3 and 5% treatments. The plants which were not treated with the biopesticide were found infested, however such plants could be saved by injecting the biopesticide *Menma* (Fig. 71). A special needle was also developed for the injection of *Menma*. From the experiments it has been learnt that when the plant attains 4 months age, spraying the pseudostem with *Nanma* @ 30-50 ml per litre can completely control the pest (Fig. 72). In case of the infested plant, injection of 15 ml of the biopesticide *Menma* just 5-8 cm below the feeding point can eradicate the infestation by pseudostem weevil. It was also observed that treatment of the biopesticide could increase the yield, because of enhanced chlorophyll content in leaves

Fig. 69. CTCRI developed biopesticides

Fig. 70. Banana pseudostem weevil

Fig. 71. Spraying of Nanma

Fig. 72. Injecting Menma

12. Novel molecules produced by unique bacteria and their bioactivity: Kerala State Council for Science Technology and Environment (KSCSTE)

From the ethyl acetate extract of Luria Broth (LB) cell free culture filtrate of *Bacillus sp.* strain N associated with *Rhabditis* sp., six proline containing cyclic dipeptides were isolated. The results of the antimicrobial studies of these DKPs assayed against both medicinally and agriculturally important bacterium and fungi showed potent inhibitory properties.

13. Differential plant volatile emission: unfolding the new mechanism of host plant resistance against important insect pests of sweet potato: (DBT)

Thirteen plant volatile compounds were evaluated in Electroantennogram Detector (EAG). Antenna of female *Cylas formicarius* has shown highest depolarization and duration (5.29 mV) to Geraniol, followed by Humulene (2.91 mV, 6.52 Sec), citrial (2.82 mv, 4.82 Sec), ylanglang oil (2.71 mV) and trans-caryophyllene (2.30 mv). The slope for these compounds was highest Geraniol (15.78 mV/Sec) followed by Humulene (11.03 mV/Sec) and Citral (3.49 mV/Sec) indicating that Geraniol and Humulene makes the antennal olfactory receptors to excite for a longer time, thus opening their Na+/K+ ion gates for longer duration, to facilitate maximum absorption of the odour in case of female insects.

Alcohols (cis-3-hexeneol) excited male antenna (4.03 mV) more than female antenna (2.86 mV). Their corresponding aldehydes and acetates have shown lesser response or depolarization of olfactory receptors on insect antenna. This indicates, the alcohols have great influence on insect behavior in diversified ways.

Headspace volatile collection System: A four chamber headspace volatile collection system has been developed with controls on the amount of air pumped in and the amount of volatiles sucked out through installation of Flow meters and Micro diaphragm vaccum pumps. This facility is used for collection of volatiles from sweet potato flowers, tubers, leaves etc. and can be operated at a stretch for 2 days. Lot of demand for these units has come from some NITs and some IITs and other ICAR institutes. This system can be used to collect volatiles from other plants, or any

food product, any diseased plant etc. thus its use is not limited to sweet potato but has broad applications. Repellents for sweet potato weevils (alpha-gurjunene and alpha-humulene) can be used to repel the sweet potato weevils in the crop.

14. AMAAS (Application of microorganisms agriculture and allied sectors) project on Isolation and development of plant growth promoting organisms from high biodiversity region for tropical tuber crops: (ICAR network project)

Potassium containing rock powder and Dolomite ($CaCO_3MgCO_3$) are good carrier materials for potassium solubilizing bacteria and bio control agent (*Trichoderma* spp) respectively as they maintain the viability and efficiency in the bioformulation. Identified the expression of genes of cell wall associated protein and protein associated with biofilm formation with potent K solubilizer, *B.subtilis,* ANctcri3. Identified the expression of genes which are involved in mycoparasitism during interaction of *T. harzianum* and *S.rolfsii.* Soil and tuber treatment of *T. asperellum* and tuber treatment of *T. harzianum* are effective in managing greater yam anthracnose and collar rot of elephant foot yam, respectively with yield enhancement.

15. *Phytophthora, Fusarium* and *Ralstonia* diseases of horticultural and field crops- Taro leaf blight: (ICAR network project on IISR Outreach Programme)

Twenty *Phytophthora colocasiae* isolates have been added to the existing collection from farms of CTCRI for studying yearly variation.The results of the media characterization indicated considerable morphological differences between isolates of *P. colocasiae*. They depicted varying morphology with respect to the different media used. Based on the morphological variation exhibited in PDA medium, isolates of *P. colocasiae* were classified into nine groups (Fig. 73), isolates from the same field/region had similar growth patterns. There was a significant difference in the growth rate of isolates from different morphotypes ($P \leq 0.05$). Isolates depicting cottony and stellate morphology had faster growth rates, while isolates with uniform concentric ring morphology were the slow growers. The remaining isolates had an intermediate growth rate. Culture characteristics of the isolates were performed and isolates were grouped according to morphology. All isolates were confirmed to the species level using specific PCR.

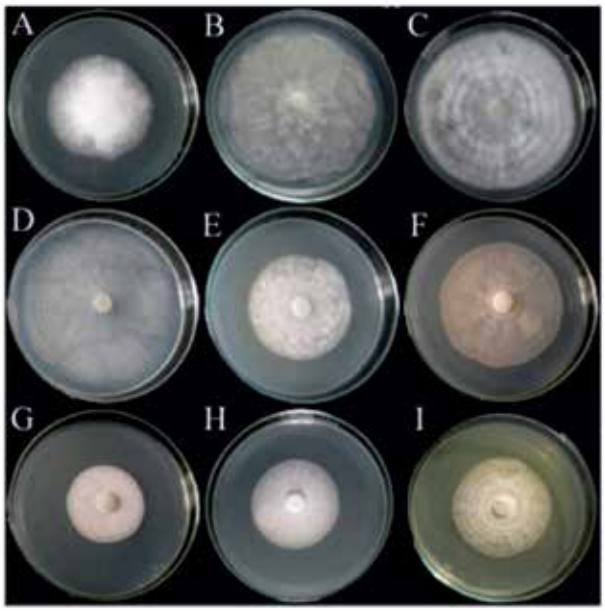


Fig. 73. Nine groups of *P. colocasiae* isolates based on colony texture : **Group A**: Cottony, **Group B**: Stellate, **Group C**: Cottony with concentric rings, **Group D**: Plain with irregular concentric rings, **Group E**: Irregular pattern, **Group F**: Plain, **Group G**: Uniform with concentric rings, **Group H**: Uniform without pattern, **Group I**: Flat with concentric rings.

Genetic diversity analysis was performed using Start Codon Targeted (SCoT) Markers. ScoT analysis was performed as described by Collard and Mackill (2009). Eight pre-screened primers that produced distinct, reproducible bands with high polymorphism were selected for the analysis. A reliable method for pathogen quantification using real-time PCR was standardized. A suitable method for isolation of high quality total RNA was standardized for pathogen and the host. Taro accessions were grouped on the basis of their resistance to *P. colocasiae* using previously standardised *in vitro* assay. Positive amplification was recorded from field symptomatic samples using the designed primers in both conventional and real-time PCR assays. In addition, putative *P. colocasiae* colonies could be isolated from these samples using *Phytophthora* selective media, which were also confirmed through PCR. Plant samples lacking visible symptoms gave negative results in PCR

16. Development of mosaic resistant transgenic cassava: (ICAR Network Project on Transgenic in Crops)

Production of Friable Embryogenic Callus (FEC) from different cassava varieties *viz*. H226, H165,

Sree Vijaya and Sree Sahya were established using different explants (Unopened leaf lobes, embryogenic structures of different stages). The time required for production of FEC initials from H 165 was found to be 3-4 months and for H 226 (Fig. 74) was upto 4-5 months. They were able to regenerate when placed in regeneration medium which confirmed that these FEC are highly potent to develop to a complete plant. The proliferation rate of FEC was very low in H 226 when compared to H 165 and very high in TMS 6044 which was kept as control for all studies. Six week old FEC were used for transformation study. It was also observed that in H 226 variety, even 5 month old embryogenic callus were able to regenerate into complete plant, hence can be used for transformation study. FEC production in other varieties of cassava *viz*., Sree Athulya, Sree Apoorva, Sree Prakash have been initiated and the finding revealed that role of incubation period or the subculture intervals, addition of tyrosine along with picloram are need to be investigated. The FEC transformation protocol was standardized using Aglo/pOYE 153 construct (GUS gene), grown to OD_{600} 0.8-1.0 and the same was used for other Aglohp construct (SLCMV_IC_Syn).

Out of the 4 attempted transformations, 36 putative transformants were maintained in G20 and 5 putative transformants gave positive for *NptII* gene through PCR. But the same gave negative result with specific gene primers. Hence it was inferred that a stringent high selection is required for production of transgenic cassava and a more efficient selectable marker like hygromycin can be used instead of geneticin. Molecular analysis of transgene (hp constructs) in *N.benthamiana* through PCR, RT-PCR and GUS assay were done and, T2 seeds were collected.

17. Development of low glycaemic index noodles from sweet potato and low calorie sago from cassava: (ICMR, Govt. of India)

Effect of legume flour fortification in reducing the glycaemic index of cassava and sweet potato spaghetti

Legume flours are reported to be rich sources of dietary fiber, besides their protein quantity and quality. It was therefore thought worthwhile to investigate how fortification with flours of legumes such as black gram, Bengal gram and green gram affected the glycaemic index of cassava and sweet potato spaghetti. Legume flours were incorporated at 15% level to cassava-maida blends (50:9:13) containing other additives such as WPC (10%), gelatinized cassava starch (5%) as binder, oil (5%) and minor additives like guar gum, ascorbic acid etc. Cooking loss was significantly reduced with legume flours, resulting from the better binding of legume proteins with starch in the pasta. Significant elevation in protein content (14-18%) compared to 9.6% in the control was a major advantage of legume flour fortification. There was also significant reduction in starch digestibility in the case of legume fortified cassava spaghetti. Accordingly RS was significantly elevated with concomitant reduction in EGI.

Effect of pre-treatment of legume flour-starch blends on the starch digestibility of sweet potato spaghetti

Although legume flour fortification could significantly reduce the starch digestibility kinetics and EGI of sweet potato spaghetti, it was found that the EGI could be brought down to a maximum of 56.8 only. Legume flour- sweet potato starch mixes were moistened and exposed to low temperature (Freezer chest of refrigerator) for 24h. This was then used to make pasta to find out whether retrogradation of starch at low temperature facilitated the production of low glycaemic pasta. It was found that all the treatments released significantly lower levels of glucose than the control at all the sampling periods from 20-12 min. When compared to the non-treated set, the treated set had much lower starch digestibility. The reduction in RDS and increase in RS in the pre- treated legume flour based spaghetti was also highly significant, when compared to the non-treated legume flour based spaghetti.

Enhancing the nutritional quality of sweet potato starch noodles through protein fortification

Whey protein concentrate (WPC), with a protein content of 70% and fat content of only 4.32% and characterized by the quality of its protein, was used as the protein source to improve the nutritional value of starch noodles, which was hitherto not attempted by anybody. 10, 20 and 30% protein fortification was done. Nutritional studies showed that significant protein enhancement (10-19%) could be achieved for the fortified noodles, which is beneficial, because for starch noodles, the nutritive value other than energy

was very poor. Resistant starch content was the lowest for the control sweet potato starch noodles and it increased proportionately with the increase in the level of protein.

Enhancing the resistant starch in sweet potato starch/flour noodles using RS enhanced cassava starch

Modification studies on cassava starch to enhance its resistant starch content showed that annealed cassava starch has high RS content of 28.6%. Therefore two types of noodles were prepared by using annealed cassava starch. This included starch noodles, where sweet potato starch was blended with annealed cassava starch and flour noodles where sweet potato flour was blended with annealed cassava starch. Annealed cassava starch was incorporated at two different levels *viz.,* 45 and 50% for the former and 50 and 60% for the latter. It was found that flour noodles released lower level of glucose than starch noodles within the 2 h duration. After 120 min, flour noodles released around 62 and 56 g glucose respectively from the noodles containing 50 and 60% RS enriched cassava starch, whereas starch noodles released 77 and 70 g glucose respectively from the samples containing 45 and 50% RS enriched cassava starch.

Development of resistant starch enriched sweet potato spaghetti using RS rich source, NUTRIOSE and studies related to nutritional, starch digestibility, ultra structural and sensory characteristics

The effect of fortification of sweet potato flour with three levels of NUTRIOSE such as 10%, 15% and 20% was studied to identify the best combination with regard to the low starch digestibility and glycaemic index. Progressively slow release of glucose was observed from the test spaghetti samples up to 80 min digestion, while the rate of digestion was more after 80 min (100 and 120 min samples) for 10 and 15%. Nevertheless, the highest IVSD was observed for 20% NUTRIOSE added set. All the samples had lower starch digestibility than the control

18. Development of a process for the production of low-moist gelatinised dough for using in cassava pappad making machine: (Contract Research-Booster International, Nagercoil)

The process details were collected from commercial *pappad* unit for nutritional and physical evaluation. The ratio of cassava flour and water was standardised. In two different treatments cassava flour was mixed with the solution of pure cassava starch (5, 10 and 15%) and whey protein (5, 10 and 15%) and evaluated for dough consistency

19. Improving the livelihoods of small holder cassava farmers through better access to growth markets (cassava gmarkets): European Commission -Food Security Thematic Programme (EU FSTP)

The process variations in the production of high quality cassava flour in India and Nigeria were recorded. Pressing studies were conducted with the texture analyser and found that 1.2%-5.48% of moisture and starch was removed when 3.5-11.5Kg load was applied. Simulation studies were conducted to optimise shape of cassava chips & gratings, loading density (10 and 15 $Kg.m^{-2}$) and type of drying (open yard and solar yard). Cassavas were converted into chips and gratings. The chips were directly dried under open sun/solar yard with10 and 15 $Kg.m^{-2}$ loading densities. The gratings were pressed at different pressures and holding time and dried in the open sun and solar yard at 10 and 15 $Kg.m^{-2}$ loading densities. The percentages of moisture and starch loss during pressing were 27.1% and 2.90%, respectively. The hourly moisture loss of the chips and grating samples at different loading densities and type of drying were analysed. The starch, sugar, ash and fibre contents of chips varied from 70.31 -80.35%, 0.90-1.73%, 1.75-2.11 and 0.96-1.22%, respectively; and in the gratings varied from 75.0-77.58%, 0.59-1.07%, 1.121-1.44%, 1.58-1.68% and 15.25-30.93%, respectively.

The viscosities of chips measured at 60, 120 and 180 rpm (Brooke field viscometer @2% solution) varied between 75.63-106.7, 50.99-58.33 and 34.42-35.56 cp, respectively. The viscosities of gratings at 60, 120 and 180 ranged between 15.25-30.93, 11.31-19.08, and 9.42-15.47 cp, respectively. The whiteness index values of the Nigerian samples ranged from 89.67-90.17% and viscosities from 32.51-51.52 cp (60-180rpm).

The cassava processing industries in Ghana were visited. Data were collected from the industries producing cassava chips, cassava flour, (*KokonteLafu*),

fermented cassava flour, fermented cassava-corn flour mix (*Banku* mix), wet cassava cake and cassava starch. Samples collected for quality evaluation showed that the HCN level in dried cassava chips was very high (13.2mg.100g^{-1}) than other samples.

20. Refinement of starch indicator developed by CTCRI and design of next generation gadget for measuring starch content of cassava (*Manihot esculenta* Crantz.) Tubers: (DST, Govt. of India)

Electrical properties of cassava tubers such as capacitance, impedance, dissipation factor and phase angle were measured using LCR meter for proximal, middle and distalportions.The analysis showed that the capacitance, impedance, dissipation factor and phase angle of cassava tuber ranged from 1.44-125.73nF, 0.785-3.454, 1.197-212.857 KΩ and -11.739 to -51.259, respectively in the frequency range of 100Hz to 350 KHz, whereas, in the frequency range of 1650 KHz -2650 KHz.the values of capacitance, impedance, dissipation factor and phase angle were found in the range of 57.95-329.44 pF, 2.68-9.958, 91.921-104.76 kΩ and -5.462 to -20.208, respectively.

21 Development, process optimization and characterization of superabsorbent polymers from cassava starch : (DST, Govt. of India)

Rheological properties of superporous hydrogels

The dynamic mechanical properties such as storage modulus, loss modulus and complex viscosity of the starch based superporous hydrogels (SPHs) were determined. Most of the samples showed frequency dependence of the moduli and both storage modulus and loss modulus increased with increase in frequency. In some cases, a crossover point, where G′ was equal to G″, which is termed as the gel point (GP) existed. At the GP, the hydrogel behaved as a concentrated solution. Depending upon the reaction conditions used for synthesis, a range of gels with different gel properties was obtained.

Soil moisture retention capacity of the SAP

The starch based SAP, which has slow and gradual water absorption property was tested in pots containing sandy loam soil, for its effect on soil moisture retention and soil physical properties. The moisture retention in the soil increased with increase in concentration of SAP and even after 30 days of initial watering, there was about 20% of moisture retention in the soil amended with 0.5% of SAP. There was a significant increase in the porosity and water holding capacity of the soil which was added with the polymer.

Biodegradability of starch based SAP

The superabsorbent polymer was tested for biodegradability by burying the film samples in soil and taking the samples at different intervals to determine the weight loss by degradation. After two weeks of burial in soil, the films prepared from the starch based superabsorbent polymer, the % degradability was 30-40% and after 2 months about 50% of the sample degraded. A weight loss of 60% was observed for the saponified starch-g- poly(acrylamide) SAP, after 9 months of degradation. The degradation rate of the SAP was faster in the initial stages. This might be due to the faster degradation of the starch moiety of the polymer. The SAP samples synthesized by suspension polymerization and the superporous hydrogels showed higher rate of biodegradation which could be due to the porous nature of the polymer, which makes the access of microbes easier. In these cases, the sample showed 78% degradation after 5 months of disposal. After 7-8 months of burial about 83% of the polymer was found to be degraded.

22. Participatory development of a web based user friendly cassava expert system : (KSCSTE)

These solutions suggested by the farmers during the interaction with them during the previous year were refined by discussing with the experts. To make these solutions available to the clienteles at one place an online expert system was developed. Major components of the system are explained below.

1. Cassava protector
2. Nutrient management system
3. Online market system
4. Machineries
5. Agro advisory
6. Literature

Sree visakham cassava expert system the online user friendly cassava expert system (Fig. 75) was developed and launched. it is available at the address

http://www.ctcritools.in/cassavaexpert .

Before launching the system some panchayats and industries were visited and the system was demonstrated to them. Their feedback on the system and its different provisions were collected and the system was refined accordingly before it was launched on tuber day, 2013. The panchayats visited were:

1. Chenkal panchayat, Thiruvananthapuram district
2. Elammad panchayat, Kollam district
3. Kadapra panchayat, Pathanamthitta district
4. Manakad panchayat, Idukki district
5. Perinthalmanna, Malappuram district

During this year the cassava based industry Asna Foods, Puthenathani, Malappuram district was also visited. The online buyer-seller forum and other components of SVC (Sree Visakham Cassava Expert System) were demonstrated. All co-operation for this venture was offered by the proprietor.

23. Development of statistical machine learning tools and methods for analysis of microarray gene expression data : (DIT, Govt of India)

Fig. 75. Cassava protector module of SreeVisakham Cassava Expert System

The specific problems which will be addressed in this project were the development of tools for gene selection and reconstruction of gene networks from microarray gene expression data. For this, it is proposed to develop methods and tools based on machine learning techniques for feature subset selection (FSS) and classification in microarray gene expression data. Since the gene expression data does not follow normal distribution and is usually log normal with long tails, a generalized p value method has been developed for gene selection with low false discovery rate. To develop tools for application of the method using the open source R statistical environment, the following functions were created in R.

- R program developed for computing the average and variance of sample.
- R program developed for Gibss sampling for probit posterior distribution
- R program developed for finding generalized p value using theoretical distribution
- R program developed for calculating generalized p-value with shrinkage
- R program developed for random draws from a normal truncated to (left, right)
- R program developed for computing moderated t-statistics along with the p-value
- R program for support vector based classification; The method uses SVM for both classification and for selecting a subset of relevant genes according to their relative contribution in the classification.

Gene expression network

A review on the different methods for gene network reconstruction and the different network visualization tools were carried out. Gene regulatory networks play an important role the molecular mechanism underlying biological processes. Modelling of these networks is an important challenge to be addressed in the post genomic era. We compared most modern approaches for reconstruction of gene regulatory networks. An interactive web based Gene network development tool, RIntGeneNet, was developed in R, the open source environment for statistical computing. It facilitates the construction of gene regulatory networks from microarray gene expression data. In the RIntGeneNet Tool, the input dataset allowed is in .csv format. The user can select the number of genes to be included in the constructed network and the method of reconstruction of the network. R programmes were developed for reconstruction of gene network using four different methods such as BC3NET, ARCANE, Fast pairwise – Mutual Information and PCA-CMI. These methods determine the extent and degree of interaction among the genes. There is an option for downloading the data set as well as the plotted

graph itself. In addition to the plot panel, there are two separate tabs for summary and table respectively. When clicked on the summary tab, the user can view the summary of the Gene expression data. The table view of the dataset can be seen under the Table panel. The dataset and the graph plotted can be downloaded from this tool.

24. Food security through asian roots and tubers (foodstart)- focus site odisha : (CIP-IFAD)

Assessment studies were conducted through house hold surveys, participatory rural appraisal, stakeholders meeting etc. The finding are mentioned below:

General food and root and tuber crops (RTC) consumption pattern and trends

The major RTC in the focus districts is sweet potato. They also grow potato, taro and yams. Some villagers are learning to grow other RTCs like elephant foot yam and cassava. Food grains and pulses form the major constituents of food among villagers. RTCs are also consumed but not in substantial quantities. Potato stands first among all the RTCs consumed. The dependency on RTCs, except potato is mainly seasonal. The period of harvesting of sweetpotato is the peak period of consumption, mainly in January-February. There is need to improve the awareness levels about the nutritional aspects of RTCs and this can improve the RTC intake among the communities.

Markets and value chains of RTCs

Sweet potato is the major RTC which is marketed. There are various agents involved in this marketing chain, ranging from farmers to small traders, middle man and representatives of credit agencies. There are areas where large commercial cultivation of sweetpotato is undertaken to cater to the needs of urban market. There is no major value addition in RTCs, particularly sweet potato. Sometimes, the fresh tubers are crushed and mixed with rice flour or flour made of a mix of rice and pulses for making certain food items. Proper marketing and value addition are the major constraints.

All the value chain studies planned for Odisha, Kerala and Tamil Nadu have been completed. From these results, the following opportunities related to RTC production for intervention and innovation have been identified, (i) Popularisation of OFSP varieties in tribal areas of focus districts, (ii) value addition opportunities for sweetpotato, mainly by product diversification, (iii) production and distribution of quality planting materials, particularly for sweet potato, yams and elephant foot yam.

RTCs productivity and uses

The yield levels of major RTCs are very low, lower than the State/National level yields for which official estimates are available which is due to lack of training among the producers on commercial cultivation of RTCs and non availability of quality planting material.

Knowledge network on RTCs

The knowledge network on RTCs in Odisha are very limited. This is confined mostly to traditional knowledge, about methods of cultivation as well as on benefits of RTC consumption. Absence of knowledge networks related to production, utilization and nutritional status of RTCs is a major problem in Odisha, but at different levels and scales among tribal and non-tribal areas.

Cropping calendar

There are two major types of cropping systems in the focus sites of Odisha. In the oldest and traditional system like *jhum* cultivation, RTCs are grown along with other crops, as in mixed cropping systems. This mainly extends from January-February with the planting, to October-December, the harvesting period. This is confined to hilly areas and in most cases done by community. The second cropping system is mainly in plain lands in sequence with food grains/pulses. The timing is largely dependent on the duration of the crops in the mixed cropping system and the pattern of occurrence of monsoon.

Crop and varietal diversity, availability and uses

The diversity of RTCs, specifically varietal diversity of taro and yams is enormous, especially in the tribal belt. This is grown mainly by indigenous people there and is less documented. With respect to availability, there is a general problem with linking of production centres with centres of consumption mainly to absence of marketing linkages and absence of storage and value addition techniques. The main form of use of RTCs is after boiling or cooking and in fresh form

in the case of cassava. The only form of substantial value addition if any is by making chips out of them after cutting, drying and frying.

Households: occupation, literacy levels

Majority of the (60 % - 80%) households in the focus villages were dependent on agriculture for their livelihood. The dependency on forest produce was also equally important due to the agro-ecological nature of their habitats. The proportion of households dependent on agriculture is lesser than Meghalaya. In recent years, during periods of less agricultural related activities the households are fully engaged in wage employment programmes, which is mostly non-agricultural work. The major wage employment programme of MNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) has been a major contributor to household incomes. The literacy levels in both the focus sites were much lower than the district as well as the State averages.

Household ownership and operational holdings

There were wide differences in the nature of ownership and operational holdings of households within the villages in the focus sites. In sites where indigenous communities are a majority, most of the land is owned by the community and there is no individual ownership of land. The ownership and operational pattern vary with the type of cultivation, crops grown, and the type of communities in particular locations. The nature of land ownership and tenures are more of that of commercial agriculture in the plain areas and traditional in nature in tribal areas.

Input use for RTC cultivation

In the plains where there is relatively more access to markets and institutions involved in technology transfer, modern inputs like fertilizers and plant protection chemicals are used by households who grow RTCs. Even this also is confined to sweetpotato and potato.

Sources of extension services, awareness and problems of RTC cultivation

Extension services are very poor in Odisha. The level of awareness about RTC production, value addition opportunities and options and nutritional qualities of RTCs were very low or almost absent among the households.

Post harvest utilization of RTCs by the cultivator

In Odisha the major form of consumption of tubers is in fresh form or after boiling and roasting. The leaves and stem of taro is used as a vegetable and is cooked along with other vegetables and spices. Cassava leaves and tubers are fed to pigs, in fresh form as well as after boiling.

Income

For majority of the households in Odisha, the major share of income comes from agriculture production. The next important contributor to household incomes is from livestock, particularly pig rearing in tribal districts of Odisha and cattle rearing in plain districts of Odisha. The third important contribution is from non-agricultural labouring out, particularly participation in wage employment programmes which is implemented in the focus sites in Odisha.

25. Intellectual property management and transfer/ commercialization of agricultural technology scheme (up-scaling of existing component i.e. Intellectual Property Rights (IPR) under ICAR Head quarters Scheme on Management of Information Services): (National Agricultural Innovation Project (NAIP) and ICAR)

The unit fosters PPP system and successfully transferred 12 technologies to 27 public/private parties for commercialization. ITMU is the driving force behind CTCRI - SFAC (Small Farmers Agribusiness Consortium) for setting Techno Incubation Centre (TIC) for Agro-processing of tuber crops and make value added products from tuber crops.

Unit association with NRDC promotes Indo-African tuber crops production, processing and marketing technologies. The unit had taken initiative in filing 4 complete patent application and 4 provisional application and 3 copyright applications. As a part of strengthening of IP and technology management, ITMU organized Industry Interface meetings, training/ workshop/seminars etc., related to IP management.

TECHNOLOGIES ASSESSED, TRANSFERRED, CONSULTANCY AND PATENT SERVICES

Technologies transferred

The Institute Technology Management Unit (ITMU) has been active in carrying out following IP activities during the period 2013-14. The unit had engaged with public/private parties for the commercialization of following technologies;

1. Value added fried products and fried chips from tapioca on a consultancy mode to Smt. Beena S. Rajasree, Melathumele, Manikanteswaram P. O, Thiruvananthapuram.
2. Collaborative (contractual) agreement for preparing gelatinized dough for making tapioca papad with M/s Boosters International, 7-72/2, Nedumangadu Road, Aravaimozhi, Kanyakumari Dist, Tamil Nadu.
3. License Agreement for Planting Material Production of Tuber Crops through consultancy with M/s Natura Nursery & Agro products, Mr. Abdul Nabeel P, Meppayur Post, Kozhikode.

Technology transfer for value added fried products and fried chips to Beena S. Rajasree

Agreement with Boosters International products

Agreement with Natura Nursery and Agro products

Patent Services

The unit taken imitative in filing one provisional patent application and three copyright applications.

Provisional application

"Electronic Crop"- an electronic device for providing realistic agro advisory to the farmers

Copyright applications

1. MADHURAM- A sweet potato growth simulation model
2. SPOTCOMS- A sweet potato growth simulation model
3. SIMCAS- A cassava growth simulation model

Technologies developed/in pipeline

Potential tuber crops genotypes

- Sree Athulya and Sree Apoorva, two cassava triploids were recommended for release and cultivation in the states of Tamil Nadu and Andhra Pradesh by Central Sub-Committee on Crop Standards
- Identified 35 potential lines of Taro.
- Salt tolerant genotypes of both white fleshed (Samrat, Pusa Safed, Kishan, Sree Bhadra, Kanchangad) and orange fleshed (ST-14, Gouri, CIP-440127, CIP-SWA-2) sweet potato were transferred to the farmers.
- Salt tolerant sweet potato genotype, Samrat for coastal saline soils.
- K efficient cassava genotypes viz. Aniyoor and 7 III E3-5 for edible and industrial uses respectively.

DUS standards

- Developed draft of DUS standards for taro and elephant foot yam.
- Developed DUS standards for cassava and sweet potato.

Production technologies

- Technology for eco-friendly weed management using weed control ground cover.
- Organic farming technology for dwarf white yam.
- Soil test based INM strategy for cassava comprising FYM, N, P, K, Mg and Zn.
- Integrated Nutrient Management (INM) strategy for sweet potato, colocasia, tannia and yam bean.
- SSNM technologies for sweet potato in saline soils.
- SSNM for elephant foot yam in major growing environments of India.
- Technology for soil moisture conservation and weed control for rainfed hill cassava cultivation.
- Nutrient rich organic manure from cassava starch factory solid waste (thippi) through composting.
- Schedules for application of Zn and Mg in deficient soils have been developed for sweet potato.
- Current and future climate suitability maps of cassava and elephant foot yam in India.

Bio-intensive management

- Management of pseudostem weevil of banana using cassava bio- pesticide.
- Headspace volatile collection system to collect volatiles from sweet potato to use as weevil repellent.
- Dolomite as a good carrier material for *Trichoderma* spp.

Healthy fortified foods

- Resistant starch enriched cassava starch for possible applications in the development of other low glycaemic foods (3 Nos.).
- Low glycaemic spaghetti from sweet potato flour (3 Nos.).
- Low glycaemic noodles from sweet potato starch (1 No.).
- Low calorie sago from cassava (3 Nos.).

Starch based products

- Technology for the production of starch based superabsorbent polymers with fast as well as slow water absorbing properties.
- Process for the production of superporous hydrogels from cassava starch.
- Injection moulded product using poly lactic acid-oxidized starch composites.

User interface

- Developed an online expert system (Sree Visakham cassava expert system)
- RIntGeneNet - A web based gene network development tool.
- Elephant foot yam growth simulation model"EFYSIM".

EDUCATION AND TRAINING

Education

CTCRI is recognized as the research centre by University of Kerala, Kannur University and Manonmaniam Sundaranar University for carrying out Ph. D programmes on tuber crops. During this reporting period, CTCRI offered exposure training to students, Ph. D programmes and project work to M. Sc students. The scientists of CTCRI handled courses at college of agriculture, Vellayani for the students of M. Sc in Integrated Biotechnology.

Particulars of the Programme	Nature and Number of Participants
M.Sc Project work for students	6
Partial fulfilment of M. Sc (Integrated Biotechnology) : KAU	7
Ph.D Programme under the guidance of CTCRI Scientists	31
Sir C. V. Raman Fellowship of DST, Government of India (Dr. Shatrack from Ghana	1

Cassava harvester developed by Dr. Shatrack from Ghana under Sir C. V. Raman Fellowship of DST, Government of India

Trainings organized by CTCRI

- Training to the farmers, development officers and scientists on "Integrated Farming System Involving Tuber Crops" at ICAR Research Complex for NEH Region Tripura Centre, Lembucherra, Agartala, Tripura under AICRPTC on 9 April, 2013.
- Three seminar cum training programmes on "Tuber Crops Technologies" at Ukhrul, Manipur on April 26, 2013 at Jalukie Block, Peren district of Nagaland on 29 July, 2013 and at Khowai, West Tripura on 9 December, 2013 under CTCRI-ICAR-NEH project.
- Two farmers' training programme on 'Package of Practices, Planting Material Production and Value Addition in Tuber Crops' on 6 May, 2013 in collaboration with Ramakrishna Mission Ashram at the Farmers' Training-cum-Exhibition Centre of the organization at Brehbeda, Narayanapur Chattisgarh and at KVK, ICAR, Tura, West Garo Hills, Meghalaya on 22 July, 2013 under institute Tribal Sub Plan Programme (TSP).
- Two one-day training programmes in Ranchi district of Jharkhand in collaboration with Ramakrishna Mission, Ranchi on "Root and Tuber Crops Production and Value Addition. The village training programmes were organized on 13 May, 2013 at Tigranayatoli village and on 14 May, 2013 at Tirlakocha village.

- Training to nineteen batches of farmers on "Tuber Crops and Processing Technologies" and on various activities of CTCRI wherein 515 farmers and 40 officials from Kerala, Karnataka, Uttar Pradesh and Tamil Nadu participated. Training on value added products from cassava was conducted for two entrepreneurs who had taken the technology from CTCRI during 4 - 7 June, 2013.
- Training on 'Sweet Potato Cultivation for livelihood & Food Security in Saline Areas' at Padmapur, Erasama, Jagatsinghpur, Odisha on 22 June, 2013 under NABARD sponsored project 'Promotion of Sweet potato to increase cropping intensity, livelihood enhancement and nutritional security in coastal saline soils of Erasama block, Jagatsinghpur district of Orissa'.
- Coordinated Annual Project Review and Planning Workshop of Food Security through Roots & Tubers (FoodSTART) during 28 -31 August, 2013. It was organized by Regional Centre of CTCRI, Bhubaneswar at Mayfair Lagoon Hotel, Bhubaneswar. The FoodSTART team members from China, Bangladesh, Indonesia, Philippines and India attended the workshop.
- A farmers' seminar cum training at Chebri, Tripura on 12 September, 2013 along with KVK, Chebri. A demonstration on cassava chipping machine and cassava frying using Tuber Chipper was done.
- Exposure visits to Regional Centre of CTCRI for the farmers of Malkangiri, Integrated Tribal Development Agency (ITDA) on 21 September, 2013; Koraput ITDA on 26 September, 2013, Parlekhamundi ITDA on 27 September, 2013; Baliguda and Gunupur ITDA on 28 September, 2013 and Nawrangpur ITDA on 30 September, 2013 under Odisha Tribal Empowerment and Livelihood Programme (OTELP)- CTCRI collaborative RKVY project.

Project Coordinator, AICRP-TC interacting with tribal farmers under TSP at Lohardaga, Jharkand

- Three days training programme for tribal farmers of Jharkhand and Chhattisgarh during 7-9 October, 2013 at Regional Centre of CTCRI, Bhubaneswar under Tribal Sub-Plan.
- A Seminar cum Workshop on 'Promotion of Sweet Potato for Livelihood and Nutritional Security in Coastal Saline Soils of Odisha' at Regional Centre of CTCRI, Bhubaneswar on 9 October, 2013 which was sponsored by NABARD.
- Demonstration on cassava mobile starch unit and cassava chipping at ICAR Research Complex Centre in Imphal, KVK, Ukhrul, Ramva village; VVD, Marangphung village in Manipur during 4-6 December, 2014.
- A farmers' discussion programme in Marangphung village on December 5, 2013 and in Riha village on 6 December, 2013.
- A Consultation meeting on value chain in cassava on 16 November, 2013 at Adoor, Pathanamthitta district, Kerala which was sponsored by CTCRI-CIP New Delhi.
- One day state level workshop was organized in collaboration with PRAVA (NGO) on 27 December, 2013 at the Regional Centre of CTCRI, Bhubaneswar for popularizing orange fleshed sweet potato in Odisha.
- Three days training programme for farmers of Kandhamal and Koraput districts of Odisha state under Institute Tribal sub-plan during 28-30 December, 2013 at Regional Centre of CTCRI, Bhubaneswar.

- Training on tuber crops technologies to eight batches of farmers, students and village level workers at RC, CTCRI, Bhubaneswar wherein 185 farmers and 112 students from Odisha and Ranchi participated.
- Kisan Gosthi and demonstration on mobile starch extraction at Narayanpur, Chattisgarh state during 17-18 January, 2014 under Tribal Sub-Plan.
- Four farmers' training on "Tuber Crops Production and Value Addition" on 19 December, 2013 at Khamara, Dhenkanal Sadar cluster (40 farmers), on 24 December, 2013 at Kabara, Khajuripada cluster (40 farmers), 9 February, 2014 at Amurlapadar, Golamunda cluster (45 farmers) and 10 February, 2014 at Santhapur, Narla cluster (45 farmers).
- Training cum awareness programme on protection of Plant Variety and Farmers Rights Act, 2001 on 11 February, 2014 at CTCRI, Thiruvananthapuram.
- "Advanced Production Technology of Tropical Tuber Crops and their Value Addition" for the farmers of of Assam, during 15 – 21 February, 2014.
- Training on "Value Addition in Tuber Crops" for the officials of KVKs from North East, Bhubaneswar and Thiruvananthapuram during 24-29 March, 2014 at CTCRI Thiruvananthapuram.
- Training programme on value addition of tropical tuber crops to 8 batches of farmers and farm women of Kerala, VFPCK members, NGOS and Entrepreneurs, sponsored by ATMA, Kerala and District Industries Centre, Pathanapuram, Kerala as well as under NEH programme.
- Training and demonstration on processing of tuber crops and post harvest machineries: 3 batches for agriculture officers, veterinary officers, dairy extension officers and technical officers of fisheries CTCRI, ATMA, Kerala
- Training programme and exhibition on processing and post harvest machineries: 4 Tribal farmers of Attappadi, Palakkad, Kerala.

Training programme in Attappadi, Kerala to Tribal farmers

- Two awareness programmes on "Production and Value Addition in Tuber Crops" was conducted for the Tribal farmers of Attappadi, Palakkad, Kerala.
- Four training programmes on value addition and post harvest machineries in tuber crops to the farmers of NEH region of India.

Farmers meet in Tripura (DKVK, Tripura)

Education and Training

Farmers seminar in Tura (KVK, Tura)

Hand on training on value addition at CTCRI

Farmers meet, Jaluki, Nagaland (Shiba welfare)

- Over 100 classes were taken by the scientists of all divisions under different programmes and assignments within and outside institute, benefitting department officials, subject matter specialists, students and farmers from different parts of the country. The topics taught were improved cultivation, agrotechniques, post harvest and value additions, integrated nutrient and pest management strategies, vermicompsost and bio control production technologies, tissue culture etc.

Trainings attended by CTCRI staff

Name	Particulars of the training
Dr. S.K. Chakrabarti	Training on " Agricultural Research Management and Leadership"in USA at Cornell University, Ithaca.
Dr. Dr. M.L. Jeeva Dr. C.A. Jayaprakas	First International Course on "Cassava Withes' Broom Diseases (CWBD)-Diagnostic methods and alternatives for integrated management", at the International Center for Tropical Agriculture (CIAT) from November 18-29, 2013 at Cali, Columbia.
Dr. G. Suja	International Short Course on "Agriculture in Transition: Innovative Approaches to Sustainable Farming" held at Wageningen UR Centre for Development Innovation (CDI) held during 13-24 May 2013 at The Netherlands, fully covered by the Netherlands Fellowship 2013 under the Netherlands Fellowship Programme (NFP).
Dr. V. Ravi	MDP Workshop on "Priority Setting, Monitoring and Evaluation (PME) of Agricultural Research Projects" at NAARM, Hyderabad during 19-23 November, 2013.
Dr. James George Dr. M. Nedunchezhiyan	Training on "Management Development Programme on Leadership Development (Pre-RMP cadre)" at NAARM, Hyderabad during 26 November to 7 December, 2013.
Ms. N. Krishna Radhika	Training on " Advanced genomics techniques for improvements in plant and human health." ICAR sponsored CAFT Training organized by Division of biochemistry, IARI from 15 November -05 December, 2013 for 21 days.

AWARDS/RECOGNITION

Awards

- Dr. S.K. Chakrabarti, Director, CTCRI received the SANGHAMYTHRI AWARD instituted by the Sanghamythry Farmers Producer Co. Ltd, Pallichal, Thiruvananthapuram from Shri. N. Sakthan, Deputy Speaker of Kerala Legislative Assembly.

Director, CTCRI receiving the SANGHAMYTHRI AWARD

- Dr. S. K. Chakrabarti received Dr. S. Ramanujam award for outstanding research/leadership in potato improvement/production for the block year 2008 - 2011.
- Shirly Raichal Anil received the Dr. A. Abraham award for the best paper in the Journal of Root Crops 2012 instituted by the Indian Society of Root Crops for the research paper entitled '*In vitro* propagation strategies for elephant foot yam (*Amorphophallus paeoniifolius* (Dennst.) Nicolson' published in Journal of Root Crops, Volume 37(2), 2012 at the International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT 2013) during 09-12 July, 2013 at Thiruvananthapuram.

Shirly Raichal Anil receiving Dr.A.Abraham award

Best oral presentation awards

- James George, S. Sunitha and C. S. Ravindran received the best oral presentation award for the paper entitled 'Potential and prospects of irrigation in tropical tuber crops' in the International Conference on Water Quality and Management for Climate Resilient Agriculture held at Jalgaon, Maharashtra from 28-31 May, 2013.
- Asha Devi, A., Dersana P. Kurup, Prakash Krishnan B. S. and Sheela M. N. received the best oral presentation award for the paper entitled 'Genetic diversity studies in *Colocasia esculenta* (L.) Schott. assessed by Inter Simple Sequence Repeat (ISSR) markers in the 16th All India Congress on Cytology and Genetics and National Symposium on Gene, Environment and Health held at the Department of Botany, University of Kerala from 22 - 24 October, 2013.
- Asha Devi, A, Pinky Francis, Prakash Krishnan, B. S. and Sheela, M. N. received best oral presentation award for the paper entitled 'Genetic diversity of Kerala landraces of taro (*Colocasia esculenta* (L.) Schott.) assessed by ISSR Markers', in the UGC sponsored National Seminar on New Frontiers in Molecular Biology at Mar Athanasius College, Kothamangalam from 12 - 13 December, 2013.

Best poster awards

- Asha V, Padmaja G, Sheriff J. T., Jeevaratnam K. and Jyothi A. N. for 'Low-calorie sago from cassava' in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.
- Chithra, S., Susan John, K. and Manikantan Nair, M. for 'Thippi compost: a possible avenue for cassava starch factory solid waste management" in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.
- Remya Remesh K. R., Byju, G., Radhakrishnan, T. for 'Impact of 2030 climate on suitability of yams in major growing environments of India' in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.
- Jata, S.K., Lenka, A. and Nedunchezhiyan, M. for 'Evaluation of different nursery techniques in cassava' in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.
- Vidya P, C. Mohan and Aswathy G. H. Nair for 'Phenotypic variations in F1 progenies of CMD resistant mapping population' in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.
- Renjusha Menon, Padmaja, G. and Sajeev, M. S. for 'Nutritional, cooking and starch digestibility characteristics of native and pre-treated legume flour fortified sweet potato spaghetti' in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.
- Archana Mukherjee for 'Antioxidants rich sweet potato (*Ipamoeabatatas* (L.)) and their antimicrobial activity' in the International Symposium on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013) organized during 09-12 July, 2013 at Thiruvananthapuram, Kerala. India.

Best poster awards

- Sheela M. N., Abhilash P.V, SreeKumari, M.T and Asha Devi, A. for 'Genetic improvement of cassava (*Manihot esculenta* Crantz) for yield and starch content through polyploidy breeding' in the 16th All India Congress on Cytology and Genetics and National Symposium on Gene, Environment and Health held at the Department of Botany, University of Kerala from 22 - 24 October, 2013.
- Ganga, G., Jeeva, M. L., Makeshkumar, T. and Hegde, V. for 'IC-RT PCR for the detection of SPFMV using the polyclonal antiserum against cloned and expressed SPFMV-CP protein' in the National Symposium on Pathogenomics for

Diagnosis and Management of Plant diseases, 24-25 October, 2013, CTCRI, Thiruvananthapuram.

- Raji S. Nair., Ravi, V., Saravanan, R., Subhash, N., Makeshkumar, T., Nita, S. and Renju, U.A. for 'Assessing cassava mosaic virus infection in cassava plants using PRI imaging' in the National Symposium on Pathogenomics for Diagnosis and Management of Plant diseases, 24-25 October, 2013, CTCRI, Thiruvananthapuram.
- Vidya, P. Aswathy G. H. Nair, Anjana, R. V. and Mohan, C. for "Identification of CMD resistance associated markers in F1 segregating population of cassava using single marker analysis" in National Symposium on Pathogenomics for Diagnosis and Management of Plant Diseases, jointly organized by CTCRI and Indian Phytopathological Society during 24-25 October, 2013 at Thiruvananthapuram, Kerala, India.
- Rajitha M., Manasa V. G. and Jeeva M. L. for 'Standardization of RNA isolation protocol from greater yam (*Dioscorea alata* L.) tubers' in the UGC sponsored National Seminar-cum-Workshop on Techniques in Biosciences, KKTM College, Kodungallur, Thrissur, 18-19 February, 2014

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 CTCRI for 2013.

- Dr. S. Chandrababu and Mrs. K. S. Sudha Devi: best technical staffs.
- Mr. Kalakar Malik: best administration staff.
- Mr. K.P. Somasekaran – best skilled support Staff.

Institute's best technical staffs award (2013) to Dr.S.Chandrababu and Mrs. K.S.Sudha Devi

Recognition

- Dr. K. Susan John was recognized as a member, in the committee for revision of 'Manual on soil, plant, organic manure and irrigation water' for the soil testing laboratories of the Department of Agriculture, Government of Kerala.
- Dr. Shirly Raichal Anil was awarded Ph. D. degree in Botany by the University of Kerala for the thesis 'Characterisation and assessment of variability in cultivated and wild species of *Amorphophallus* Blume ex Decne.' during May 2013.
- Dr. Asha Devi, Dr, M. L. Jeeva, Dr. A. N. Jyothi, Dr. G. Padmaja, Dr. M. N. Sheela, , Dr. T. Makeshkumar and Dr. S. S. Veena were recognized as guides for M. Sc. (Integrated) Biotechnology – Kerala Agricultural University.
- Dr. C. A. Jayaprakas was awarded the Fellow of Kerala Science Academy by the Chief Minister, Govt. of Kerala.

- Dr. C.A. Jayaprakas, Head, Crop Protection was conferred Karma Shresta Award of the District Library Council, Thiruvananthapuram.
- Dr. T. Makeshkumar was invited as external examiner for evaluating M. Sc. (Plant Science) course papers of CUK on February 19, 2014.
- Dr. Shirly Raichal Anil as external examiner for evaluating M. Sc. (Genetics and Plant Breeding (CSSII) on 25 -26, September, 2013, University of Kerala, Thiruvananthapuram.
- Dr. Asha, K. I as external examiner for evaluating M. Sc (Genetics and Plant Breeding (CSSII) on 16 and 19, November 2013 , University of Kerala, Thiruvananthapuram.
- Dr. Shirly Raichal Anil as a member of expert committee for the purchase of lab equipments for Biotechnology and Model Floriculture centre, Kazhakuttom, Directorate of Agri., Govt. of Kerala, Thiruvananthapuram.

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. CTCRI is also a partner to the CIP-IFAD project on Root and tubes for food security. One Indo-Swiss project on cassava mosaic disease has been approved in 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, MOEF, DIT, UGC and NABARD, Kerala State Planning Board, State Horticulture Mission, 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.

Harvest festival of banana in an RKVY project

Department of Agriculture, Government of Kerala, in collaboration with CTCRI prepared and distributed soil health cards and nutrient management plans at Panchayat, block and district levels based on the soil analytical data generated for the 108 panchayats, 17 blocks and two districts of Kerala viz., Pathanamthitta and Kottayam by CTCRI.

Evaluation of production technologies in the farmer's field

The North East 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.

The Regional Centre established active linkage with OTELP, Bhubaneswar, Directorate of Horticulture, Bhubaneswar, PRAVA and other development agencies for conducting front line demonstration, capacity building, information exchange etc. Under tuber crops development scheme funded by Department of Agriculture, Government 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.

ALL INDIA COORDINATED RESEARCH PROJECT ON TUBER CROPS

Head Quarters

Central Tuber Crops Research Institute
Thiruvananthapuram – 695017, Kerala

All India Coordinated Research Project on Tuber Crops (AICRP TC), functioning since 1968 is the largest national network of tropical Tuber and Root crops covering sixteen states and one Union territory (Andaman and Nicobar Islands). The AICRP TC centres are located in 12 State Agricultural Universities, 4 ICAR Institutions and one Central Agricultural University. The details of the centres and their mandate crop details are mentioned below.

Sl. No.	Name of the coordinating centres	Year of start	Mandate Crops
1	Central Tuber Crops Research Institute, Thiruvananthapuram 695017, 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, 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 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 and yams, sweet potato, elephant foot yam and taro
12	Narendra Dev University of Agriculture and Technology, Faizabad 224 229, U.P.	1987	Sweet potato, taro and elephant foot yam
13	Navsari Agricultural University, Navsari 396 450, Gujarat	1994	Cassava, sweet potato, taro and yams
14	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, Karnatak	2007	Sweet potato and aroids

Achievements of AICRP on Tuber Crops

The mandate of AICRP TC is generating 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 and conservation of genetic resources

One of the major objectives of 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 centers. A total of 4426 accessions of different root and tuber crops were being maintained at different field gene banks in various AICRP- Tuber Crops centers. Maximum accessions of ten tuber crops (1304) were maintained at Dholi. Sweet potato accessions was contributing a major share to the total (1782) followed by taro (783) and cassava (606). The centers are maintaining a total of 965 accessions of *Colocasia* Spp, 246 collections of elephant foot yam and 163 accessions of yam bean. Efforts are being made by different centers to characterize the available germplasm and to obtain IC numbers for the rest of the collections. Molecular characterization of genotypes of taro (20), EFY (18), Sweet potato (45), Swamp taro (15) and yam bean (11) have been done using RAPD, SSR markers at BCKV, Kalyani. Exploration trips were made in Car Nicobar and Harminder Bay and collected 14 germplasm of various tuber crops during the current year. At BCKV, Kalyani, expressed sequence tag-PCR based markers as well as corresponding primers were developed from ESTs and were successfully screened in 70 genotypes of taro. Thirteen SSR were used for screening of elephant foot yam collections and found that 11 primers are suitable for the detection of genetic diversity in EFY. Forty SSR were used for study on the genetic diversity of 100 sweet potato germplasm and distinctive groups of the white, orange and purple fleshed sweet potato have been formed with distinctive characters.

Testing of genetic resources of various agro climatic environments

Under URT on cassava mosaic resistant entries, maximum tuber yield per hectare was recorded in TCMS-7 (41.52 t ha^{-1}) at VR Gudem, TCMS-2 at Yethapur (45.5 t ha^{-1}) and TCMS -5 at Dapoli (42.73 t ha^{-1}). Under MLT on Cassava (2007-1st Year), Out of the six entries evaluated during 2013-14, Me 833 recorded maximum tuber yield at VR Gudem (41.90 t ha^{-1}) and at Yethapur (44.32 t ha^{-1}).

Among the entries evaluated in IET for weevil resistance in sweet potato, TSp-12-4, TSp-12-5 performed well and the marketable yield was significantly high (22.13 and 21.97 t ha^{-1} respectively) at Kalyani. At Dholi, TSP 12-7 recorded lowest weevil infestation (8.6%) with highest marketable tuber yield (15.3 t ha^{-1}) and TSp 12-4 and TSp 12-7 at Rajendranagar. Under MLT in Orange flesh Sweet potato entries, maximum marketable yield was recorded from NFSP-1 (24.20 t ha^{-1}) followed by 1GSP-15 (19.69 t ha^{-1}) at Imphal. Under another MLT on sweet potato, S-1-60 recorded highest marketable tuber yield, harvest index (72.5%) and minimum weevil infestation at Dholi and Rajendranagar.

The MLT of EFY with the promising lines from Coimbatore, Jagdalpur and Kalyani was conducted across the centers and found that AC-14 from Jagdalpur and BCA-3 of Kalyani performed well at Kalyani centre, the Appakudal from Coimbatore gave very small size corms. AC 14 gave highest yield at Kovvur whereas Appakudal local gave maximum yield at Coimbatore.

In taro, TTr 12-2 was found superior in yield (19.74 tha^{-1}) under new IET started during this year at Ranchi. The entry T Tr12-5 recorded the highest weight of cormels (493.16 g /plant) and cormel yield (17.26 t ha^{-1}) at Kalyani, TTr 12-7 at Coimbatore and TR 12-1at Dholi. Under URT, IGB-5 recorded maximum yield at Jagdalpur and BCB-2 at Kalyani. The taro entry AAU Col. 46 recorded highest cormel yield of 19.3 t ha^{-1} and lowest disease incidence (11.3%) in MLT over four locations conducted during 2013-14 at Dholi whereas IG Col E-9 recorded maximum yield at Jagdalpur (24.63 t ha^{-1}). Among all the five

Colocasia entries tested across the centers, RNCA-1 recorded highest cormel yield (13.6 t ha^{-1}) at Dholi, Faizabad and Rajendranagar.

Under IET in greater yam, highest tuber yield was recorded in the entry TGy 12-4 at Udaipur and TGy 12-3 at Kovvur. The entries TGy12-3 and TGy 12-6 performed better at Bhubaneswar and TGy12-5 and Tgy12-7 at Jagdalpur. Under URT, IGDa-2 gave the highest yield at Navsari (12.55 tha^{-1}), IGDa -3 at Jagdalpur (29.67 tha^{-1}) and AAU Da-8 at Jorhat (22.8 tha^{-1}). Highest and significantly superior mean tuber yield of 13.38 tonnes ha^{-1} was recorded in the entry DE-17 at Ranchi under MLT on lesser yam. Maximum yield was recorded in RAU-2 at Jorhat and De 96 at Thiruvananthapuram. Under new IET on aerial yams, TDb 13-10 gave maximum yield at Jagdalpur followed by TDb13- 6 and TDb 13-1. TDb 13-9, 6 and 1 were good yielders at Dapoli and at Ranchi, TDb 13-5 performed better followed by TDb13-1.

BCYB-1 was emerged as the most suitable variety of Yam bean for West Bengal conditions and performed well in terms of tuber yield and harvest index followed by DPH-5 at Kalyani and BCYB-1 may be promoted in W. Bengal for releasing as variety.

The meeting recommended three varieties, two in cassava (Sree Athulya and Sree Apoorva for central release) and one in *Colocasia* (ML- 1 for North Eastern areas) for release.

Taro variety ML-1 recommended
for North Eastern areas

Agro techniques

Experiments on use of cassava leaves for eri silk production at Jorhat revealed that cassava varieties Sree Vijaya and Sree Jaya can be effectively used for rearing of *eri* silkworm. There was additional net income of Rs 41,895/- when sericulture component was included.

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 as 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. The local cultivar exhibited better performance in all aspects like vegetative growth, yield attributes, productivity and harvest index as compared to the Muktakeshi at Kalyani under phenology studies in taro. Phenology studiers in greater yam indicated better attributes of Sree Keerthi compared to local variety at all centres.

Site specific nutrient management studies in cassava indicated that maximum tuber yield was recorded with standard fertilizer dose followed by soil test based application of nutrients. Under SSNM experiment, higher tuber yield and high B/C ratio were obtained in elephant foot yam cv. Gajendra under the treatment where nutrients were applied based on soil test data and at Kalyani, Dholi and Navasari. However this was at par with the application of recommended dose of nutrients.

Under farming system studies involving tuber crops in tribal areas of Port Blair, about 130 kg Elephant foot yam, 48 kg Greater yam and 62 kg Colocasia were obtained from 300 sq.m. Similarly, the average growth of piglets and chicks ranged from 15-16 kg and 1.8-2.0 kg, respectively. Farming system model having different tuber crops at pivotal position with the incorporation of animal, fisheries, horticultural and agronomical components established at Anandapur village of Lohardaga district, in the state of Jharkhand. Recorded the highest B: C ratio of 3.2:1 with elephant foot yam followed by taro (2.25:1) as compared to other crops. Under the crops component Amorphophallus/Zimikand resulted in the highest B:C ratio 3.27 followed by *Dioscorea bulbifera* (3.12), and Colocasia (Bunda) (2.66) as compared to other crops under farming system studies conducted in tribal areas of Jagdalpur. The community pond based farming systems involving tuber crops in tribal

belts of Bhubaneswar produced 19,479 kg of rice equivalent yield and net return of Rs 2,27,980/2.5 ha, whereas rice alone produced 8,960 kg of rice and net return of Rs 91,700/2.5 ha.

Pests and disease management

Planting sweet potato with garlic at 1:1 ratio could reduce the weevil infestation and resulted in higher marketable tuber yield at Kalyani centre. Sweet potato + coriander (1:1) recorded lowest tuber infestation (10.6%) and gave higher marketable tuber yield (17.3 t ha^{-1}) which was at par with chemical spray at Dholi and maximum net profit (Rs. 16920 ha^{-1}) was derived with S.P. + Coriander at 1:1 followed by sweet potato + Garlic at 1:1 ratio (Rs. 16830/ha).

The first season trial on the integrated management of sweet potato weevil showed that application of the components of collection and destruction of crop residues, removal of alternate hosts of SPW, earthing up 30 and 45 DAP, irrigation at weekly interval, and harvest at 105 DAP and the application of bio-pesticide NANMA @ 5% at 15 days was most potential to reduce the weevil damage and increased the tuber yield to 21.10 t ha^{-1} compared to untreated control (15.01 t ha^{-1}) at Kalyani. Application of Nanma @ 5% at 15 days intervals was found equally effective in controlling sweet potato weevil as chemical control at Ranchi. Application of all components along with vine treatment by chlorphyriphos (20 EC) @ 0.02% followed by two round spraying of same insecticide at 30 and 60 days after planting resulted in least infestation by weevils and highest healthy tuber yield at Dholi.

The evaluation of seven coded taro entries against *Phytophthora* blight indicated that TCbl-3 and TCbl-4, TCbl-2 and TCbl-1 are promising against blight disease at Kalyani. The entries viz. TCbl 12-4 and TCbl 12-5 recorded lower level of disease incidence and highest side cormel yield (20.9 t ha^{-1} and 20.4 t ha^{-1}) respectively at Dholi.

The results of the 4th season trial concluded that application of 5% aqueous solution of yam bean seed extract could reduce the population of leaf eating caterpillar in swamp taro and significantly reduced the leaf damage and improved the stolon yield to 24.13 t ha^{-1}at Kalyani. Yam bean seed extract (YBSE) at 5 and 2 per cent proved most efficacious in minimizing aphid population on mustard as against foliar spray of dimethoate @ 0.05% at Dholi.

Planting material production

Altogether the centres have produced 1.66 Lakhs of cassava stems, 382.5 t of elephant foot yam, 6.77 lakhs of sweet potato vine cuttings, 1.99 t of sweet potato tubers, 7.5 tons of taro, and 9.8 Tons of Yams. A total of 2100 kg of elephant foot yam, 1000 setts of cassava and 1000 vine cuttings of sweet potato were multiplied during the current year at CARI.

Research extension interface

The centres were regularly involved in organizing training programmes, conducting demonstrations, participating in exhibitions, radio and television programmes. CARI Conducted two training programmes on "Cultivation of tuber crops and value addition" for Nicobari tribes at Car Nicobar & Harminder Bay. Organized one day farmers' training programme on "Scientific cultivation of tuber crops" with 100 farmer participants in each programme at 4 different Farming System Demonstration Farm under AICRP-TC, CAU, Imphal Centre. Training on post harvest processing and nutrition awareness using tuber crops was given to the women of different self-help groups and tribal community at Kalyani.

13th AGM

The XIII Annual group Meeting of AICR TC for the year 2012-13 was held at AAU, Jorhat during 26 – 28 April, 2013. Dr. K M Bujarbaruah, Hon'ble Vice Chancellor, AAU, Jorhat formally inaugurated the event, which was presided over by Dr. S K Malhotra, Hon'ble Asst. Director General (Hort.), ICAR. The Best Centre Award during 2012-13 was presented to Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal by Dr. N. K. Krishna Kumar, Hon'ble DDG (Hort.), ICAR during the plenary session.

Hon'ble ADG Dr. S K Malhotra releasing a publication on "Post-Harvest Management of Tropical Tuber Crops"

PUBLICATIONS

Papers in Research Journal (National & International Journals)

1. Abhinand, C. S., Santhosh Mithra, V. S. and Sreekumar, J. 2013. An algorithm for plant microRNA target prediction, *J.Root Crops,* **39**(1)**:** 22-27.
2. Anantharaman, M., Ramanathan, S., Sivakumar, P. S., Srinivas, T. and Nedunchezhiyan, N. 2013. Problem diagnosis and research prioritisation of sweet potato in India. *J. Root Crops*, **39**(2): 215-220.
3. Dwivedi, N. K., Indiradevi, A., Asha, K. I., Asokan Nair, R. and Suma, A. 2014. A protocol for micropropagation of *Aloe vera* L. (Indian Aloe) – a miracle plant. *Res. Biotechnol.*, **5**(1): 1-5.
4. Hridya, A. C. and Byju, G. 2014. Effects of microbial inoculations on soil chemical, biochemical and microbial biomass carbon of cassava (*Manihot esculenta* Crantz) growing Vertisols. *Archs. Agron. Soil Sci.,* **60**(2): 239-249.
5. Imas, P. and Susan John, K. 2013. Potassium nutrition of cassava. *International Potash Institute Research Findings, e-ifc*, **34**: 1-2.
6. Jayaprakas, C. A., Ratheesh, S. and Rajeswari, L. S. 2013. Biopesticidal activity of cassava (*Manihot esculenta* Crantz) seed oil against bihar hairy caterpillar (*Spilarctia obliqua*) and cowpea aphid (*Aphis craccivora*). *J. Root Crops,* **39**(1)**:**73-77.
7. Jyothi, A. N. and Suja, G. 2014. Enzymatic debranching of starch: A comparison between cassava and potato starches in relation to structure and resistant starch formation. *Trends in Carbohydrate Res.,* **6**(1)**:** 30-37.
8. Latha, M., Suma, A., Asha, K. I., Dwivedi, N. K., Mani, S. and Indiradevi, A. 2013. Seed polymorphism in South Indian horse gram (*Macrotyloma uniflorum* (Lam.) Verdc.: A comprehensive study. *J. Appl. Biology Biotech.,* **1**(4)**:** 1-6.
9. Laxminarayana, K. 2013. Impact of INM on soil quality, yield, proximate composition and nutrient uptake of sweet potato in alfisols. *J. Root Crops,* **39** (1): 48-55.
10. Laxminarayana, K. and Burman, D. 2013. Location specific nutrient management for sweet potato (*Ipomoea batatas* L.) in saline inceptisols of West Bengal. *J. Indian Soc. Coastal Agric. Res.,* **31** (1): 26-33.
11. Lenka, A. and Nedunchezhiyan, M. 2013. Biochemical composition of two edible aroids. *E-planet,* **10** (2): 39-42.
12. Pandey, M. and Veena, S, S. 2012. Characterization and conservation of edible and medicinal mushrooms of Western Ghats of India. *Indian J. Trop. Biodiv*, **20**(1): 37-44.
13. Mithun Raj, Azim, T., Vishnu S Nath, Senthil @ Sankar, M., Jeeva, M. L. and Vinayaka Hegde. 2013. Molecular Characterisation of *Colletotrichum gloeosporioides* causing anthracnose in *Dioscorea alata* L. based on 18s and ITS rDNA sequence. *Int. J. Biotech. Biochem.,* **9**(3): 319-323.
14. Mithun Raj, Vinayaka Hegde, Jeeva, M. L., Senthil @ Sankar, M., Vishnu S Nath, Pravi Vidyadharan and Archana, P. V. 2013. Molecular diagnosis of *Colletotrichum gloeosporioides* causing anthracnose/ dieback disease in greater yam (*Dioscorea alata* L.). *Archs. Phytopath. Plant Prot.,* **46** (8): 927-936.
15. Mithun Raj., Vishnu Sukumari Nath., Muthukrishnan Senthil alias Sankar., Muthulekshmi Lajapathy Jeeva. and Vinayaka Hegde. 2013. Rapid Isolation of DNA from *Dioscorea* species suitable for

PCR, restriction digestion and pathogen screening. *Archs. Phytopath. Plant Prot.*, **47**(6): 753 - 760.

16. Mohan, C., Shanmugasundaram, P. and Senthil, N. 2013. Simple Sequence Repeat (SSR) markers for identification of true hybrid progenies in cassava. *Bangladesh J. Bot.,* **42** (1): 155-159.

17. Mohan, C., Shanmugasundaram, P., Maheswaran, M., Senthil, N., Raghu, D. and Unnikrishnan, M. 2013. Mapping new genetic markers associated with CMD resistance in cassava (*Manihot esculenta* Crantz) using simple sequence repeat markers. *J. Agric. Sci.*, **5** (5): 57-65.

18. Vishnu, S. Nath., Sankar, M. S., Hegde, V. M., Jeeva, M. L., Misra, R. S., Veena, S. S. and Raj, M. 2013. Analysis of genetic diversity in *Phytophthora colocasiae* using AFLP and RAPD markers. *Ann. of Microbiology*. **64**: 185-197.

19. Vishnu S. Nath, Neetha Soma John, Anjanadevi ,I. P, Vinayaka Hegde, Jeeva, M. L., Misra, R. S., and Veena, S. S. 2013. Characterization of *Trichoderma* spp. antagonistic to *Phytophthora colocasiae* associated with leaf blight of taro. *Ann. Microbiology,*64(1): 185-197

20. Nedunchezhiyan, M. and Sankaran, M. 2013. Cormels and minicorm sett techniques for seed corm production in *Amorphophallus*. *Aroideana,* **36**: 136-145.

21. Nedunchezhiyan, M., Byju, G., Dash, S. N. and Ranasingh, N. 2013. Selected soil enzyme activities, soil microbial biomass carbon and root yield as influenced by organic production systems in sweet potato. *Communs. Soil Sci. Plant Analysis,* **44**(8): 1322-1339.

22. Nedunchezhiyan, M., Sinhababu, D, P. and Sahu, P. K. 2013. Effect of soil amendments and irrigation regimes on minimum tillage planted sweet potato (*Ipomoea batatas*) in rice (*Oryza sativa*) fallows under lowland conditions. *Indian J. Agric. Sci.,* **84** (3): 371–375.

23. Nedunchezhiyan, M. 2013. Crop architecture effects on elephant foot yam (*Amorphophallus paeoniifolius*) productivity and economics under rainfed conditions. *Indian J. Agron.* **59** (1): 122-127.

24. Nishanth Kumar, S., Dileep, C., Mohandas, C., Bala Nambisan and Jayaprakas, C.A. 2014. Cyclo(D-Tyr-D-Phe): a new antibacterial, anticancer, and antioxidant cyclic dipeptide from *Bacillus* sp. N strain associated with a rhabditid entomopathogenic nematode. *J. Peptide Sci.,* **20 :**173–185,

25. Nishanth Kumar, S., Mohandas, C., Bala Nambisan., Sreerag, R. S. and Jayaprakas, C. A. 2013. Cyclo (L -Pro-D-Arg): a new antibacterial and antitumour diketopiperazine from *Bacillus cereus* associated with a Rhabditid entomopathogenic nematode. *Folia Microbiologica,* **58:** 6.

26. Rajasekhara Rao Korada, Swagatika Misra, Naskar, S. K., Bhaktavatsalam, N., Prasad, A, R., Khushboo Sinha, Jayaprakas, C. A. and Mukherjee, A. 2013. Plant volatile organic compounds as chemical markers to identify resistance in sweet potato against weevil *Cylas formicarius*. *Curr. Sci.,* **105** (9): 1247-1253.

27. Ravi, V., Chakrabarti, S. K., Makeshkumar, T. and Saravanan, R. 2014. Molecular regulation of storage root formation and development in sweet potato. *Hort. Rev.,* **42:** 157-206.

28. Regy Johnson and Padmaja, G. 2013. Comparative studies on the production of glucose and high fructose syrup from tuber starches. *Int. Res. J. Biol. Sci.*, **2**(10): 68-75.

29. Santhosh Mithra, V. S., Abhinand, C. S. and Sreekumar, J. 2014. Horoscope algorithm to predict potential yield of cassava. *World Applied Sci. J.,* **30** (3): 341-344.

30. Santhosh Mithra, V. S., Sreekumar, J. and Ravindran, C. S. 2013. Computer simulation of cassava growth: A tool for realizing potential yield. *Archs. Agron. Soil Sci.,* **59**(4): 603-623.

31. Shirly Raichal Anil, Siril, E. A. and Suhara Beevy, S. 2013. Diversity analysis in *Amorphophallus* using isozyme markers, *Int. J. Veg. Sci.*, DOI: 10.1080/19315260.2013.803509.

32. Soudamini Mohapatra, Veena, S. S., Meera Pandey and Deepa, M. 2012. Biodegradation of Gamma-Hexachlorocyclohexane by various *Pleurotus* species. *Pesticide Res. J.,* **24**(2): 212-216.

33. Soumya, B. Nair and Jyothi, A. N., 2013. Cassava starch–konjac glucomannan biodegradable blend films: *In vitro* study as a matrix for controlled drug delivery. *Starch/Stärke,* **65**(3-4): 273–284.

34. Suja, G. and Sreekumar, J. 2014. Implications of organic management on yield, tuber quality and soil health in yams in the humid tropics. *Int. J. Plant Prod.,* **8**(3): 291-310.

35. Suja, G. 2013. Comparison of tuber yield, nutritional quality and soil health under organic versus conventional production in tuberous vegetables. *Indian J. Agric. Sci.,* **83**(11): 35-40.

36. Sunitha, S, Ravi, V., James George and Suja, G. 2013. Aroids and water relations: an overview. *J. Root Crops,* **39**(1): 10-21.

37. Susan John, K., Ravi, V., Sanida Beegum, S, U., Ravindran, C. S., Manikantan Nair, M. and James George. 2014. Recommended nutrient management practices in the carbon sequestration potential of cassava. *Indian J. Fertilisers,* **10(4):** 28-33.

38. Susan John, K., Ravindran, C. S., James George, Manikantan Nair, M. and Suja, G. 2013. Potassium: A key nutrient for high yield and better tuber quality in cassava. *Better Crops South Asia,* International Plant Nutrition Institute, **7**(1): 26-28.

39. Susan John, K., Remya Raj, R. T. and Suja, G. 2013. Dolomite: the best soil ameliorant for tannia in an Ultisol of Kerala. *Indian J. Fertilizers,* **9**(11): 44-55.

40. Swagatika Misra, Rajasekhara Rao Korada and Bijoy Kumar Mishra. 2013. Thermo mediated activity of *Cryptolaemus montrouzieri* Mulsant (Coleoptera: *Coccinellidae*) predating on *Rhizoecusa morphophalli* Betren (Hemiptera: *Rhizoecidae*) on elephant foot yam. *J. Biol. Control,* **27**(3): 225–228.

41. Vishnu S Nath, Vinayaka Hegde, Jeeva, M. L., Misra, R, S., Veena, S.S., Mithun Raj, Suresh, K., Unnikrishnan and Sree S. Darveekaran. 2014. Rapid and sensitive detection of *Phytophthora colocasiae* responsible for the taro leaf blight using conventional and real-time PCR assay. *FEMS Microbiol Lett*, **1–10** doi: 10.1111/1574-6968.12395.

Books

1. Misra, R. S. and Nedunchezhiyan, M. 2013. *Aroids: Opportunities and Challenges.* Allied Publishers Private Limited, New Delhi, 364 p.

2. Nedunchezhiyan, M. and Misra, R. S. 2013. *Tropical Tuber Crops: Production and Value addition*. TSP Series-1, Regional Centre, Central Tuber Crops Research Institute, Bhubaneswar, Odisha, India, 56 p.

3. Nedunchezhiyan, M., Misra, R. S. and Jata, S. K. 2013. *Kandha Pasala Uthpadana ou Mulyajuktha Uthpadan (Odia)*. TSP Series-2, Regional Centre, Central Tuber Crops Research Institute, Bhubaneswar, Odisha, India, 60 p.

4. Ravi, V., Suja, G., Asha Devi, A., Makeshkumar, T., Sajeev, M. S., Veena, S. S. and Santhosh Mithra, V. S. 2013. *Abstract of Papers, International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climate,* 09-12 July 2013, Thiruvananthapuram, Kerala, India, published by ISRC and CTCRI. 271 p.

5. Veena, S. S., Makeshkumar, T., Jeeva, M. L., Chakrabarti, S. K., Adil Hakkim and Leen N Abraham. 2013 (Eds). *Abstract of Papers. National Symposium on Pathogenomics for Diagnosis and Management of Plant Diseases*, 24-25 October, 2013. CTCRI, Thiruvananthapuram. 168 p.

Book Chapters

1. Anantharaman, M., Ramanathan, S., Nedunchezhiyan, M. and Sivakumar, P. S. 2013. Problem diagnosis and research prioritization of taro in India. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi, pp. 357-361.

2. Chakrabarti, S.K. 2013. Tropical tuber crops- an Indian perspective. Souvenir, *International Confernece of Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate,* Indian Society of Root Crops & CTCRI, Thiruvananthapuram, Kerala, India, pp. 56-59.

3. Geetha, K., Susan John, K., Dhanyamol, K., Praveena, N., Radhika, T. A., Manikantan Nair, M., Jibi Joseph., Sherin Paul and Anuroopa, S. 2013. Soil fertility: Kottayam district. In: *Soil Fertility Assessment and Information Management for Enhancing Crop Productivity in Kerala* (Eds. Rajasekharan, P., Nair, K. M., Rajasree, G., Suresh Kumar, P. and Narayanan Kutty, M. C.), Kerala State Planning Board, Thiruvananthapuram, Kerala), pp. 284-304.

4. Jata, S. K., Nedunchezhiyan, M. and Misra, R. S., Quantitative and qualitative variability of elephant foot yam (*Amorphophallus paeoniifolius*) in different locations of Odisha. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi, pp. 82-87.

5. Jayaprakas, C. A., Sreerag, R. S., Harish, E. R. and Ragesh, L. 2013. Biological control of insect pests of tuber Crops. In: *Biopesticides in Sustainable Agriculture- Progress and Potential* (Eds. Opender Koul *et al*), Scientific Publishers (India), pp. 334- 358.

6. Jyothi, A. N. and Antonio J. F. Carvalho. 2013. Starch-g-copolymers: Synthesis, Properties and Applications, In: *Polysaccharide Based Graft Copolymers* (Eds. Kalia, S. and Sabaa, M.W.), Springer-Verlag GmbH, Berlin, Heidelberg, pp. 59-109.

7. Lenka, A., Nedunchezhiyan, M. and Jata, S. K. 2013. Characterization of nutritional value of fresh and processed cormels and corms of taro and elephant foot yam. In: *Proceedings of Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi, pp. 339-343.

8. Mukherjee, A, Nedunchezhiyan, M., Naskar, S. K. and Bala Nambisan, 2013. Recalcitrancy in elephant foot yam: sprouting under *in vivo* and *in vitro*. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied publishers Pvt. Ltd., New Delhi, pp. 263-264.

9. Nair, K. M., Saifudeen, M., Suresh Kumar, P., Narayan Kutty, M. C. and Susan John, K. 2013. Fertility of Soils of Kerala. In: *Soil Fertility Assessment and Information Management for Enhancing Crop Productivity in Kerala* (Eds. Rajasekharan, P., Nair K. M., Rajasree, G., Suresh Kumar, P. and Narayanan Kutty, M. C.), Kerala State Planning Board, Thiruvananthapuram, Kerala), pp. 136-168.

10. Nedunchezhiyan, M. 2013. Utilization and value addition in tuber crops for food and nutritional security. In: *Post Harvest Management of Horticultural Crops for Food and Nutritional Security* (Ed. Swain, S. C), Manglam Publications, New Delhi, pp. 319-332.

11. Nedunchezhiyan, M., Mukherjee, A. and Misra, R. S. 2013. Mass multiplication of elephant foot yam (*Amorphophallus paeoniifolius*) through sprout bud culture. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi, pp. 269-273.

12. Ravi, V., Byju, G., Saravana Raju. and Hridya, A. C. 2013. Method for predicting corm yield per plant in elephant foot yam based on leaf morphological characters. In*: Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi pp. 143-153.

13. Sankaran, M., Nedunchezhiyan, M., Misra, R. S., Damodaran, V. and Suresh Kumar, P. 2013. Biodiversity of *Amorphophallus* spp. and their conservation in India. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd.. New Delhi, pp. 31-55.

14. Senthil Sankar, M., Vishnu S. Nath, Raj Shekhar Misra, Jeeva, M. L., Vinayaka Hegde and Veena, S. S. 2013. Comparison of eliciting activity of culture filtrates from a virulent and a non-virulent isolate of *Phytophthora colocasiae* on taro. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied publishers Pvt. Ltd., New Delhi, pp. 250- 254.

15. Sinhababu, D. P., Nedunchezhiyan, M., Pandey, V. and Sahu, P. K. 2013. Performance of elephant foot yam (*Amorphophallus paeoniifolius*) as an intercrop in rice-fish-horticulture based farming system. In: *Proceedings of the Global Conference on Aroids: Opportunities and Challenges*, Allied publishers Pvt. Ltd., New Delhi, pp. 154-158.

16. Srinivas, T., Nedunchezhiyan, M. and Misra, R. S. Integration of taro markets in India. In: *Proceedings of the Global Conference on Aroids–opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Private limited, New Delhi, pp. 352-356.

17. Sunitha, S. 2013. Performance of ornamental aroid, *Anthurium* in interspaces of mature oil palm plantations of humid tropics. 2013. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi, pp. 214-218.

18. Susan John, K., Remya Raj, R. T. and Suja, G., 2013. Integrated nutrient management strategy for tannia (*Xanthosoma sagittiofolium* L.Schott) in an Ultisol of Kerala, India. In: *Proceedings of the Global Conference on Aroids–Opportunities and Challenges* (Eds. Misra, R. S. and Nedunchezhiyan, M.), Allied Publishers Pvt. Ltd., New Delhi, pp. 170-183.

19. Susan John, K., Manikantan Nair, M., Jibi Joseph, Sherin Paul, Anuroopa, S., Geetha, K., Dhanyamol, K., Praveena, N. and Radhika, T. A. 2013. Nutrient status and soil nutrient management plan for Pathanamthitta district of Kerala. In: *Soil Fertility Assessment and Information Management for Enhancing Crop Productivity in Kerala*. (Eds. Rajasekharan, P., Nair, K. M., Rajasree, G., Suresh Kumar, P. and Narayanan Kutty, M. C.) Kerala State Planning Board, Thiruvananthapuram, Kerala.

Technical Bulletin

1. Laxminarayana, K. 2013. *Sweet Potato for Livelihood and Nutritional Security in Coastal Saline Soils,* Technical Bulletin Series 59, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 28 p.

2. Sivakumar, P. S., Anantharaman, M., Ramanathan, S., Misra, R. S., Laxminarayana, K. and Jha A. K. 2013. *CTCRI Rooting Ahead to North-Eastern Hill India*. Technical Bulletin Series 58, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 32 p.

3. Sivakumar, P. S., Anantharaman, M., Thirugnanvel, A., Ramanathan, S. and Punitha, P. 2014. *Traditional Tuber Crops Food of North Eastern India,* Technical Bulletin Series 57, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, 37 p.

4. Susan John, K., Ravindran, C.S., Manikantan Nair, M. and James George. 2014. *Nutrient Status of Cassava Growing Soils of Kerala.* Technical Bulletin Series 56, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 60 p.

5. Susan John, K., Ravindran, C .S, Manikantan Nair, M. and James George. 2014. *Soil Test Based Fertilizer cum Manurial Recommendation for Cassava Growing Soils of Kerala,* Technical Bulletin Series 56, Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 44 p.

Popular articles

1. Asha Devi, A., Sheela, M. N., Mohan, C., Shirly Raichal Anil and Asha, K. I. 2013. Varietal wealth for enhancing tuber production. *Indian Hort.e,* **58**(3): 12-14.

2. Asha Devi, A., Sheela, M. N., Mohan, C.,

Shirly Raichal Anil and Asha, K. I. 2013. Bhakshya surakshakke kizhangu vila inangal. *Krishianganam*, **18**(2): 11-14.

3. Chakrabarti, S. K**.** 2013. Tubers for socio-economic upliftment. *Indian Hort.,* **58**: 25-27.
4. Ravi, V., Chakrabarti, S.K**.,** Saravanan, R. 2013. Mitigating climate change- reaping bumper harvest of tubers in adverse conditions. *Indian Hort.,* **58**: 34-36.
5. Harish, E. R., Jayaprakas, C. A. and Rajasekhara Rao. 2013. Kizhangu vilakalilae keedaniyanthirathinu paristhithi sougyatha margangal. *Krishianganam*, **18**(2): 25-28.
6. James George, Sunitha, S. and Ravindran, C. S. 2013. Quality planting material of tubers pays, *Indian Hort.,* (ICAR), **58**(3):, 7-11.
7. Jyothi, A. N., Sajeev, M. S.and Padmaja, G. 2013. Promising tubers for industrial revolution. *Indian Hort.,* **58**(3):28-31.
8. Laxminarayana, K. 2013. Vermiculture technology for maintenance of soil quality and sustainable crop production. *Odisha Hort.*, **2**(2): 37-54.
9. Meera Pandey and Veena, S. S. 2012. Gulabi oyster khumb-*Khadyopayogiswadishtdesikhumb* (Hindi). Bagwani, IIHR, Bengaluru, 69.
10. Meera Pandey and Veena. S. S. 2012. Milky Mushroom cultivation. *Agri Clinic* , August, 21-23.
11. Padmaja, G., Sheriff, J .T. and Sajeev, M. S. 2013. Healthy food from tubers. *Indian Hort.,* **58**(3): 18-21.
12. Padmaja, G., Sheriff, J. T. and Sajeev, M. S. 2013. Kizhangu vargangalile ulpannavaividhyavalkaranavum avayude vipanana sadhyathakalum (Malayalam). *Kerala Karashakan,* **15**(2): 35-36.
13. Ravi, V., Chakrabarti, S. K. and Saravanan, R. 2013. Reaping bumper harvest of tubers in adverse conditions. *Indian Hort*. **58**(3) : 34-37.
14. Ravindran, C. S., Sunitha, S. and James George. 2013. Kizhanguvaragangalum nadeelvasthu-kkalum (Malayalam). *Krishiaganam*, **18**(2): 14-18.
15. Ravindran, C .S., Sunitha, S. and James George. Kizhanguvilakalkku kunjan naduthalakal (Malayalam). *Keralakarashakan* (Farm Information Bureau, Department of Agriculture, Govt. of Kerala), May 2013, 20-21.
16. Sajeev, M. S. and Sheriff, J. T. 2013. Marachini vilavotharasaskarana yanthrangal (Malayalam). *Krishiaganam,* **18**(2): 37-39.
17. Sajeev, M. S. and Sheriff, J. T. 2013. Mechanization add value in cassava product. *Indian Hort.*, **58**(3): 48-51.
18. Sheela, M. N. 2014. New varieties of cassava and sweet potato (In Malayalam), *Karshakasree*, January, 2014.
19. Shirly Raichal Anil, Sheela, M. N., Asha Devi, A., Mohan, C., Krishna Radhika, N. and Asha, K. I. 2013. Exploring genetic wealth of tubers for prosperity. *Indian Hort.* **58**(3): 3-6.
20. Sivakumar, P, S., Anantharaman, M., Ramanathan, S., Misra, R. S., Laxminarayana, K. and Jha, A.K. 2013. Technologies to make food and livelihood secured. *Indian Hort.*, **58**(3): 41-44.
21. Sreerag, R. S. and Jayaprakas, C. A. 2014. Major sucking pests infesting stored tubers of elephant foot yam, *Amorphophallus paeoniifolius*. *Kerala Karshakan,* **16**(8): 22-25.
22. Suja, G., Sreekumar, J. and Jyothi, A.N. 2013. Organic tubers for health and wealth. *Indian Hort.*, **58**(3): 15-17.
23. Susan John, K., Laxminarayana, K. and Ravindran, C. S. 2013. Meeting nutrient demand of tubers. *Indian Hort.*, **58**(3): 45-49.
24. Susan John, K. 2013. Integrated nutrient management practices profitable in tropical tuber crops (In Malayalam). *Krishiaganam,* **18**(2): 19-24.
25. Susan John, K. 2013. Tuberous vegetables (Malayalam). *Krishiaganam*, **18**(3): 37-44.

26. Veena, S. S, Makeshkumar, T., Jeeva, M. L. 2013. Kizhanguvarga vilakalile rogangalum avayude niyanthranamargangalum (Malayalam). *Krishiyankanam*, **18**(2):29-34.

Folders/leaflets/pamphlets

1. James George and Sunitha S. 2013. *Rapid multiplication of quality planting materials in tuber crops (Booklet-Malayalam)* published under Tuber Crops Development Project, CTCRI.

1. James George, Sunitha, S. and Ravindran, C. S. 2013. *Cassava (Booklet- Malyalam),* published under Tuber Crops Development Project, CTCRI.

2. James George, Sunitha, S. and Ravindran, C. S. *Elephant foot yam* (Folder), 2013, published under Tuber Crops Development Project, CTCRI.

3. James George, Sunitha, S. and Ravindran, C. S. *Yams* (Folder), 2013, published under Tuber Crops Development Project, CTCRI.

4. Laxminarayana, K., Misra, R. S. and Jata, S. K. 2013, *Unnati pranalire kandamula sasa'* (in Odiya), published under NABARD sponsored project.

5. Sree Athulya and Sree Apoorva - *New Hybrids of Cassava* (Folder) released during ICTRT 2013.

Papers in conferences/proceedings/seminars

1. Abhilash, P. V. and Sheela, M. N. 2013. DUS testing criteria for the protection of cassava varieties in India. International Conference on Tropical Roots and Tubers for sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

2. Abhinand, C. S., Santhosh Mithra, V.S., Makeshkumar, T. and Sreekumar. J. 2013. Identification of micro RNAs in dasheen mosaic virus and the prediction of target regions in *Amorphophallus*. National Symposium on Pathogenomics for Diagnosis and Management of Plant Diseases, held at Thiruvananthapuram, Kerala, during 24-25 October 2013.

3. Alam, S., Euphemia Shylla., James George and Saud, B. K. Aroids and Yams of Assam, 2013. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

4. Anish, T., Anil, Suja, G. and Byju, G., 2013. Organic management impacts on micro-environment and yield in cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

5. Anjana Devi, I. P., Neetha Soma John, Jeeva, M. L., Susan John, K. and Veena, S. S. 2014. Phosphate solubilizing rock inhabiting bacteria from Ponmudi, India. National Seminar on Frontiers in Applied Microbiology held at Annamalai University, Annamalai Nagar, Tamil Nadu on 14 Ferbruary 2014.

6. Archana Mukherjee, Naskar, S. K., Pati K, Misra, R. S., Sahoo, B. K., Chakrabarti, S. K., James George, Vimala, B., Unnikrishnan, M. and Sreekumari, M. T. 2013. Valued traits in genetic resources of tuber crops: ascent to food and nutrition security under changing climate. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

7. Asha Devi, A., Dersana P. Kurup, Prakash Krishnan, B. S. and Sheela, M. N. 2013. Genetic Diversity Studies in *Colocasia esculenta* (L.) Schott assessed by Inter Simple Sequence Repeat (ISSR) Markers. 16th All India Congress on Cytology and Genetics and National Symposium on Gene, Environment and Health, held at the Department of Botany, University of Kerala, Thiruvanathapuram, during 22 - 24 October 2013.

8. Asha Devi, A., Pinky Francis, Prakash Krishnan, B. S. and Sheela, M. N. 2013. Genetic diversity of Kerala Landraces of Taro (*Colocasia*

esculenta (L.) Schott.) Assessed by ISSR Markers. National Seminar on New Frontiers in Molecular Biology held at Mar Athanasius College, Kothamangalam, during 12 - 13 December 2013.

9. Asha Devi, A., Suja, G. and Sreekumar, J. 2013. Analysis of genetic diversity in edible aroids accessions of India based on morphological characters. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July, 2013.

10. Asha Devi, A. 2014. Bio-techniques in crop improvement of tuber crops. National Seminar cum Workshop on Techniques in Biosciences, organized by the Department of Botany, KKTM Govt. College, Kodungallur, during 18-19 February, 2014.

11. Asha, K.I., Dwivedi, N.K., Indiradevi, A. and Asokan Nair, R. 2013. *In vitro* propagation of Chinese Potato (*Solenostemon rotundifolius* (Poir) J.K. Morton) - an important tropical minor tuber crop through axillary shoot bud culture International Conference on Tropical Roots and Tubers for sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

12. Asha, V., Padmaja, G., Sheriff, J .T., Jeevaratnam, K. and Jyothi, A .N. 2013. Low-calorie sago from Cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

13. Aswathy G. H. Nair., Vidya, P. and Mohan, C., 2013. Evaluation of orange fleshed sweet potato genotypes for tuber yield and dry matter content. 23rd Swadeshi Science Congress held at Mahatma Gandhi University, Kottayam, Kerala, during 6-8 November 2013.

14. Aswathy G. H Nair., Vidya, P., and Mohan, C., 2013. Genetic variability studies of sweet potato accessions using Start Codon Targeted (SCoT) polymorphism. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

15. Aswathy, G. H. Nair., Mohan, C. and Vidya, P. 2013. Effects of gibberellic acid, water and sulphuric acid treatment on germination of sweet potato. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

16. Athira, G. K. and Jyothi, A. N, 2013. Octenyl succinate starch as a controlled release carrier for the drug theophylline. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

17. Athira, G, K. and Jyothi, A. N., 2012. Synthesis of starch nanoparticles (SNP) - different approaches. National Seminar on Frontiers in Chemistry (NSFC-2012) held at Department of Chemistry, University of Kerala, Thiruvananthapuram, during 25-27 April 2012.

18. Bhubaneswari, S., Manonmani, R., Janavi, G., Pugalendhi, L., Dasguptan, I., Makeshkumar, T. and Rabindran, R. 2013. Production of virus free planting material through meristem tip culture and mass multiplication in cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

19. Byju, G., Hridya, A. C., Suchitra, C. S. and Sabitha Soman. 2014. Geoinformatics for precision nutrient management of crops at field scale. 27th National Convention of Agricultural Engineers, held at Thiruvananthapuram, Kerala, during 22-23 February 2014.

20. Byju, G., Sabitha Soman, Remya Remesh, K. R. and Vani, M. 2013. Impact of 2030 climate on suitability of yams in sub–Saharan Africa

and Asia. Yams 2013 (First global conference on yam), held at Accra, Ghana, IITA, Nigeria, during 3-6 October 2013.

21. Chithra, S., Susan John, K. and Manikantan Nair, M. 2013. Management of cassava starch factory solid waste (thippi) through composting to a nutrient rich organic manure. International Conference on Ecosystem Conservation, Climate Change and Sustainable Development, held at Thiruvananthapuram, Kerala, during 3-5 October 2013.

22. Chithra, S., Susan John, K. and Manikantan Nair M., 2013. Thippi compost: A possible avenue for cassava starch factory solid waste management. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

23. Deepthi, D. C., Makeshkumar, T., Unnikrishnan, M., Chakrabarti, S. K. and Winter, S. 2013. Relationship between cassava mosaic disease symptom expression and viral load in recovery phenotypes of cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

24. Dhanya Jayaseelan, Beena, M. R., Winter ,S., Makeshkumar, T. and Chakrabarti, S. K., 2013. Development of resistance against Sri Lankan Cassava mosaic virus in Nicotiana benthamiana using hairpin RNA constructs International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

25. Dwivedi, N .K., Asha, K. I., Asokan Nair, R., Indiradevi, A. and Suma, A. 2013. Collection and conservation of genetic resources of tropical root and tuber crops for sustainable livelihood. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

26. Ganga, G., Jeeva, M. L., Makeshkumar,T. and Hegde, V., 2013. IC-RT PCR for the detection of SPFMV using the polyclonal antiserum against cloned and expressed SPFMV-CP protein. National Symposium on Pathogenomics for Diagnosis and Management of Plant Diseases, held at CTCRI, Thiruvananthapuram, during 24-25 October 2013.

27. Gayatree Priyadarshinee, Archana Mukherjee. and James George. 2013. High starch, low sugar yielding sweet potato genotypes and their micro propagation. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

28. Hridya, A. C. and Byju, G. 2013. Balanced fertilizer application on tuberous root yield of four cassava *(Manihot esculenta* Crantz) cultivars. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

29. Hridya, A., C. and Byju, G. 2013. Validation of site specific nutrient management for cassava (*Manihot esculenta* Crantz) at village level. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

30. James George. and Sunitha S. 2013. All India Coordinated Research Project on Tuber crops: a unique mechanism for the dissemination of new varieties and technologies. In: Souvenir, International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

31. James George., Sunitha, S. and Shiji, R. 2013. Rapid production of disease free planting material in cassava: a success story from India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under

Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

32. James George, Sunitha, S. and Ravindran, C. S., 2013. Potential and prospects of irrigation in tropical tuber crops. International Conference on Water Management for Climate Resilient Agriculture, held at Jalgaon, Maharashtra, India during 28-31 May 2013.

33. Jata, S, K., Lenka, A. and Nedunchezhiyan, M. 2013. Evaluation of different nursery techniques in cassava, International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

34. Jeeva, M. L., Dhanya Jayaseelan, Rajitha, M., Makeshkumar, T. and Vinayaka Hegde, 2013. *In vitro* approaches to manage yam mild mosaic virus (YMMV) in greater yam. Yams 2013 (First Global Conference on Yam) held at Accra, Ghana, during 3-6 October 2013.

35. Jeeva, M. L., Veena, S. S. and Dyna, N. 2014. *Trichoderma asperellum*- An efficient biocontrol agent for greater yam anthracnose management. National Seminar on Frontiers in Applied Microbiology, held at Annamalai University, Annamalai Nagar, Tamil Nadu, on 14 February 2014.

36. Jeeva, M. L., Veena, S. S., Nedunchezhiyan, M., Jyothi, A. N. and Sreekumar, J. 2013. Characterization and management of greater yam anthracnose in India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

37. Jyothi, A. N., Sajeev, M. S. and Susan John, K. 2013. Cassava starch based novel biomaterials for agricultural, food and pharmaceuticala Applications. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

38. Jyothi, A. N. 2013. Resistant Starch: An overview on its functional properties and importance in human nutrition. National Seminar on Emerging Trends in Chemical Sciences held at Department of Chemistry, University of Kerala, Kariavattom, Trivandrum, during 29-31 May 2013.

39. Kamala, S. and Makeshkumar, T. 2013. Rapid detection of dasheen mosaic virus in elephant foot yam by reverse transcription loop mediated isothermal amplification. National Symposium on Pathogenomics for Diagnosis and Management of Plant diseases, held at CTCRI, Thiruvananthapuram during 24-25 October 2013.

40. Kamala, S. and Makeshkumar, T. 2013. Large scale *in vitro* multiplication of *Amorphophallus paeoniifolius.* International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

41. Kamala, S., Makeshkumar, T., Chakrabarti, S. K. and Winter, S. 2013. Diagnosis and characterization of Dasheen mosaic virus in *Amorphophallus paeoniifolius* using molecular techniques. International Conference on Tropical Root and Tubers for Sustainable Livelihood under Changing Agro- Climate, held at Thiruvananthapuram, during 09-12 July, 2013.

42. Krishna Radhika, N. 2013. *In vitro* micro propagation of CMD resistant cassava clones. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

43. Krishna Radhika, N., Sheela, M, N., Asha Devi, A., Sreekumar, J., Makesh Kumar, T. and Chakrabarti, S. K. 2013. Gene modification for designer starch from cassava. National Seminar on GM crops: Prospects and Issues held at Kerala Agricultural University, Vellanikkara during 17-18 March 2014.

44. Lakshmi, B. K. M., Dilip Babu, J., Reddy, R. V. S. K. and James George. Climate effect on taro (*Colocasia esculenta*) yield and leaf blight disease in Southern India. International Conference on Tropical Roots and Tubers for sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

45. Lenka, A., Jata, S. K. and Nedunchezhiyan, M. 2013. Tuber crops interventions to improve livelihood security in disadvantaged districts of Odisha. Paper presented at International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climate, held at Central Tuber Crops Research Institute, during 9-12 July 2013 Thiruvananthapuram, Kerala, India,

46. Makeshkumar, T., Jeeva, M. L. and Chakrabarti, S. K., 2013. Tropical tuber crops: a reservoir for plant viruses and its challenges. Asia Pacific Congress of Virology organized by Indian Virological Society held at Amity University, Noida, India, during 17-20 December, 2013.

47. Manasa, V. G., Rajitha, M. and Jeeva, M. L., 2014. Nucleic acid based detection of *Maclura virus* infecting greater yam (*Dioscorea alata* L.). National Seminar cum Workshop on Techniques in Biosciences, held at KKTM College, Kodungallur, Thrissur, during 18-19 February, 2014.

48. Marion Liebrecht, Kamala, S., Makeshkumar. T. and Winter, S. 2013. Unravelling the diversity of Dasheen mosaic virus in aroids and development of reliable diagnostics to ensure virus freedom of crops. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

49. Misra, R. S., Nedunchezhiyan, M., Ray, R. C., Mukherjee, A., Laxminarayana, K., Rao, K. R. and Pati, K. 2013. Food and nutritional security through root and tuber crops in the tribal region of Odisha, Chhattishgarh and Jharkhand state of India International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

50. Mithun Raj., Jeeva, M. L. and Vinayaka Hegde. 2013. PCR based detection of *Colletotrichum gloeosporioides* causing anthracnose disease in greater yam. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

51. Mithun Raj., Jeeva, M. L. and Vinayaka Hegde. 2013. Phosphate solubilizing rock inhabiting bacteria from Ponmudi, India. National Seminar on Frontiers in Applied Microbiology, held at Annamalai University, Annamalai Nagar, Tamil Nadu, on 14 February 2013.

52. Mohan, C., Rajitha, R., Deena T Kochunni., Senthil, N., Raghu, D., Makeshkumar, T. and Unnikrishnan, M. 2013. Identifying defense responsive genes in CMD resistant parent (MNga-1) using substracted cDNA library International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

53. Mukherjee, A., Naskar, S. K., Pati, K., Misra, R. S., Sahoo, B. K., Chakrabarti, S. K., James George, Vimala, B., Unnikrishnan, M. and Sreekumari, M. T. 2013. Valued traits in genetic resources of tuber crops: ascent to food and nutrition security under changing climate. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

54. Nath, V. S., Hegde, V. M., Jeeva, M. L., Misra, R. S., Veena, S. S. and Raj, M. 2013. Rapid and sensitive detection of *Phytophthora colocasiae* responsible for the taro leaf blight using conventional and real time PCR assay. National Symposium on Pathogenomics for Diagnosis and Management of Plant diseases,

held at CTCRI, Thiruvananthapuram, during 24-25 October, 2013.

55. Nath, V, S., Hegde, V. M., Jeeva, M. L., Misra, R. S., Veena, S.S., Raj, M. 2013. Morpho-cultural and molecular characterization of *Phytophthora colocasiae* infecting taro and identification of genes differentially expressed during infection. National Symposium on Pathogenomics for Diagnosis and Management of Plant diseases, held at CTCRI, Thiruvananthapuram, during 24-25 October 2013.

56. Nath, V. S., Sankar, M. S., Hegde, V .M., Jeeva, M. L., Misra, R. S., Veena, S. S., Raj, M. 2013. Analysis of genetic diversity in *Phytophthora colocasiae* associated with leaf blight of taro. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

57. Nedunchezhiyan, M., Byju, G. and Misra, R. S. 2013. Effect of fertigation interval, dose and duration on growth and yield of elephant foot yam. National Conference on Tuber crops (other than potato) for Sustainable Agriculture and Livelihood Security in Climate Change Scenario, held at Assam Agricultural University, Jorhat, Assam, on 29 April 2013.

58. Nedunchezhiyan, M., Ravindran, C. S. and Ravi, V. 2013. Weed management in root and tuber crops in India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

59. Nedunchezhiyan, M. 2013. Intercropping spices and tuber crops in cashew orchards. State level Seminar on Cashew, held at Odisha State Cashew Development Corporation Ltd, Bhubaneswar, during 6-7 March 2014.

60. Neetha Soma John, Anjana Devi, I, P., Jeeva, M. L. and Veena, S. S. 2014. Identification of an efficient isolate of bio-control agent for the management of collar rot of elephant foot yam caused by *Sclerotium rolfsii.* National Seminar on Frontiers in Applied Microbiology, held at Annamalai University, Annamalai Nagar, Tamil Nadu, on 14 February 2014.

61. Padmaja, G., Renjusha Menon., Jyothi, G. Krishnan. and Sajeev, M. S. 2013. Cassava and sweet potato pasta as novel functional foods with low starch digestibility and high nutritional value. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

62. Pati, K., Mukherjee, A. and Rath, D. 2013. DUS testing in elephant foot yam and taro. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

63. Pooja, N. S. and Padmaja, G. 2013. A Comparative study on the effect of pretreatment techniques in enhancing the biodegradability of agricultural and processing residues of cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

64. Pooja, N. S., Padmaja, G. and Shanavas, S. 2013. Enhancing the fermentable sugar yield from agricultural residues of cassava using pretreatments and improved saccharifying enzymes. National Seminar on Green Revolution through Agricultural Engineering Technologies, held at Thiruvananthapuram, during 22-23 February 2014.

65. Pravi Vidyadharan, Jeeva, M. L. and Archana, P. V. 2013. Molecular diagnosis of *Sclerotium rolfsii*- A PCR and hybridization based approach. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

66. Rajasekhara Rao, K. 2013. Evidence of plant

volatile suppression in sweet potato by insect vectors transmitting sweet potato feathery mottle virus. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

67. Raji, S. N., Subhash, N., Ravi, V., Makeshkumar, T., Mohanan, C. N., Nita, S., Renju, U. A. and Saravanan, R. 2013. Sunlight induced fluorescence imaging as an effective technique for monitoring biotic and abiotic stress in cassava International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

68. Raji S Nair, Ravi, V., Saravanan, R., Subhash, N., Makeshkumar, T., Nita, S. and Renju, U. A. 2013. Assessing cassava mosaic virus infection in cassava plants using PRI imaging. National Symposium on Pathogenomics for Diagnosis and Management of Plant Diseases, held at CTCRI, Thiruvananthapuram, during 24-25 October 2013.

69. Rajitha, M. and Jeeva, M. L. 2014. Molecular Detection of *Yam Mild Mosaic Virus* in *Dioscorea* spp. National Conference on Advances in Biology, held at St. Joseph's College, Tiruchirappalli, Tamil Nadu, during 6-7 January 2014.

70. Rajitha, M., Manasa, V. G. and Jeeva, M.L. 2014. Standardization of RNA Isolation protocol from greater yam (*Dioscorea alata* L.) Tubers. National Seminar cum Workshop on Techniques in Biosciences, held at KKTM College, Kodungallur, Thrissur, during 18-19 February 2014.

71. Ramesh, V., James George, Jissy, S. Jyothi, S. N. and Shibili, S. M. A. 2013. Nutrient use of efficiency of zeolites in sweet potato (*Ipomea batatas* L.). International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

72. Rath, D., Mukherjee, A., Kalidas Pati and Sahoo, B. K. 2013. Dus testing in taro (*Colocassia esculenta* L.) Schoot. National Conference on Tuber Crops (other than potato) for Sustainable Agriculture and Livelihood Security in Climate Change Scenario, held at Assam Agricultural University, Jorhat on 29 April 2013.

73. Ravi, V., Chakrabarti, S. K., Sreekumar, J., Makeshkumar, T. and Saravanan, R. 2013. Gene expression in tuber forming root of sweet potato under heat stress. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

74. Ravi, V., Suja, G., James George, Nedunchezhiyan, M. and Byju, G. 2013. Critical period of water requirement for elephant foot yam (*Amorphophallus paeonifolius*). International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

75. Ravindran, C. S., Ravi, V., Byju, G., Suja, G., Susan John, K., Sunitha, S. and Ramesh, V. 2013. Enhancing cassava production in India through improved crop production practices. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

76. Remya Remesh, K. R. and Byju, G. 2013. Adaptation of yam to 2030 climate of India. International Conference on Ecosystem Conservation, Climate Change and Sustainable Development, held at Thiruvananthapuram, Kerala, during 3-5 October 2013.

77. Remya Remesh, K. R., Byju, G. and Radhakrishnan, T. 2013. Impact of 2030 climate on suitability of yams in major environments of India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013),

held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

78. Renjusha Menon., Padmaja, G. and Sajeev, M. S. 2014. Sweet potato starch and flour based noodles as functional food. National Seminar on Green Revolution through Agricultural Engineering Technologies, held at Thiruvananthapuram, during 22-23 February, 2014.

79. Renjusha Menon., Padmaja, G. and Sajeev, M. S. 2013. Nutritional, cooking and starch digestibility characteristics of native and pre-treated legume flour fortified sweet potato spaghetti. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

80. Sabitha Soman and Byju, G. 2013. Adaptation of cassava to 2030 climate of India. International Conference on Ecosystem Conservation, Climate Change and Sustainable Development, held at Thiruvananthapuram, Kerala, during 3-5 October 2013.

81. Sabitha Soman, Byju, G. and Radhakrishnan, T. 2013. Assessment and mapping of spatial variation of selected soil physical and chemical characteristics of CTCRI farm. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

82. Sabitha Soman, Byju, G. and Radhakrishnan, T. 2013. Impact of 2030 climate on suitability of cassava in major environments of India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

83. Sajeev, M. S. and Jyothi, A. N. 2014. Biodegradable packaging films from cassava (*Manihot esculenta* Crantz) starch. National Seminar on Green Revolution through Agricultural Engineering Technologies, held at Institution of Engineers, Thiruvananthapuram, during 22-23 February 2014.

84. Sajeev, M. S. and Jyothi, A. N. 2013. Development of biodegradable films from modified cassava stach-nanoclay composites. 7th International Food Convention "Nsure Healthy Foods" IFCON 2013, held at CFTRI, Mysore, during 18-21 December 2013.

85. Sajeev, M. S., Jyothi, A. N. and Sheriff, J. T. 2013. Physico-mechanical and hygroscopic properties of modified cassava starch based biodegradable films. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

86. Sajeev, M. S., Padmaja, G. and Sheriff, J. T. 2013. Novel value addition technologies to change the status of traditional crops into high value commodities: Experience in tuber crops. National Conference on Tuber crops for Sustainable Agriculture and Livelihood Security in the Climate Change Scenario, held at Assam Agricultural University, Jorhat, Assam on 29 April 2013.

87. Sankaran, M., Damodaran, V., Singh, D. R., Dam Roy, S. and James George. 2013. Evaluation of cassava and sweet potato varieties in Andaman and Nicobar Islands, India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

88. Sankaran, M., Damodaran, V., Singh, L. B., Zamir Ahmed, S. K., Vivekananda Singh, Singh, D. R., Dam Roy, S. and James George. 2013. Participatory demonstration of tuber crops technologies in Andaman and Nicobar Islands, India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

89. Seena Radhakrishnan, A. R., Suja, G. and Anish, T. Anil. 2013. Organic management of cassava for sustainable yield and soil restoration. International Conference on Eco-system Conservation, Climate Change and Sustainable Development (ECOCASD 2013), held at Thiruvananthapuram, Kerala, during 3-5 October 2013.

90. Seena Radhakrishnan, A. R. and Suja, G. 2013. Growth dynamics, biomass, nutrient uptake and soil properties under organic management in cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

91. Senthil@Sankar M, Vishnu S. Nath, Misra, R. S., Jeeva, M. L. and Mithunraj. 2013. Cassava tuber rot caused by *Phytophthora colocasiae* in India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

92. Shanida Beegum, S. U., Susan John, K. and Sreekumar, J. 2013. Nutrient efficient genotypes and nutrient management practices in the carbon sequestration potential of cassava: a theoretical approach. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

93. Shanida Beegum, S .U., Susan John, K. and Sreekumar, J. 2013. Nutrient efficient genotypes and soil based nutrient management in cassava for sustainable soil productivity under global climate change. International Conference on Eco-system Conservation, Climate Change and Sustainable Development (ECOCASD 2013), held at Thiruvananthapuram, Kerala, during 3-5 October 2013.

94. Sheela, M. N., Abhilash, P. V., Mohan, C. and Asha Devi, A. 2013. Comparative analysis of the effect of ploidy manipulation on agronomical and biochemical traits with emphasis on cassava and yams. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

95. Sheela, M. N., Abhilash, P. V. and Abraham, K. 2013. Comparative evaluation of dwarf and tall hybrids of white yam for morphological agronomical and biochemical traits. Yams-2013 (First Global Conference on Yam), held at Accra, Ghana, during 3-6 October 2013.

96. Sheela, M, N., Abhilash, P. V., Sreekumari, M. T. and Asha Devi, A. 2013. Genetic improvement of cassava (*Manihot esculenta* Crantz) for yield and starch content through polyploidy breeding. 16th All India Congress of Cytology and Genetics and National Seminar on Gene environment and Health, held at University of Kerala, Thiruvananthapuram during 22-24 October 2013.

97. Sheela, M. N., Abhilash, P. V., Sreeja Thankappan, Asha, K. I. and Krishna Radhika, N. 2013. Genetic diversity for agronomical and morphological traits in yams originated from different regions in India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

98. Shiji, R., James George and Sunitha, S. 2013. Efficiency of tissue culture techniques for rapid multiplication of planting material production in cassava (*Manihot esculenta* Crantz). International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

99. Shirly Raichal Anil., Siril, E. A. and Suhara Beevy, S. 2013. Assessment of diversity in *Amorphophallus* using isozyme and ISSR markers. National Seminar on New Frontiers in Molecular Biology held at Mar Athanesius College, Kothamangalam, Kerala, during 12-13 December 2013.

100. Shirly Raichal Anil., Siril, E. A. and Suhara Beevy, S. 2013. The role of chromosomal translocation in the evolution of *Amorphophallus bonaccordensis*. 16th All India Congress of Cytology and Genetics, held at Department of Botany, Kariavattom, University of Kerala, Thiruvananthapuram during October 22-24, 2013.

101. Shirly Raichal Anil., Siril, E. A. and Suhara Beevy, S. 2013. Karyosystematics studies in *Amorphophallus* Blume ex Decne. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

102. Singh, H., Khurana, D. S., Chakrabarti, S. K., Mukherjee, A. and Nedunchezhiyan, M. 2013. Performance of short duration cassava varieties in trans-gangetic plain region of Punjab in India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

103. Soumya B. Nair., Sajeev, M. S. and Jyothi, A. N. 2013. Cassava starch/montmorillonite nanocomposite films: preparation and characterization. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

104. Sreekumar, J. and Santhosh Mithra, V. S. 2013. Data mining for SSRs in EST and EST-SSR marker development in tuber crops. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

105. Sreekumar, J. and Santhosh Mithra, V. S. 2014. Statistical modelling and simulation of gene regulatory networks. National Seminar on International Year of Statistics (NCSTC-2014) held at University of Kerala, Thiruvananthapuram on 22 March 2014.

106. Suja, G., Sreekumar, J. and Jyothi, A. N. 2013. Is organic yam production feasible? Lessons from India. Yams-2013 (First Global Conference on Yam), held at International Institute of Tropical Agriculture, Accra, Ghana during 3-6 October 2013.

107. Suja, G., Sreekumar, J., Jyothi, A. N., Susan John, K. and Sundaresan, S. 2013. Organic farming improves yield, quality and soil health-a decade experience in tuber crops. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

108. Suja, G. 2014. Is organic farming sustainable? Insights from tuber crops. In: Souvenir, National Seminar on the Role of Organic Farming in Climate Resilient and Sustainable Agriculture, 9-10 January 2014, Navsari Agricultural University, Navsari, Gujarat, pp.171-180.

109. Suja, G. 2013. Prospects and strategies for organic tuber production: Highlights of a decade research in India. Asia Pacific Regional Symposium on Entrepreneurship and Innovation in Organic Farming, held at Bangkok, Thailand, duirng 2-4 December 2013.

110. Sunitha, S., James George and Sreekumar, J. 2013. Productivity of cassava (*Manihot esculenta* Crantz) as affected by drip fertigation in humid tropics. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

111. Susan John, K., Ravi, V., Shanida Beegum, S. U., Ravindran, C. S., Manikantan Nair, M. and James George. 2013. Cassava: a potential C sequestration climate resilient crop for food security and sustaining soil productivity. Workshop on Managing Soils for Food Security and Climate Change Adaptation, held at Department of Soil Survey and Soil conservation, Government of Kerala, on 5 December, 2013.

112. Susan John, K., Ravindran, C. S., James George and Manikantan Nair, M., 2013. Soil test based low input nutrient management strategy for cassava in an Ultisol of Kerala: Experience from a long term fertilizer experiment. National Seminar on Development in Soil Science, held at CAZRI, Jodhpur, during 23-26 October 2013.

113. Susan John, K., Shanida Beegam, S. U., Sheela, M. N. and Suja, G. 2013. Nutrient efficient genotypes: a better option for low input management in cassava. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

114. Vani, M., Byju, G. and Radhakrishnan, T. 2013. Impact of 2030 climate on suitability of *Amorphophallus* in major environments of India. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

115. Veena, S. S., Jeeva, M. L., Rajeswari, L. S., Sabna, A., Pravi Vidyadharan, Nedunchezhiyan, M., Sreekumar, J. and James George. 2013. Worm power against fungal diseases in aroids: prospects and future strategies. International Conference on Tropical root and Tubers for Sustainable Livelihood under Changing Agro-Climate, 09-12 July 2013, Thiruvananthapuram.

116. Vidya, P., Aswathy, G. H. Nair., Anjana., R. V. and Mohan, C. 2013. Identification of CMD resistance associated markers in F_1 segregating population of cassava using single marker analysis. National Symposium on Pathogenomics for Diagnosis and Management of Plant Diseases, held at CTCRI Thiruvananthapuram, Kerala, during 24-25 October, 2013.

117. Vidya, P., Aswathy, G. H. Nair., Anjana, R. V. and Mohan, C. 2013. Validation of CMD resistant markers in F_1 mapping population of 732×MNga-1. 23rd Swadeshi Science Congress, held at Mahatma Gandhi University, Kottayam, Kerala, during 6 - 8 November 2013.

118. Vidya, P., Mohan, C. and Aswathy, G. H. Nair. 2013. Phenotypic variations in F_1 progenies of CMD resistant mapping population. International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-climate (ICTRT-2013), held at Thiruvananthapuram, Kerala, during 09-12 July 2013.

119. Vinutha, K. B., Asha Devi, A. and Sreekumar, J. 2014. Morphological characterization of taro (*Colocasia esculenta* (L.) Schott) from North-East India for assessment of diversity. National Seminar cum Workshop on Techniques in Biosciences, held at the Dept. of Botany, KKTM Govt. College, Kodungallur, during February 18-19, 2014.

Other publications

1. CTCRI. 2013. Annual Report 2012-2013, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, p. 128

2. CTCRI-AICRP 2013, Annual Report 2012-2013, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, p.124

3. CTCRI. 2013. Proceedings of 39th Institute Research Council held during 16-18 April, 2013, p.68

4. CTCRI. 2013. Activity Milestones 2013-2014, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, p.62

5. CTCRI. 2013. Research Highlights 2012-2013, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, p. 28

6. CTCRI News. 2014. **30**(2), April-June 2013

7. CTCRI News. 2014. **30**(3), Juy-September 2013

8. James George and Sunitha, S. Technical Report, 13th Annual group meeting of All India Coordinated Research Project on Tuber Crops, 2013 held at AAU, Jorhat.

9. Jyothi, A. N. and Padmaja, G. 2014. Nutritional aspects of tuber crops. In: Course Document of the National Training on Value Addition in Tuber Crops 24-29 March 2014, Central Tuber

Crops Research Institute, Thiruvananthapuram.

10. Jyothi, A. N. 2014. Starch and starch based products. In: Course Document of the National Training on Value Addition in Tuber Crops, 24-29 March 2014, Central Tuber Crops Research Institute, Thiruvananthapuram.

11. Ravi ,V., Suja, G., Asha Devi, A., Makeshkumar, T., Sajeev, M. S., Veena, S .S., Santhosh Mithra, V. S, Ramanathan, S. and Byju, G. (Eds). Souvenir, International Conference on Tropical Roots and Tubers for Sustainable Livelihood Under Changing Agro-Climate (ICTRT 2013), 9-12 July 2013, Thiruvananthapuram, Kerala, India, 110 p

12. Ravindran, C. S., Ramanathan, S., Susan John, K. and Sudha Devi, K. S., Kizhangu vargangalude krishireethikal (Bulletin in Malayalam), Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram, Kerala, India, 40 p.

13. Suja, G. 2014. Sustainable resource management of cropping systems involving tuber crops: Prospects and strategies. In: Course Document of the Training on Advanced Production Technology of Tropical Tuber Crops and their Value Addition, 15-21 February 2014, Central Tuber Crops Research Institute, Thiruvananthapuram, pp.60-70.

14. Susan John, K. 2014. Recent trends in soil fertility and nutrient management of tropical tuber crops In: Course Document of the Advanced Production Technology of Tropical Tuber Crops and its Value Addition, Central Tuber Crops Research Institute, Thiruvananthapuram, 15-21 February 2014, pp.60-70.

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	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, C.A. 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	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,	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. Shreiff
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	Project title	PI	Co-PI	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	DUS testing centre for cassava	M. N. Sheela	Archana Mukherjee	PPV& FRA
3	Development of standards of DUS testing for varietal gene bank in elephant foot yam and taro.	Archana Mukherjee	Kalidas Pati	PPV& FRA
4	Rehabilitation of existing tissue culture laboratory for micro propagationof disease planting material	James George	S. Sunitha	SHM, Kerala
5	Soil- based plant nutrient management plan for agro ecosystems of Kerala	K. Susan John	G. Suja M. Manikantan Nair	DoA, Govt. of Kerala
6	Development of eco-friendly technologies for quality cassava production and to safeguard soil health and environment	G. Suja	K. Susan John J. Sreekumar VinayakaHegde	MoEF
7	Sustainable rural livelihood and food security to rainfed farmers of Odisha	M. Nedunchezhiyan	K. Laxminarayana K. Rajashekara Rao P. S. Sivakumar	NAIP

8	Promotion of Sweet potato to increase cropping intensity, livelihood enhancement and nutritional security in coastal saline soils of Erasama block, Jagatsinghpur district of Orissa	K. Laxminarayana	-	NHM, Directorate of Horticulture, Govt of Odisha
9	Establishment of Leaf/Tissue Analysis Laboratory	K. Laxminarayana	-	NHM, Directorate of Horticulture, Govt of Odisha
10	Development of tuber crops	James George	S. Ravindran, C. A. Jayaprakas M. N. Sheela S.Ramanathan G. Byju, T. Makeshkumar S. Sunitha M. L. Jeeva M. S. Sajeev V. R. Sasankan,T5 D. T. Rejin, T1	DoA, Govt. of Kerala
11	Novel Molecules produced by unique bacteria and their bioactivity	C.A. Jayaprakas	Nil	DST-DPRP
12	Popularisation of cassava biopesticide against borer pests of banana in three districts of Kerala.	C.A. Jayaprakas	S. Ramanathan Santhosh Mithra G. Byju Shri. E.R. Harish	RKVY
13	Differential plant volatile emission: Unfolding the new mecnanism of host plant resistance against important insect pests of sweet potato	Rajasekhara Rao Korada	C. A. Jayaprakas, K. Laxminarayana	DBT, Govt of India
14	AMAAS (Application of Microorganisms Agriculture and Allied Sectors) project on "Isolation and Development of Plant Growth Promoting Organisms from High Biodiversity Region for Tropical Tuber Crops"	M. L. Jeeva	Susan John K R. S. Misra Veena, S.S.	ICAR network project
15	Phytophthora, Fusarium and Ralstonia Diseases of Horticultural and Field Crops	M. L. Jeeva	S. S. Veena R.S.Misra	ICAR Network Project
16	Development of mosaic resistant transgenic cassava	T. Makeshkumar	S.K. Chakrabarti M.N. Sheela	ICAR Network Project
17	Development of low glycaemic noodles from sweet potato and low calorie sago from cassava as anti diabetic foods	G. Padmaja	K. Jeevaratnam J. T. Sheriff M. S. Sajeev A. N. Jyothi	ICMR, Govt. of India

18	Synthesis , process optimization and characterisation of superabsorbent polymers from cassava starch	A. N. Jyothi	M. S. Sajeev	DST, Govt. of India
19	Development of a process for the production of low-moist gelatinised dough for using in cassava pappad making machine	J. T. Sheriff	A. N. Jyothi G. Padmaja M. S. Sajeev	Contract Research: Boosters International Kanyakumari District Tamil Nadu
20	Improving the livelihoods of smallholder cassava farmers through better access to growth markets (CassavaGmarkets)	J. T. Sherif	G. Padmaja V. Ravi M. S. Sajeev A. N. Jyothi	Food Security Thematic Programme (FSTP), Component 1 – Research and Technology to European Commission
21	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. Sherif	G. Padmaja M. S. Sajeev	DST, Govt. of India
22	Participatory Development of a web based user friendly cassava expert system	V. S. Santhosh Mithra	M. Anatharaman S. Ramanathan G. Byju	KSCSTE, Govt. of Kerala
23	Development of Statistical Machine learning Tools and Methods for analysis of Microarray Gene expression data	J. Sreekumar,	V. S. Santhosh Mithra C. Mohan	DIT, Govt. of India
24	Food security through Asian Roots and Tubers (FoodSTART)- Focus site Odisha	R. S. Misra	M. Anatharaman M. Nedunchezhiyan K. Laxminarayana V. S. Santhosh Mithra	CIP- IFAD
25	Intellectual Property Management and Transfer/ Commercialization of Agricultural Technology Scheme (up-scaling of existing component i.e. Intellectual Property Rights (IPR) under ICAR Head quarters Scheme on Management of Information Services)'	M. Anantharaman,	M. L. Jeeva M. S. Sajeev	National Agricultural Innovation Project (NAIP) and ICAR

INSTITUTE RESEARCH COUNCIL (IRC)/ QUINQUENNIAL REVIEW TEAM (QRT)/RESEARCH ADVISORY COMMITTEE (RAC)/ INSTITUTE MANAGEMENT COMMITTEE (IMC)

Institute Research Council

The 39th Institute Research Council meeting of CTCRI was held during 16 - 18 April, 2013. Dr. S.K. Chakrabarti chaired all the sessions. Dr.(Mrs). M. L. Jeeva, secretary, IRC welcomed the chairman and all participating scientists including the newly joined scientists, Dr. Kalidas Pati, Shri. Harish, E. R and Dr. Asha, K. I and congratulated Dr. M. N. Sheela who joined as Head of Division of Crop Improvement. The projects of Regional Centre have been merged with the respective divisions of Head quarters from this year onwards and as per the suggestion of ICAR and RAC the number of projects were reduced into 17 with multidisciplinary approach.

The Director in his initial remarks expressed his happiness about the technology commercialized and patenting filed from CTCRI. He was also glad that our institute is recognized internationally which is revealed by the invitations to our scientists from abroad for consultancy, impart training and invited talk. He also congratulated Dr. M. N. Sheela for being joined as Head, Crop Improvement. He asked the newly joined scientists to learn new procedures and all to have collaboration and interaction with other divisions for multidisciplinary approach in research projects and added that the training acquired from abroad like Marker Assisted selection has to be exploited for our progress . He informed that our institute has very good technologies which have tremendous opportunities among international community which we have to be made use. Regarding value addition he added that there is huge market demand for starch and since sago is the primary product of cassava the expectation of sago factories has to be looked into. As regards XIIth plan the Director informed that the plan document has been prepared with lot of inputs and care from all. Cassava mosaic disease, value addition and cost of cultivation are the prioritized areas of our institute during next plan. He also highlighted the achievements of each division.

There were 7 technical sessions *viz*. Crop Improvement, Crop Protection, Crop Production, Crop Utilization, Extension and Social Sciences, New projects presentation and plenary session. Totally 53 on-going research sub projects under 5 mega projects were presented and discussed. All the sub projects were concluded and seventeen new multidisciplinary projects were proposed and approved. The decisions taken in the concluded projects, details of on-going externally aided projects and the proceedings and activity milestone of the new projects have been prepared and distributed to the scientists.

Quinquennial Review Team

The Indian Council of Agricultural Research (ICAR), New Delhi has constituted the Quinquennial Review Team to review the work done during 01.04.2008 to 31.03.2013 at the Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala as well as the All India Coordinated Research Project on Tuber Crops (AICRP-TC) vide F.No.1(3)/2013-IA.V dated 14th August, 2013 and 3rd January, 2014 with the following composition:

1. Dr. S. B. Dandin — Chairman
   Vice Chancellor
   University of Horticulture Sciences
   Sector-60, Navanagar, Bagalkot 587 102
   Karnataka
2. Dr. Lalitha Anand — Member
   Rtd. Principal Scientist (Bio-Tech.)
   IIHR, Bangalore
3. Dr. P. Parvatha Reddy — Member
   Ex-Director
   IIHR, Bangalore
4. Dr. N. T. Yaduraju — Member
   Knowledge Sharing & Innovation
   ICRISAT, Patancheru
   Andhra Pradesh 502 324
5. Shri. K. K. Kaushal IFS — Member
   Managing Director
   Sagoserve, Salem 636 302 Tamil Nadu
6. Dr. S. Ramanathan — Member-Secretary
   Principal Scientist
   CTCRI, Sreekariyam
   Thiruvananthapuram 695 017

The Team visited CTCRI HQ, Thiruvananthapuram, Regional Centre, Bhubaneswar, AICRPTC Centres at Navasari, Gujarat, Coimbatore, Tamil Nadu, Patna, Bihar and Guwahati, Assam and reviewed in detail the work done during the past five years. The Team members also held in depth discussion with the scientists and other staffs and also visited experimental fields at various places. Sagoserve, Salem, Tamil Nadu and a few cassava based industries were also visited by the team to understand the working of industries and their constraints. Detailed recommendations including research, administration, policy issues etc. have been made by the QRT Team.

Research Advisory Committee (RAC)

The third meeting of the Research Advisory Committee-VI of CTCRI, Thiruvananthapuram was held on January 09, 2014 under the chairmanship of Dr. S. P. Ghosh.

Members Present

Dr. S. P. Ghosh	Chairman
Dr. Narayan Rishi	Member
Dr. Ramesh Chandra	Member
Dr. R. H. Singh	Member
Dr. S. K. Chakrabarti	Member (Ex-Officio)
Dr. S. K. Malhotra	Member (SMD Representative)
Dr. M. N. Sheela	Member Secretary

The meeting was also attended by the Heads of Divisions of CTCRI *viz.*, Dr. G. Padmaja, Crop Utilization; Dr. C. S. Ravindran, Crop Production; Dr. C. A. Jayaprakas, Crop Protection; Dr. M. Anantharaman, Extension and Social Sciences and Dr.R.S. Misra, Regional Centre. In addition, Dr.

James George, Project Coordinator (AICRP (TC)), Dr. S. Ramanathan (Member Secretary, QRT), Dr. V. Ravi (Scientist-in-Charge, PME) and all Scientists/ Programme Leaders of different Divisions also attended the meeting.

After a brief introduction of the members by Dr. M. N. Sheela, Member Secretary, Dr. S. P. Ghosh took over the chair. He congratulated the CTCRI team for their achievements. He stressed the need for reorientation of research focus of the institute. He also emphasized on finding alternative uses of tuber crops so that sustainable growth of the sector can be assured. He highlighted the need for enhancing nutritional quality through biofortification approach. Development of Good Agricultural Practices (GAPs) for important tuber crops is needed. He also emphasized the need for involving KVK's in multiplication of planting materials.

Dr. S. K. Chakrabarti, Director presented the Institute profile as well as salient achievements during 2013-14. He detailed on scientific manpower, research projects, varieties, distribution of quality planting material, plant production and protection techniques, crop utilization aspects, publications, international collaborative programs, international exposure of scientists, training programs organized, externally funded projects etc. He also presented the list of technologies commercialized and IPR assets during 2013-14.

Dr. Sheela, M. N., Member Secretary, presented the action taken report which was discussed in detail. The Heads of Divisions presented the salient achievements of their respective divisions during 2013-14. Winding up the discussions, the chairman suggested that the following recommendations of the RAC have to be periodically reviewed, in order to ensure the follow up action.

Crop Improvement

- Germplasm characterization should be given priority so that duplicates can be avoided. Under *in vitro* active gene bank, core collections and pre-breeding lines of all crops need to be conserved in slow growth media. Tissue culture protocols for major crops already developed and further refinements of technologies may be attempted for long term storage.
- Development of TLB resistant taro and collar rot as well as dasheen mosaic resistant elephant foot yam should be given priority.
- In white yams dwarf varieties may be released and popularised.

Crop Production

- Work on development of Good Agricultural Practices (GAP) need to be initiated for important tuber crops. Pesticide use to be restricted/limited and pesticide residue analysis for edible parts (roots & tubers) to be considered.
- Basic studies on the role of potassium towards quality and other yield attributes in cassava should be undertaken.

Crop Protection

- Development of standard seed production system for all major tropical tuber crops should be perfected, documented, and implemented on priority to facilitate mass production of quality planting materials. The Project Co-ordinator, AICRP (TC) may compile past work and take lead in bringing out Nursery Manuals for the use of development partners, including AICRP Centres, KVKs etc.
- Impact of climate change on disease and pest incidences and spread and use of biopesticides/ biofertilizers/botanicals (including leads of CTCRI) for control of major insect pests, including vectors of viral diseases, need to be intensified.

Crop Utilization

- Bio-fortification of food products especially pasta with high carotene/anthocyanin rich sweet potato and anthocyanin rich yams may be undertaken on priority.

Extension and social Sciences

- Quantification of the spread of CTCRI varieties and varietal replacement of older varieties with new ones needs to be undertaken to assess the impact of CTCRI varieties. Constraints in variety spread should also be studied for suggesting remedial measures.

Regional Centre

- Regional Centre along with Section of Extension & Social Sciences may take up extension activities with respect to released varieties of yams including white yam for adoption in Odisha.

The following members were present.

- Region specific technology development, particularly for sweet potato, yams, colocasia and elephant foot yam should receive priority.

General

- Among others, the AICRP centres may be given the responsibility to take up multiplication of quality planting material of selected crops for faster spread.

Institute Management Committee (IMC)

The Director, CTCRI chaired the X Institute Management Committee meeting held on 20th December, 2013 at 11.00 a.m.

1.	Director, CTCRI, Thiruvananthapuram - 695 017	Chairman
2.	Dr. C. Ashwath, Principal Scientist & Head, Division of Biotechnology, IIHR, Bangalore-560089.	Member
3.	Dr. M. Anantharaman, Principal Scientist & Head, Social Science, CTCRI, Thiruvananthapuram – 695 017	Member
4.	Sri. K. G. Jagadeesan, Finance and Accounts officer i/c, Indian Institute of Spices Research, Calicut	Member
5.	Dr (Mrs.) G. Padmaja, Head, Division of Crop Utilization, CTCRI, Thiruvananthapuram	Special Invitee
6.	Dr. C. S. Ravindran, Head, Division of Crop Production, CTCRI, Thiruvananthapuram	Special Invitee
7.	Dr. James George, Project Coordinator(TC), CTCRI, Thiruvananthapuram	Special Invitee
8.	Dr (Mrs.) M. N. Sheela, Head, Division of Crop Improvement, CTCRI, Thiruvananthapuram	Special Invitee
9.	Dr. C.A. Jayaprakas, Head, Division of Crop Protection, CTCRI, Thiruvananthapuram	Special Invitee
10.	Dr. S. Ramanathan, Principal Scientist, CTCRI, Thiruvananthapuram	Special Invitee
11.	Dr. C. Ravi, Principal Scientist & SIC (PME), CTCRI, Thiruvananthapuram	Special Invitee
12.	Dr. (Mrs.) M.L. Jeeva, Principal Scientist, CTCRI, Thiruvananthapuram	Special Invitee
13.	Smt. R. Sari Bai, Finance & Accounts Officer, CTCRI, Thiruvananthapuram 695 017	Special Invitee
14.	Administrative Officer, CTCRI, Thiruvananthapuram	Member Secretary

The Director welcomed all the members to the X IMC of CTCRI. The Director briefed the members about the major activities and achievements of the institute during April to November 2013. Some of the major activities include the Institute Research Council Meeting held on 16 – 18 April 2013, All India Coordinated Research Project (Tuber Crops) workshop held on 26-27 April 2013 at Assam Agricultural University, Jorhat, Assam and Brain Storming Session on Cassava Mosaic Disease Management held on 18th May 2013 at CTCRI, Thiruvananthapuram.

The Member Secretary presented the regular agenda items for discussions. Dr. Ravi, Principal Scientist and in-charge, PME Cell made a power point presentation on the major activities of the Institute.

The committee has approved fresh proposals for 2013-14.

PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA ETC. IN INDIA

Dr. M. Anantharaman

- Second Annual Review meeting of CIP – IFAD Food START project at Bhubaneswar during 26-31 August, 2013.
- Consultation meeting of focus sites/value chain studies for Odisha at Bhubaneswar during 6-8 November, 2013.
- Consultation Meeting on Value chain of cassava in Tamil Nadu at Salem.

Dr. (Mrs.) Archana Mukherjee

- Technological platform for LANSA (Leveraging Agriculture for Nutrition in South Asia) and FSN (Farming System for Nutrition) at Bhubaneswar under the Chairmanship of Prof. M. S. Swaminathan during 22-23 December, 2013at OUAT, Bhubaneswar, as Panel member.
- Review meeting of 'EU aided INEA taro and CIP-IFAD FOODSTART projects in foreign aided projects at KAB-II, New Delhi under the Chairmanship of Honorable DDG, Dr. K. Krishnakumar on 16 January, 2014 and presented progress report.
- State level workshop on orange flesh sweet potato and imparted training on nutritional values of orange flesh sweet potato, as expert on 27 December, 2013 at Bhubaneswar.
- Hindi workshop at CHES, Bhubaneswar on 18 September, 2013.
- CIP and IFAD meeting of FOODSTART at Hotel Mayfair, Bhubaneswar on 28 August, 2013.
- NABARD sponsored workshop on "Sweet Potato for Livelihood and Nutritional Security in coastal saline soils": and delivered theory and practical teachings on "Potential of Sweet potato varieties in salt affected areas"as resource person on 10 October, 2013.

Dr. (Mrs.) Asha Devi, A.

- National Seminar on Plant Reproductive Biology held at the Department of Botany, University of Kerala, Thiruvananthapuram on 25 July, 2013.
- UGC sponsored National Seminar cum Workshop on Techniques in Biosciences, 18-19 February, 2014, organized by the Dept. of Botany, KKTM Govt. College, Kodungallur and served as the lead speaker on the topic, 'Bio-techniques in crop improvement of tuber crops'.
- District Children's Science Congress, Thiruvananthapuram:17-18 January, 2014

Dr. S. K. Chakrabarti

- National Symposium on "Abiotic and Biotic Stress Management in Vegetable Crops" held at IIVR, Varanasi, Uttar Pradesh during 12-14 April, 2013 and delivered a lead talk on "Diagnostics for virus detection in horticultural crop".
- Presided over the His Highness Sree Visakham Tirunal Endowment Lecture function at the Central Tuber Crops Research Institute (CTCRI) on 18 May, 2013.
- The 85th Foundation day of ICAR and related meetings during 15-17 July, 2013.
- Annual Project Review and Planning Workshop of Food Security through Roots & Tubers (FoodSTART), organized by Regional Centre of CTCRI, Bhubaneswar at Mayfair Lagoon Hotel, Bhubaneswar during 28 -31 August, 2013.
- The 21st meeting of "Central sub-committee

on crops, standards, notification and release of varieties for horticultural crops" under the chairmanship of Dr. N. K. Krishna Kumar, Deputy Director General (Hort.), ICAR on 7 October, 2013.

- Training programme on "Livelihood improvement through tuber crops for farmers of Chhattisgarh and Jharkhand states" under Tribal Sub Plan during 7-9 October, 2013 at Regional Centre of CTCRI, Bhubaneswar.
- Conglomerate on Innovative Partnership on 19 October, 2013 at AP Shinde Symposium Hall, NASC Complex, ICAR New Delhi.
- National Symposium on gene, environment and health" held at Department of Botany, University of Kerala, 22-24 October, 2013 and delivered a lead talk on "Gene to genome-what next".
- Farmers' Awareness Progoramme under TSP at BAU, Ranchi during 29-30 October 2013.
- QRT briefing meeting with Deputy Director General (Hort.) at NASC Complex, New Delhi on 9 November, 2013.
- Interactive workshop on administrative and financial matters for the ICAR institutes located in southern region held at NAARM, Hyderabad during 9-10 December, 2013.
- Asia-Pacific Congress of Virology (Virocon-2013) held at Amity University, NOIDA, Uttar Pradesh during December 17-20, 2013
- The 122nd Academic Council and Convocation of TNAU held at Coimbatore on 26 December, 2013.
- ICAR Directors' & Vice Chancellors' meeting held at Pune/Baramati, Maharashtra during 18-21 January 2014.
- The discussion with delegates of Bill and Melinda Gates Foundation on issues related to tuber crops at ICAR, New Delhi during 18-19 February, 2014.

Dr. James George

- International Conference on Water Quality and management for climate resilient agriculture held at Jalgaon, Maharashtra from 28 - 30 May, 2013.

Dr. C. A. Jayaprakas

- The "Pesticide residue meeting" at Rubber Research Institute, Kotayam, Kerala on 29 - 30 September, 2013.

Dr. (Mrs) M. L. Jeeva

- Institute bio safety committee meeting on 21August, 2013 and 29 January, 2014.

Dr. (Mrs) A. N. Jyothi

- The group monitoring workshop of DST project advisory committee meeting held at Bangalore University on 23 August, 2013 and presented the final report of the DST funded project.
- Participated and presented an invited paper at the National Seminar on Emerging Trends in Chemical Sciences held at Department of Chemistry, University of Kerala, Kariavattom, Trivandrum, during 29-31 May, 2013.

Dr. Kalidas Pati

- CIP & IFAD workshop at Hotel May Fair Langoon, Bhubaneswar on 28August, 2013.
- National training on Agro biodiversity conservation and sustainable livelihood from 2- 6 September, 2013 supported by DST, Govt. of India at M. S. Swaminathan Research Foundation (Regional Centre) Jeypore, Odisha.
- RAJBHASHA meeting at AayakarBhawan, Bhubaneswar on 30 October, 2013.

Ms. Krishna Radhika, N.

- National Seminar on GM crops: Prospects and issues held at Kerala Agricultural University, Vellanikkara on 17-18 March,2014 and co-chaired one of the sessions.

Dr. K. Laxminarayana

- ARRW Golden Jubilee International

Symposium on "Sustainable Rice Production and Livelihood Security: Challenges and Opportunities" held at Central Rice Research Institute, Cuttack from 2-5 March, 2013.

- National Seminar on 'Developments in Soil Science - 2013' held at the Central Arid Zone Research Institute, Jodhpur, Rajasthan during 23-26 October, 2013.
- Seminar on 'Integrated Nutrient Management for Sustainable Crop Production' organized by Bhubaneswar Chapter of Indian Society of Soil Science, OUAT, Bhubaneswar on March 14, 2014.

Dr. T. Makeshkumar

- National seminar on Horticulture Biotechnology, held at IIHR, Bangaluru on 14 June, 2013.
- Executive committee meeting of IPS on 2 August, 2013 at IARI.
- Attended Institute bio safety committee meeting 21 August, 2013 and 29 January, 2014.
- Meeting on Pesticide – related issues in Rubber and Other crops organized by Rubber Research Institute of India, Kottayam during 29-30 August, 2013.
- IBSC meeting of IISR, Calicut on 25 September, 2013 and 11 March, 2014.
- CIP-IFAD Consultation meeting on Cassava value chain at Salem on 11 November, 2013.
- Virocon 2013 – Asia –Pacific congress of Virology during 17-20 December, 2013 at Amity University, Noida (New Delhi, NCR).
- Training program on tuber crops production at Agali (12 March, 2014), Attappadi and Kinanur (13 March, 2104), Nilambur under the project on Tuber Crops development in Kerala sponsored by Govt. of Kerala
- Review meeting to finalise the technical programme and action plan of ICAR Seed Project (Horticulture component) under XII Five year plan, held at IIHR, Bangaluruon 22 February, 2014

Dr. C. Mohan

- National seminar on Horticulture Biotechnology, held at IIHR, Bangaluru on 14 June, 2013.
- CIP-IFAD Consultation meeting on Cassava value chain at Salem on 11 November, 2013

Dr. M. Nedunchezhiyan

- State level seminar on cashew, 6-7 March 2014, at Odisha State Cashew Development Corporation Ltd, Bhubaneswar.

Dr. (Mrs) G. Padmaja

- Discussion meeting conducted on 30 April, 2013 by Mr. K. R. Jyothilal, Secretary (Agric.) Govt. of Kerala, to identify the most suitable varieties of seeds for each region.
- Seminar on Tuber Crops at KVK, Mitraniketan on July 16, 2013 and gave a lecture on 'Value added food products from tuber crops' for small scale entrepreneurship.
- 74th FRC meeting of the faculty of Agriculture held at COA Vellayani, on 23 July, 2013.
- Technology week celebration at KVK, Mitraniketan& gave lecture on 'Value added products on tuber crops' on 29 October, 2013.
- Technology Clinic held by District Industries Centre (DIC), TVPM on16 January, 2014 and delivered a talk on 'Value added products from cassava and their potential for small scale entrepreneurship'.
- Training programme on tuber crops cultivation and value addition organized byNavsakthi Trust, Thazhava on 21 December, 2013.

Dr. Rajasekhara Rao Korada

- Workshop on "New Molecules for insect pest management with special emphasis on Cyazypyr" on 19 September, 2013 in Ramiah Hall of College of Agriculture, OUAT, Bhubaneswar.
- Workshop on "Viral Diseases of Vegetables Crops and their Management" on 5 December, 2013 organised by Society of Plant Protection

and Environment, in Biju Patnaik Hall, OUAT, Bhubaneswar and sponsored by Extension Reforms, Dept. of Agriculture, Govt. of Odisha and delivered a Guest Lecture on "Chemical Interactions in Viral Diseases of Crop Plants" and co-chaired the Technical Session.

Dr. R. C. Ray

- Sixth International Conference on "Fermented foods, health status, and social well beings', 6-7 December, 2013, Anand Agricultural University, Anand, India.

Dr. S. Ramanathan

- Consultation Meeting on Value chain of cassava in Kerala at Adoor, Kerala on 11 November, 2014.

Dr. C. S. Ravindran

- International Conference on "Water Quality and Management for Climate Resilient Agriculture from 28-31 May, 2013 at Jalgaon, Maharashtra.
- International Conference "Asia-Africa Agri business forum" organized by FICCI, New Delhi in collaboration with Ministry of Agriculture, Ministry of commerce and industry, Ministry of External affairs and Ministry of food processing industries, Govt. of India at New Delhi from 3 February, 2014.
- National Symposium on "Managing Natural Resources for enhancing Agricultural and Allied Productivity in Coastal Region under Changing Climate" during 11-14 December, 2013 at Bharuch, Gujarat.

Dr. V. S. Santhosh Mithra

- Second Annual Review meeting of CIP – IFAD Food START project at Bhubaneswar during 26-31, August, 2013.
- Consultation meeting of focus sites/value chain studies for Odisha at Bhubaneswar during 6-8 November, 2013.
- International Symposium Bioinformatica Indica 2014, held at Department of Bioinformatics at University of Kerala during 09 to 11 January, 2014.

Dr. M. S. Sajeev

- National Seminar on Green Revolution through agricultural engineering technologies, organised by Institution of Engineers (I), Kerala State Centre, 22-23 February, 2014, Trivandrum
- Consultation meeting on value chain in cassava, 16 November, 2013, Adoor, Pathanamthitta organised by CTCRI-CIP, New Delhi.
- 75th Faculty Research Council Meeting, MSc Integrated Biotechnology course, 29-30 November, 2013, KAU, Vellayani, Trivandrum.
- Seventh International Food Convention "Nsure Healthy Foods" IFCON2013, 18-21, December 2013, CFTRI, Mysore.
- International Conference "Asia Africa Agribusiness forum" organised by FICCI and Govt of India, 4-6 February, 2014, New Delhi.
- XXVII National Convention of Agricultural engineers and National Seminar on Green Revolution through agricultural engineering technologies, organised by Institution of Engineers (I), Kerala state Centre, 22-23, February 2014, Trivandrum.
- Co-ordination committee meeting of AICRP on PHT, 7-9, March 2014, CIPHET, Ludhiana.

Dr. (Mrs) M. N. Sheela

- Attended the Management Development Programme in Agricultural Research at NAARM, Hyderabad on 23-27 July, 2013.
- 21st meeting Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Horticultural Crops at NBPGR, New Delhi on 7 October, 2013.
- Training programme for tribal farmers of Chattisgargh at Bhubaneswar on 8 October 2013
- The 16th All India Congress on Cytology & Genetics at University of Kerala, Thiruvananthapuram from 22-24 October, 2013.

- PGR review meeting at NRC, Grapes on 29 November, 2013.
- Consultation Meeting of the Food START project on Cassava Value Chain in Kerala atAdoor, Kerala on 16 November, 2013.
- Awareness programme on Cassava cultivationat Puthur, Attappady, Kerala on 4 December, 2013.
- Awareness programme on Elephant foot yam cultivationat Agaly, Attappady on 23 January, 2014.
- Awareness programme on Yams cultivationat Sholiyur, Attappady on 24 January, 2014.
- Awareness programme on Yams cultivation at Kasargode on 30 January, 2014.
- 8th Review Meeting of DUS test centres organized by PPV & FRA at UAS. Dharwad from 28 February, 2014 to 1 March, 2014.

Dr. J. T. Sheriff

- Recent Trends of National Seminar (NFPTRD-2014) on 'Emerging Food Processing Technologies for Rural development' at Gandhigram Rural Institute-Deemed University during 4-5 January, 2014.
- SCOFTECH-2014, the first national student conference on food technology held at IICPT, Thanjavur during 7- 8 February, 2014.
- The second RAC meeting of IICPT held on 13-14 September, 2013 at Thanjavur.
- Tenth Meeting of Agriculture and Food Processing Equipments Sectional Committee (FAD 20) of Bureau of Indian Standards at NASC, New Delhi on March 28, 2014.
- Farmers seminar cum training programme at Tura on 22 July, 2013 under CTCRI-NEH programme.
- Review meeting of Foreign aided project organised by DDG (Horticulture).
- Workshop cum training on high pressure processing for food preservation at CIFT Cochin on 7 March, 2014.

Dr. (Mrs) Shirly Raichal Anil

- National Seminar on Plant Reproductive Biology on July 25, 2013 at Dept.of Botany, Kariavattom in connection with Inauguation of Dr.A.N.Nampoothiri Plant Reproductive Biology Laboratory.
- Cytogenetics FISH Workshop RCC 2013 at Regional Cancer Centre, Thiruvananthapuram from 28-30 November,2013.
- Brainstorming Meeting and Training cum Demonstration on Cryopreservation and *in vitro* conservation in Horticultural Crops co-sponsored by Bioversity International as part of ICAR-BI work plan held at IIHR, Bengaluru on 21-22 February, 2014.
- Technical Expert Committee meeting to finalise the purchase of equipments for for Biotechnology and Model Floriculture Centre, Kazhakuttom.
- One day Workshop on Plant Tissue Culture Techniques organised by Department of Botany, All Saints College, Thiruvananthapuram on 7 March, 2013 and was the resource person for the Workshop.
- National Seminar on Green Conservation –Traditional Methods at the Department of Botany, All Saints College, Thiruvananthapuram on 10 March, 2014 and delivered an invited talk on" Plant Tissue culture Techniques''.
- District Children's Science Congress, Thiruvananthapuram:17-18 January, 2014.

Dr. J. Sreekumar

- Review meeting of the DIT funded project "Development of statistical machine learning tools and methods for microarray gene expression data" on 10 May, 2013 at New Delhi.
- Third National Seminar on Horticulture Biotechnology held on 14 July, 2013 at IIHR, Bangalore.
- Nodal officers workshop of the NAIP consortium "Strengthening Statistical

Participation in Symposia

Computing for NARS funded by NAIP (ICAR) at UAS, GKVK Bangalore during 15-16 November, 2013.

- International Symposium on Bioinformatica Indica 2014, held at Department of Bioinformatics at University of Kerala during 9 – 11, January, 2014.
- Attended the National Seminar NCSTC-2014, on International Year of Statistics at Department of Statistics, University of Kerala on 22 March, 2014.
- Panel Discussion with the Course Directors of the National Trainings under NAIP jointly organized by the National Agricultural Innovation Project (NAIP) and the International Food Policy Research Institute (IFPRI) on Monday, 13 January, 2014 at NASC Complex, Pusa, New Delhi.

Dr. (Mrs) G. Suja

- Review Meeting of the Network Project on Organic Horticulture organized by IISR, Kozhikode on 2 April, 2013. A project proposal titled "Organic Production of Tuber Crops: Special focus in Coconut based Cropping System" for a total budget of Rs. 55 lakhs has been submitted for approval with IISR as the lead centre.
- World Environment Day 2013-Climate Change and Food Security: Think. Eat. Save, organized by the Dept. of Environmental Sciences, University of Kerala, Kariavattom on 5 June, 2013 and delivered and invited lecture on "Food and Nutritional Security-Tuber Crops a Viable Option".
- Meeting at NABARD Regional Office, Thiruvananthapuram, on 27 September 2013, to discuss about the fixation of unit cost (horticultural crops/ various enterprises) for various investments in the farm sector.
- National Seminar on Role of Organic Farming in Climate Resilient and Sustainable Agriculture during 9-10 January, 2014 at Navsari Agricultural University, Navsari, Gujarat and presented a lead lecture "Is Organic Production Sustainable? Insights from Tuber Crops".
- 31st Zonal Research Extension Advisory Council (ZREAC), Southern Zone, held on 18 February 2014, at College of Agriculture, Vellayani and co-chaired the technical session on Crop Protection.
- Summer Camp organized for students on 21 March 2014 at St. Thomas Residential School, Mukkola, Thiruvananthapuram and delivered an invited lecture titled "Instilling Agriculture Temper in Young Minds".

Dr. (Mrs) S. Sunitha

- International Conference on Water Quality and management for climate resilient agriculture held at Jalgaon, Maharashtra from 28– 30 May, 2013.

Dr. (Mrs) K. Susan John

- National Seminar on ' Developments in Soil Science' held at CAZRI, Jodhpur during 23-26 October, 2013.
- National level workshop on 'Soil fertility evaluation: Towards a state framework for 12th and 13th Five year plan' at Thiruvananthapuram during 8-9 October, 2013.
- State Level Seminar organized in connection with the 'World Soil day' celebration organized by the Department of Soil Survey and Soil Conservation, Government of Kerala on 5 December, 2013 at Kottayam.

Dr. (Mrs) S. S. Veena

- Agricultural Minister's (Govt. of Kerala) conference on pest and diseases of coconut on 27 November, 2013.
- Children's Science Congress, Thiruvananthapuram District: 17- 18 January, 2014.
- Celebration of successful validation of bio-pesticides and harvest festival, Pallichal, Thiruvananthapuram - 14 June, 2013

Note:

- All scientists and technical staffs of the

Institute participated in the 'International Conference on tropical roots and tubers for sustainable livelihood under changing agro-climate' (ICTRT-2013) held at The Mascot Hotel, Thiruvananthapuram during 9-12 July, 2013 and ISO 9001 certification - briefing class.

- All scientists, technical and other staffs of CTCRI attended National Science Day, 2014 on 25 -26 February, 2014 ; Tuber Crops day 2013 at CTCRI on 13 December, 2013
- The following scientists attended the 13th AICRP on TC annual meeting at Assam Agricultural University (AAU), Jorhat from April 26 to 28, 2013 and National Conference on Tuber Crops other than potato for sustainable agriculture and livelihood in climate change scenario, held at Assam Agricultural University, Jorhat on 29 December, 2013.

Dr. S. K. Chakrabarti, Dr. James George, Dr. Archana Mukherjee, Dr. C. A. Jayaprakas, Dr. T. Makeshkumar, Dr. R. S. Misra, Dr. C. Mohan, Dr. M. Nedunchezhiyan, Dr. S. Ramanathan, Dr. C. S. Ravindran, Dr. M. S. Sajeev, Dr. V. S. Santhosh Mithra, Dr. M. N. Sheela and Dr. S. Sunitha.

- The list of scientists attended the brainstorming session on Cassava Mosaic Disease and its management on May 18, 2013 under the chairmanship of Dr. N. K.Krishnakumar , DDG Horticulture at CTCRI, Thiruvananthapuram is given below.

Dr. S. K. Chakrabarti, Dr. James George, Shri. E. R. Harish, Dr. C. A. Jayaprakas, Dr. T. Makeshkumar, Dr. C. Mohan, Dr. G. Padmaja, Dr. S. Ramanathan, Dr. C. S. Ravindran, Dr. V. S. Santhosh Mithra, Dr. M. N. Sheela, Dr. S. Sunitha and Dr. K. Susan John.

- Dr. S. K. Chakrabarti, Dr. C. A. Jayaprakas, Dr. M. L. Jeeva, Dr. T. Makeshkumar, Dr. C. Mohan, Dr. V. Ravi, Dr. V. S. Santhosh Mithra, Dr. R. Saravanan, Dr. J. Sreekumar and Dr. S. S. Veena attended the National Symposium on "Pathogenomics for Diagnosis and Management of Plant Diseases 24-25, October 2013 at CTCRI, Thiruvananthapuram.
- Shri. E. R. Harish, Dr. M. L. Jeeva, Ms. Krishna Radhika, Dr. C. A. Jayaprakas, Dr. T. Makeshkumar, Dr. Shirly Raichal Anil and Dr. S. S. Veena participated in the celebration of successful validation of bio-pesticides and harvest festival, Pallichal, Thiruvananthapuram on June 14, 2013.

VISITS ABROAD

Name of the scientists	Period	Place	Purpose
Dr. S. K. Chakrabarti	23 February to 8 March, 2014	Cornell University, Ithaca, United State of America and Co operative programs in Washington DC and New York city.	Training on " Agricultural Research Management and Leadership"
	29 April to 1st May, 2013.	Bandung, Indonesia	Meeting on late blight disease resistance development efforts by the partners to review the progress of research work done so far and decide future research activities under the CPRI-ABSP II collaborative research project entitled, "Engineering late blight resistance in susceptible commercial Indian potato cultivars"
Dr. M. L. Jeeva Dr. C. A. Jayaprakas	3-5 October, 2013	Accra, Ghana	The First Global Conference on Yams "Yams 2013"
	18-29 November, 2013	CIAT, Columbia	The International course: Cassava witches'-broom disease diagnostic methods & alternatives for the integrated management of the disease at International Centre for Tropical Agriculture during
Dr. V. S. Santhosh Mithra Dr. M. Nedunchezhiyan	23 February to 1March, 2014	Manila, Philippines	Regional workshop on "Yield gap analysis of potato and sweet potato under changing climate" organized by CIP under FoodStart project

CTCRI Scientists in "Yams 2013" at Accra, Ghana

CTCRI Scientists at CIAT, Columbia for an International Course

Dr. V. S. Santhosh Mithra	1-5 April, 2013	Michigan State University, Michigan, USA	As a consultant to the university research programme "Study of impact of climate change on the growth of sweet potato in eastern African region based on the sweet potato simulation model SPOTCOMS"
Dr. J. T. Sheriff	1 -5 August, 2013 6 -11 August, 2013 28 September to 5 October, 2013	Abeokuta Nigeria (CSIR- FRI), Accra, Ghana Accra, Ghana	Annual meeting of the European Union Funded Cassava G markets Project in Nigeria The meeting of the sustainable cassava post harvest systems in India and Ghana 12th ISTRC-African Branch meeting and First Global conference on Yams -Yams 2013
Dr. G. Suja	13-24 May, 2013 2-4 December, 2014	Wageningen UR Centre, Netherlands Bangkok, Thailand	International Course on Agriculture in Transition: Innovative Approaches to Sustainable farming Asia-Pacific Regional Symposium on Entrepreneurship and Innovation in Organic farming

Dr. G. Suja in International course at Netherlands

Dr. V. S. Santhosh Mithra at Michigan State University

CTCRI Scientists at Regional workshop organized by CIP under Food Start project in Manila

DISTINGUISHED VISITORS

The following distinguished persons visited CTCRI during the year.

- Princess Gouri Parvathi Bayi, Member of Royal Family of erstwhile Travancore.
- Dr. S. Ayyappan, Secretary, DARE and DG, ICAR.
- Dr. N. K. Krishnakumar, DDG (H), ICAR.
- Dr. P. K. Chakrabarti, ADG, Plant Protection.
- Dr. S. K. Malhotra, ADG, Horticulture.
- Dr. K. Ramasamy, Vice Chancellor, TNAU, Coimbatore, Tamil Nadu.
- Dr. Abraham Varghese, Director, NBAII, Bengaluru.
- Dr. K.Veluthampi, MKU, Madurai, Tamil Nadu.
- Dr. Indranil Dasgupta, University of Delhi, South Campus, New Delhi.
- Dr. Rajagopal Raman, University of Delhi, New Delhi.
- Dr. M. Krishna Reddy, IIHR, Bangalore.
- Dr. R. Rabindran, Dy. Registrar, TNAU, Coimbatore, Tamil Nadu.
- Sri. K.K. Ramakrishnan, Managing Director, Small Farmers Agribusiness Consortium, Govt. of Kerala.
- Prof. Chathrapati Ghanta, Director, Staff Training College, Dr. B. R. Ambedkar Open University, Hyderabad.
- Dr. Ram C. Chaudhary, Chairman, PRDF, Gorakhpur.

Besides, more than 50 foreign delegates visited the institute during the "International Conference on Tropical Roots and Tubers"

MANAGERIAL PERSONNEL

Director	:	Dr. S. K. Chakrabarti
Project Co-ordinator	:	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. S. Ravindran
Vigilance officer	:	Dr. V. Ravi

Head of Divisions/Section

Crop Improvement	:	Dr. M. N. Sheela
Crop Production	:	Dr. C. S. Ravindran
Crop Protection	:	Dr. C. A. Jayaprakas
Crop Utilisation	:	Dr. G. Padmaja
Extension and Social Sciences	:	Dr. M. Anantharaman

PERSONNEL

Director	Dr. S. K. Chakrabarti
Project Co-ordinator (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	Dr. C. S. Ravindran
Crop Protection	Dr. C. A. Jayaprakas
Crop Utilization	Dr. G. Padmaja
Social Sciences	Dr. M. Anantharaman
Division of Crop mprovement	
Dr. Asha K. I	Principal Scientist
Dr. C. Mohan	Principal Scientist
Dr. (Mrs) Asha Devi	Senior 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. Lila Babu Rtd on 31.05.2013	Principal Scientist
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 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	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	Chief Technical Officer
Dr. S. Chandra Babu	Chief Technical Officer
Shri. M. Manikantan Nair	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	Senior 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. S. Divakaran Rtd on 30.04.2013	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	Senior Technical Assistant
Shri. G. Suresh	Technical Assistant
Shri. N. P. Ramadasan	Technical Assistant
Shri. A. S. Manikuttan Nair	Senior Technical Assistant
Shri. Luke Armstrong	Senior Technician
Shri. T. Raghavan	Senior Technician
Shri. G. Shajikumar	Technical Assistant
Shri. B. Satheesan	Technician
Shri. D. T. Rejin	Technician
Shri. T. M. Shinil	Technician
Shri. S. Shanavas	Technical Assistant
Shri. B. S. Prakash Krishnan	Technical Assistant
Administrative and Accounts	
Shri. P. J. Davis transferred to CIFT Kochi on 22.06.2013	Administrative Officer
Shri. Davis Joseph Joined on 17.09.2013	Administrative Officer
Smt. R. Sari Bai	Finance and Accounts Officer
Shri. T. Jayakumar	Assistant Administrative Officer
Smt. Jessymol Antony	Asst.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
Smt. K. V. P. Sarada Rtd on 31.05.2013	Assistant
Shri. P. C. Noble	Assistant
Smt. B. Presanna	Assistant
Shri. Vijayakumara Kurup	Assistant
Shri. P. S. Suresh Kumar	Assistant
Shri. J. Unni	Assistant
Shri. Unnikrishnan Nair	Assistant
Smt. Geetha Nair	U.D.C
Shri. Harendra kumar	U.D.C
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. Adarsh. R. S	L.D.C
Shri. Jayachandran N.	L.D.C
Mrs. Chandra Bindhu C. G.	L.D.C

Canteen Staff

Shri. S. Radhakrishnan Nair	Skilled Support Staff

Supporting Staff

Shri. A. R. Bhaskaran Rtd on 30.06.2013	Skilled Support Staff
Smt. S. Thankamani Amma Rtd on 30.11.2013	Skilled Support Staff
Shri. G. Ravindran Rtd on 30.09.2013	Skilled Support Staff
Smt. S. Ushakumari	Skilled Support Staff
Shri. V. G. Sankaran Rtd on 31.08.2013	Skilled Support Staff
Shri. K. P. Somasekaran	Skilled Support Staff
Shri. M. Krishnan Rtd on 30.04.2013	Skilled Support Staff
Smt. P. Sarojini Rtd on 31.10.2013	Skilled Support Staff
Shri. Udayakumar	Skilled Support Staff
Shri. 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	Skilled Support Staff
Shri. L. Samynathan	Skilled Support Staff
Shri. 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. Yudhistra Sahoo Rtd on 31.10.2013	Technical Officer
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	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
Shri. Sanatan Senapati	Skilled Support Staff

OTHER IMPORTANT EVENTS

Brainstorming session on Cassava mosaic disease

Brainstorming session on cassava mosaic disease and its management was held on 18 May, 2013. It was inaugurated by Dr. N. K. Krishnakumar, DDG (Hort.) and was attended by Dr. Abraham Vargheese, Director, NBAII, Bangalore, Dr. K. Veluthampi, Madurai Kamaraj University, Madurai, Dr. Indranil Dasgupta, University of Delhi South Campus, New Delhi, Dr. Rajagopal Raman, University of Delhi, Delhi, Dr. M. Krishna Reddy, IIHR, Bangalore, Dr. R. Rabindran, Dy. Registrar, TNAU, Coimbatore, all the HOD's & Scientists of Division of Crop Protection. In the inaugural address, DDG stressed the need to give all round focus to address the long standing serious problem of cassava mosaic disease. During this meeting six presentations were made on status of cassava mosaic disease, begomovirus characterisation, management of begomovirus through transgenic approach, management of sucking pests and *Bemisia tabaci* biotypes. At the end of the meeting, road map for the cassava mosaic disease management for the next five years was made.

H H Sree Visakham Thirunal Endowment Lecture- 2013

The fourth H H Sree Visakham Thirunal Endowment Lecture was delivered by Dr. N. K. Krishnakumar, Deputy Director General (Horticulture), Indian Council of Agricultural Research (ICAR), New Delhi on 'Bio-security and perceived threats to Indian agriculture' at the Central Tuber Crops Research Institute (CTCRI) on 18 May, 2013. It was Visakham Thirunal Rama Varma V (1880-85) who encouraged the cultivation of cassava on a large scale among the people, and his interest helped popularise cassava's acceptance as an important food source. Dr. N. K. Krishnakumar said in his lecture that India's food security could be at risk from invasive alien species. Preparedness for pest management was crucial to thwart the menace and the huge economic loss likely to be caused by the invasion. He said India was highly vulnerable to the threat posed by at least 10 to 12 species of dreaded invasive crop pests including the cassava mealy bug (*Phenacoccus manihoti*) and giant whitefly that infests ornamental plant species in nurseries and gardens. Weed invasions were also major threats because they could alter the native biodiversity and cause ecological imbalance. He stressed the need for the country to step up vigil against the emerging threats. The talk was organised by the Indian Society for Root Crops and CTCRI. Princess Gouri Parvathi Bayi, member of the royal family of erstwhile Travancore was the chief guest. Dr. S. K. Chakrabarti, Director, CTCRI, presided over the function.

Harvest festival at pallichal

In order to celebrate the success of the validation of biopesticide developed by CTCRI against pseudo stem weevil in banana at the farmer's field, a harvest festival was conducted at Pallichal on 15 June and this was inaugurated by Shri. N. Sakthan, Deputy Speaker of kerala legislative assembly. A galaxy of eminent personalities were also present on the occassion.

International Conference on Tropical Roots and Tubers (ICTRT 2013)

The Indian Society for Root Crops (ISRC) in association with Central Tuber Crops Research Institute (CTCRI) organized four days International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climate (ICTRT 2013) during 09-12 July, 2013 at Hotel Mascot, Thiruvananthapuram, Kerala, India. The ICTRT 2013 was inaugurated on 9 July 2013 with the lighting of the lamp by the chief guest, Sri. Oommen Chandy, Hon. chief minister, government of kerala. Dr. Shashi Tharoor, Hon. Union Minister of State for Human Resources Development, Government of India was the guest of honour. Dr. S. Ayyappan, Secretary, DARE and Director General, Indian Council of Agricultural Research presided over the function. Dr. N. K. Krishna Kumar, Deputy Director General (Horticulture), Indian Council of Agricultural Research also graced the inaugural function. Dr. S. K. Chakrabarti, Director, Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala, India gave the introductory remarks about the conference.

There were 13 lead talks, 74 oral presentations and 104 poster presentations which were represented by 15 countries. As a part of the conference, a scientist-Industry interface was also organised which was chaired by Mr. K. K. Kaushal I.F.S., Managing Director, SAGOSERVE, Salem, India and co-chaired by Dr. P. L. Saroj, Director, Directorate of Cashew Research, Puttur, India.

Techno-Incubation Centre at CTCRI

The foundation stone for the Techno-Incubation Centre fully funded by the Govt. of Kerala was laid at CTCRI on 17 August , 2013 by Dr. S. K. Chakrabarti, Director CTCRI in the presence of Shri. K. K. Ramakrishnan, Managing Director, Small Farmers Agribusiness Consortium (SFAC), Govt. of Kerala. The main objective of the Techno-Incubation centre at CTCRI with essential facilities required for the manufacture of value added products is to help the prospective entrepreneurs to utilize the facility and add value to their crop so that a sustainable income could be assured to them. Besides training will also be a major activity under the techno-incubation Centre.

Harvest Festival at Kasaragod

Banana harvest festival and celebration of successful validation of efficacy of cassava based biopesticide against pseudostem weevil of banana, was organized at Periya Community hall in Kasragod on 27 July, 2013. Krishi Vigyan Kendra, CPCRI, Kasaragod has conducted field level demonstrations on effectiveness of CTCRI developed cassava biopesticide, *Nanma* and *Menma* against pseudostem weevil in banana as a part of RKYV project at Periya and Madikai Panchayaths of Kasaragod district. A total of 10000 banana plants were treated with the cassava biopesticides, *Nanma* and *Menma* developed by CTCRI. The harvest festival was inaugurated by Sri. K. Kunhiraman, MLA, Uduma. Dr. George V Thomas, Director, CPCRI, Kasaragod presided over the function and delivered the key note address. Dr. C. A. Jayaprakas, Head, Division of Plant Protection, CTCRI, Trivandrum, gave an overview of the project and briefed about the activities being carried out in three districts of Kerala. Dr. S. Leena presented

the report on the activities being undertaken for the implementation of the project in Kasaragod district.

Annual Project Review and Planning Workshop of FoodSTART

Annual Project Review and Planning Workshop of Food Security through Roots & Tubers (FoodSTART) was organized by Regional Centre of CTCRI, Bhubaneswar at Mayfair Lagoon Hotel, Bhubaneswar during 28 -31 August 2013. The FoodSTART team members from China, Bangladesh, Indonesia, Philippines and India attended the workshop. Dr. N. K. Krishna Kumar, DDG (Hort), ICAR, New Delhi delivered the key note address during the inaugural function. In his speech, he stressed the importance of root and tuber crops in food and nutrition security of tribal and poor farmers. He also enumerate that in the changing climate, root and tubers have greater role to play for strengthening the food basket. Earlier, Dr. Dindo Campilan welcomed the delegates. Dr. S. K. Chakarabarti, Director, CTCRI, Dr. Julian Parr, CIP, and Mr. Sana Jatta, IFAD gave welcome messages.

Consultation Meeting on Cassava Value Chain in Tamil Nadu, India under **FoodSTART project on Root and Tuber Crops for Food Security of CTCRI, India**

The consultation meeting of the stakeholders of the cassava value chain in Tamil Nadu, India under Food START project on Root and Tuber Crops for Food Security undertaken by CTCRI, Trivandrum was held at Hotel Grand Estancia on 11 December, 2013 at Salem, Tamil Nadu. About 50 participants attended comprising CTCRI Scientists , CIP Scientist, Tamil Nadu State Horticulture Department Officials, Tamil Nadu Cooperative Department officials, Starch and Sago factory Entrepreneurs, Wafer making small units entrepreneurs and Starch traders, SAGOSERVE (Cooperative Marketing society for sago) WAFERSERVE (Cooperative marketing society for Cassava Wafers), Tamil Nadu Agricultural University scientists, Krishi Vignan Kendra (arm Science Centre) subject matter specialists and farmers. Dr. M. Anantharaman, Head, Extension and Social sciences, CTCRI welcomed the guests and a brief message followed by introduction of each other. Shri. Arulmurugan, chairman of SAGOSERVE inaugurated the meeting and stated that technologies have major say in improving cassava value chain business. Shri. K. K. Kaushal, MD, SAGOSERVE put forth an idea of starting Tapioca (Cassava) board like other commodities namely tea, coffee etc. Dr. V. Surjit gave a brief introduction about FoodSTART and mode of operation. Presentations were made by Dr. M. Anantharaman: Value chain study on Cassava in Tamil Nadu., Shri. R. Sivakumar: Cassava processing industries in Tamil Nadu, Shri. S. S. Natarajan: Experiences with Modern Cassava factory in Tamil

Nadu and Shri. K. K. Kaushal: Role of cooperative organization in Marketing Cassava.

Consultation meeting Under CIP –IFAD Project at CTCRI RC, Bhubaneswar

A consultation meeting under the CIP- IFAD project on FoodSTART was organized at CTCRI RC, Bhubaneswar during 6-7 November, 2013. About 30 delegates representing CIP, CTCRI, Department of Agriculture, Orissa, OTLP, Orissa NGOs and farming community participated. Theprogramme had an opening session in which welcome address was given by Dr. R. S. Misra followed by overall review of FoodSTART by Dr. Dindo Campilan. Assessment studies preparations were done by Dr. V. Surjit, CIP, Dr. M. Nedunchezhiyan and Dr. V. S. S. Mithra. Dr. M. Anantharaman presented a paper on value chain analysis on sweet potato in Orissa.

Indo-Swiss cassava network meeting

Indo Swiss Cassava Network project approved under Indo Swiss collaboration in biotechnology with an objective of development of transgenic cassava resistant to cassava mosaic disease in India (Cultivars – H 226, Sree Apoorva & Sree Athulya) with partners ETH- Zurich & University of Basel from Switzerland and Central Tuber Crops Research Institute from India under the CTCRI biotechnology component and Tamil Nadu Agricultural University, India under the Socio economic component.

Indo-Swiss cassava network meeting was held during 19-20, January 2014 at CTCRI, which was sponsored by Indo Swiss collaboration on Biotechnology (ISCB). This meeting was mainly convened by ISCB to facilitate the network partners to familiarize the activities, guidelines and finalising the work schedule of Indo-Swiss cassava Network which was approved in October 2013 with network partners comprising ETH, Zurich & University of Basel from Switzerland and CTCRI & TNAU from India with Dr.Herve Vanderschuren, ETH, Zurich (Network coordinator). Sixteen participants attended the meeting, which includes 6 from Switzerland and rest from India. The project will start on 1st May 2014 and the duration of the project is for three years

ICAR entrance exam

ICAR's 18th All India Entrance Examination for admission to U.G. and P.G. degree programmes in agriculture and allied science subjects [AIEEA-UG-2013 & AIEEA - PG - 2013] was held on Saturday, the 20th April 2013 and Sunday, the 21st April 2013

Exhibitions

1. Niravu haritha samruthi 2013, Kodungallur, 21-24 May, 2014.
2. ICRTC 2013 ISRTC & CTCRI, at Mascot Hotel, 9 - 12 July, 2013.
3. Bharat Nirman Campaign 2013, PIB, Alappuzha , 6 – 9 September, 2013.
4. Technology week Celebration 2013, Trivandrum, 28 October to 1 Novovember, 2013.
5. Eureka Science Exhibition, Trivandrum, 29 October, 2013.
6. Niravu Haritha Samithi 2013, Trissur 21-24 May, 2013.
7. School Expo 2013, New Jyothi Cental School, Trivandrum 22 & 23 November, 2013.
8. SYMSAC-VII, IISR, Madikeri, Karnataka27 -29 November, 2013.
9. India International Trade Fair 2013, New Delhi, 14- 27 November, 2013.
10. Tuber Crops day 2013, Trivandrum, 13 December 2013.

11. Karshikamela 2014, Thodupuzha, 26st December, 2013 to 4 January, 2014.
12. 26th Kerala Science Congress Expo 2014, Wayanad, 28 - 31 January, 2014.
13. Haritholsavam Mahamela - 2014, Kannur, 25 January to 2 February, 2014.
14. Krshivasant National Exhibition 2014, Nagpur, 9 – 13 February, 2014.
15. Mega Exhibition 2014, Kollam, 10 – 13 February, 2014.
16. Second Globlal Ayurveda Festival & Expo 2014, Ernakulam 20 - 24 February, 2014.
17. Green Revoluation through Agrl Eng. Tech, 2014, Trivandrum, 22 & 23 February, 2014.
18. South Zone Regional Agri Fair 2014, Trissur, 28 February to 6 March, 2014.

Krishi Vasant, Nagpur

Medigiri, Karnataka

National Science Day Celebration

National Science Day 2014 was celebrated during 25-26 February, 2014 on the focal theme "Fostering Scientific Temper" and the event was sponsored by 'Kerala State Council for Science, Technology and Environment' and supported by 'Department of Science & Technology, Govt of India.' Various programmes like guest lectures, quiz, elocution & poster making competitions were organized for college students and staff of CTCRI during the occasion. Prof. V. K. Damodaran, Chairman, Centre for Environment and Development and Sri. N. T. Nair, Chief Editor, Executive Knowledge Lines, Thiruvananthapuram delivered lectures on 'Science, Prejudice and Scientific Temper 'and 'Science, Technology and Innovation for India's Resurgence'.

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:

- Seventy one books were added to the stock and these books were made ready for circulation.
- Entries were added to integrated library database.
- One hundred and thirty nine current journal issues were added to the Kardex sheet.
- Twenty four issues of Current Science Journal and three issues of Journal of Root Crops were sent to Regional Centre of CTCRI, Bhubaneswar.
- Reactivation of indiastat.com for the ready reference of statistical data.
- DDR requests were processed from CeRA and action was taken.

वर्ष 2013-14 के दौरान इस संस्थान में की गयी राजभाषा कार्यान्वयन से सम्बन्धित कार्यक्रम

राजभाषा कर्यान्वयन समिति की बैठक का आयोजन

इस संस्थान की निदेशक की अध्यक्षता में ता 29.06.2013, 30.09.2013, 21.12.2013 और 28.03.2014 को राजभाषा कार्यन्वयन समिति की बैठकों का आयोजन किया गया इस अवसर पर राजभाषा कार्यन्वयन से संबधित विभिन्न मुद्दों पर विचार - विमर्श किया गया उसके आधार पर उक्त मुद्दों के अनुपालन किया जा रहा है।

हिन्दी कार्यशाला का आयोजन

1. संघ सरकार की राजभाषा नीति के अनुपालन में इस संस्थान के सभी कर्मचारीयों के लिए 27.07.2013 को "हिन्दी व्याकरण और इसके उपयोग" 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 श्रीमती श्रीलता, हिन्दी प्रध्यापक, हिन्दी शिक्षण योजना, वीएसएससी, तिरुवनंतपुरम का स्वागत किया और कार्यशाला में अच्छी उपस्थीति पर संतोष प्रकट किया। श्रीमती श्रीलता ने हिन्दी व्याकरण और इसके उपयोग पर क्लास लिया। कुल 50 प्रतिभागियों ने कार्यशाला में उत्साहपूर्व भाग लिया। प्रतिभागियों की राय थे कि इस तरह के कार्यशालाओं की बारंबारी बढाई जानी चाहिए क्यों कि उन्हें यह बहुत फायदेमंद लगा। श्रीमती टी के सुधालता, तकनीकी अधिकारी (हिन्दी) ने धन्यवाद प्रस्ताव पेश किया और श्रीमती श्रीलता की क्लास की सराहना की।
2. 2. ता 21.12.2013 को "हिन्दी पत्राचार /शब्दावली" पर एक हिन्दी कार्यशाला आयोजित किया गया। डॉ. एस. के चक्रवर्ती, निदेशक और अध्यक्ष (राजभाषा), कार्यशाला का उद्घाटन किया। डॉ. वी. एस संतोष मित्र, वरिष्ठ वैज्ञानिक और संपर्क अधिकारी (राजभाषा) ने सभा का स्वागत किया। श्रीमती श्रीलता, हिन्दी प्राध्यापक (हिन्दी शिक्षण योजना, विएसएससी, तिरुवनंतपुरम) ने क्लास लिया। कुल 51 प्रतिभागियों ने कार्यशाला में उत्साहपूर्व भाग लिया। श्रीमती. टी.के सुधालता, तकनीकी अधिकारी (हिन्दी) ने ध्यानवाद प्रस्ताव पेश किया और सभी प्रतिभागियों को कार्यशाला से प्रास ज्ञान उपयोग करने के लिए अनुरोध किया।

जुलाई 2013 में आयोजित ट्रॉपिकल कंद फसलों संबधित, अतंरराष्ट्रीय सम्मेलन में प्रथम दिवस आवरण द्विभामी रूप में तैयार करके विमोचित किया गया।

कृषि मंत्रालय, डेयर, नई दिल्ली के अवर सचिव, श्रीमती रेखा आनंद, और श्री पूरन सिंह, सहायक निदेशक (राजभाषा) द्वारा ता 16 और 17 अप्रैल 2013 को, भारत सरकार की राजभाषा नीति के अनुपालन के संबंध में इस कार्यालय का निरीक्षण किया था। उनके निरीक्षण के दौरान, इस संस्थान द्वारा किये गये राजभाषा कार्यन्वयन से संबंधित सभी कार्यों की सराहना की। कुछ कमियों को भी बताया गया और समिति ने नोट किया था कि उक्त कमियों की लक्ष्य प्राप्त पास करने केलिए प्रयत्न किया गया।

हिन्दी पखवाडा समारोह का आयोजन

ता. 14-18 सितम्बर 2013 को हिन्दी पखवाडा मनाया गया । संस्थान की स्टाफ और बच्चों के लिए विविध हिन्दी प्रतियोगिताएं आयोजित की गई। (निबंध लेखन, अनुवाद, भाषण, कविता-पाठ, सुलेख, खुला मंच, अन्ताक्षरी, सिर्फ एक मिनट आदि)

ता 29.11.2013 को डॉ.एस. के. चक्रवर्ती, निदेशक महोदय की अध्यक्षता में पुरस्कार वितरण किया गया। अध्यक्ष भाषण में उन्होंने सभी प्रतियोगियों/पुरस्कार विजेताओं को बधाई प्रकट किया। समापन समारोह की अवसर पर आमंत्रित विशेष अतिथि, विमेन्स कालेज, तिरुवनंतपुरम की असिस्टेंट प्रोफसर (हिन्दी विभाग), डॉ. आर. आई. शांती द्वारा सभी विजेताओं को पुरस्कार और प्रमाण-पत्र वितरण की गई और आर्शीवाद भाषण दी गई।

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

तिरुवनंतपुरम नगर राजभाषा कार्यान्वयन समिति के बैठकों में, इस संस्थान के निदेशक महोदय और अध्यक्ष (राजभाषा), डॉ. एस. के. चक्रवर्ती, डॉ. वी एस संतोष मित्र, वरिष्ठ वैज्ञीनिक और संपर्क अधिकारी (राजभाषा), श्री. डेविस जोसफ, प्रशासनिक अधिकारी और सदस्य (रा भा) और श्रीमती टी. के सुधालता, तकनीती अधिकारी (हिन्दी) ने भाग लिया

इस संस्थान का वार्षिक रिपोर्ट/सी टी सी आर आई समाचार आदि अनुवाद करके मुद्रित किया गया और सभी संस्थानों को भेजा गया।

हिन्दी प्रशिक्षण कार्यक्रम

भारत सरकार की राजभाषा नीति के अनुसार इस संस्थान की 19 कुशल समर्थन स्टाफ 2 प्रधान वैज्ञानिक और 1 वरिष्ठ वैज्ञानिक को हिन्दी प्रबोध प्रशिक्षण कार्यक्रम दिया गया कक्षाएं ता 05.फरवरी 2013 से 16 मई 2013 तक शुरु कर दिया श्रीमती श्रीलता, वी एस एस सी की हिन्दी प्राध्यापक ने उनको क्लास लिया।

प्रतिभागियों को यह बहुत लाभान्वित किया प्रतिभागियों ने ता. 21 मई 2013 को परीक्षा में उपस्थीत थे तेरह स्टाफ सदस्यों ने परिक्षा उत्तीर्ण की जिनमें चार सदस्यों ने प्रोत्साहन के लिए पात्र थे और उनको पुरस्कार वितरण किया गया।

हिन्दी प्रोत्साहन योजना

हिन्दी में काम करनेवालों को प्रोत्साहन योजना शुरु किया गया प्रोतसाहन योजना में भाग लिए/प्रोत्साहन के पात्र कर्मचारियों को नकद पुरस्कार दिया गया इस अवधि के दौरान 3 प्रतिभागियों को पुरस्कार वितरण किया गया।

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

सभी परिपत्र, धारा 3(3) के सभी कागजात द्विभाषी रूप में किये गए।

हिन्दी में प्रास पत्रों के उत्तर हिन्दी में दिए गए।

वार्षिक कार्यक्रम के निर्धारित लक्ष्यानुसार अधिक से अधिक पत्राचार हिन्दी में किये गए।

प्रशासनिक कामकाज में उपयोग द्विभाषी प्रपत्र arisnetshare पर शामिल किये गए।