CTCRI/OSF/RP/424

Research Highlights
2013-2014

केन्द्रीय कन्द फसल अनुसंधान संस्थान
(भारतीय कृषि असुसंधान परिषद्)
श्रीकार्यम, तिसुवनन्तपुरम -६९५ ०१७, केरल, भारत

CENTRAL TUBER CROPS RESEARCH INSTITUTE
An ISO 9001:2008 Certified Institute
(Indian Council of Agricultural Research)
Sreekariyam Thiruvananthapuram
Kerala India



CTCRI/QSF/RP/424

अनुसंधान की मुख्य विशेषताएं
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Front cover : Elephant foot yam field with drip irrigation
Taro, Greater yam, Coleus
Back cover : Yam bean plant and tuber

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PREFACE

It gives me immense pleasure to place before you the Research Highlights of Central Tuber Crops Research Institute for the year 2013- 2014. The Institute established in 1963 with its head quarters at Thiruvananthapuram, Kerala, has grown over the years into a premier research organization of international repute and become an **ISO 9001 : 2008 Certified Institute since 31 March, 2014**. In fact, we celebrated the Golden Jubilee of the institute during 9-12 July, 2013, where the entire global scientific fraternity working on tropical tuber crops participated. As a public institution, it is our paramount responsibility to keep informed our clientele farmers, entrepreneurs, industrialists, extension personnel, and policy makers about the latest achievements of the institute. To fulfill that commitment, a concise document on research progress and achievements made on other related activities of the institute during 2013- 2014 has been prepared and presented here.

As the national germplasm repository for tropical tuber crops, CTCRI is conserving 5,832 accessions as field gene bank. During the year, two triploid cassava hybrids *viz.,* Sree Athulya and Sree Apoorva were recommended for cultivation in the states of Tamil Nadu and Andhra Pradesh by the Central Sub-Committee on Crop Standards. Besides, several elite clones of cassava with novel traits *viz.,* cassava mosaic disease resistance with high starch content and good fried chip quality, high dry matter with CMD resistance and keeping quality have been identified. The greater yam variety Da 293 with good culinary quality and compact tuber is being widely cultivated by the farmers in Ganjam district of Odisha.

Rice-pulse-short duration cassava has been identified as a profitable crop sequence. Similarly, organic farming of yams and aroids has been demonstrated to be equally stable as that of conventional practice over a period of five years. The technology of using weed control ground cover (WCGC) completely suppressed the weeds during the entire crop period of cassava with highest tuber yield and net income of Rs.1,60,450 ha^{-1}. Current and future climate suitability maps of cassava and elephant foot yam in India were developed using geoinformatics tool. The efficacy of the biopesticide formulations *Menma* for management of banana pseudostem weevil was validated on large scale (over 30,000 plants) in the farmers' fields in three districts (Thiruvananthapuram, Malappuram and Kasaragod) of Kerala. An innovative injection needle with multiple discharge points was designed and fabricated for efficient delivery of *Menma* in banana pseudo-stem. Bio-intensive management schedules have been standardized for taro blight, collar rot of elephant foot yam and greater yam anthracnose. Reverse Transcription Loop Mediated Isothermal Amplification (RT- LAMP) and dip-stick kit were developed for rapid detection of *DsMV* in less time.

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. Cereal grain shaped pastas were made from cassava-maida blends as well as cassava-rice blends. 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, and injection moulded product using poly lactic acid-oxidized starch composites have been developed. A web based interactive tool for tuber crops statistics has been developed using R environment for statistical computing. Similarly, Elephant Foot Yam Growth Simulation Model (EFYSIM), Sree Visakham Cassava Expert System, 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. 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.

I would like to take this opportunity to place on record my sincere thanks to Dr. S. Ayyappan, Secretary, DARE and Director General, ICAR for his sustained encouragement and guidance. I would also like to thank 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 support. I appreciate the sincere efforts of the editorial committee in compiling the report and all the scientists, officers and staff members for their effort in the advancement of our institute.

Thiruvananthapuram
21. 06. 2014

S. K. Chakrabarti
Director

RESEARCH ACHIEVEMENTS

There were 17 ongoing institute research projects and 25 externally aided projects during 2013- 2014. The salient achievements of the projects are highlighted here. The scientific staff strength was 41 including the Director during the reporting period.

CROP IMPROVEMENT

- 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.

Field view of sweet potato gene bank (a);
New collections of germplasm : elephant foot yam cv karunaikizhangu (b); taro (c) and arrow root (d)

- 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.

Cassava variety Sree Athulya

- 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.

CMD resistant cassava

- 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.

CROP 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. 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.

Harvest of first crop of rice

- 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.

Rooting pattern in K use efficient cassava genotypes

On Farm trial of production technologies

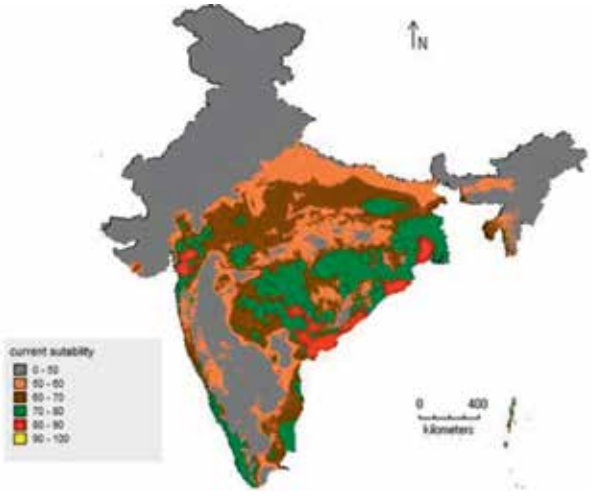
- The low input management strategy comprised of the NUE genotype (Ac. No. 906) with low cost soil fertility management involving soil test based application of fertilizers (NPK@106:0:83 kg ha^{-1}), green manuring *in situ* with cowpea as organic source and use of nutrient efficient biofertilizers resulted 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.

Drip irrigation in elephant foot yam

Weed control ground cover 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.



Climate suitability map

- 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 (Sree Vijaya) and elephant foot yam (Gajendra) were produced through micropropagation followed by indexing and distributed to the farmers.

Elephant foot yam Cassava

Hardening of virus free plants

CROP PROTECTION

- 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) effectively managed weevil in sweet potato field. Validated the efficacy of *Menma* against banana pseudostem weevil (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 banana pseudostem weevil in banana. Standardized a technique to detect cyanogen in the cassava biopesticide by using gas chromatography.

Monitoring sweet potato weevil populations

Application of *Menma* to banana

- 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 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}.

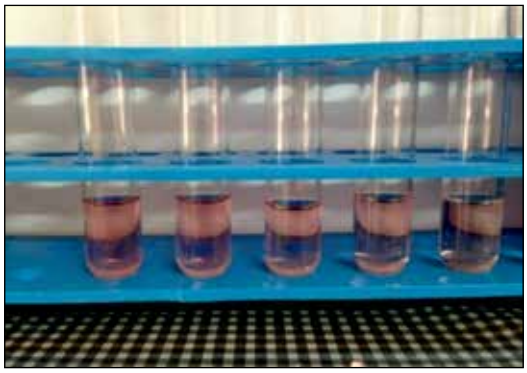
Field experiment : Utilisation of organic amendments to manage elephant foot yam collar rot

- 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.

Growth promotion by 13-9



IAA Production

- Spraying of carbendazim (0.05%) alone showed the lowest disease intensity (PDI, 33%) and highest yield (15.16 t ha^{-1}) in 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.

Callus proliferation and regeneration in greater yam

- *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.

Taro

Elephant foot yam

Dasheen mosaic virus infection

- DAS- ELISA performed with 46 virus infected greater yam leaves using *YMMV* and yam *Macluravirus* 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.

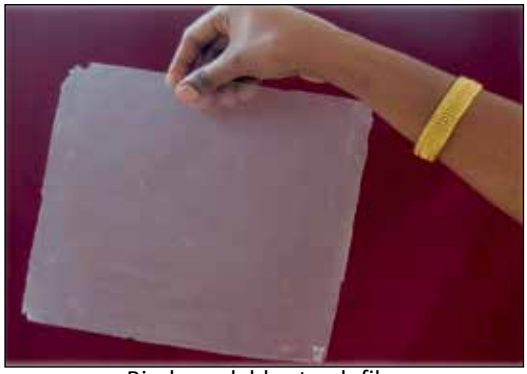
CROP UTILIZATION

- 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.

Sweet potato starch noodles

Cereal grain shaped pasta

- 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.



Biodegradable starch film

- 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 composites were prepared using modified 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.

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

- 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 mach`ine was about 2400 litres per hour.
- 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%).

EXTENSION AND SOCIAL SCIENCES

- 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.

FLD on Taro in Mon district, Nagaland

Elephant foot yam demonstration plot in Tripura

- 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.

ALL INDIA COORDINATED RESEARCH PROJECT ON TUBER CROPS (AICRPTC)

- A total of 58 new accessions of various tuber crops were added to the field gene bank, thus maintaining a total of 4837 accessions in different AICRP centres. 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 were suitable for the detection of genetic diversity in elephant foot yam. 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.
- Under MLT on cassava, out of the six entries evaluated during 2013-2014, Me 833 produced maximum tuber yield at VR Gudem, Andhra Pradesh and Yethapur. The MLT of EFY with the promising lines was conducted across the centres and found that AC-14 from Jagdalpur performed better at Kalyani, Jagdalpur and Kovvur. Among all the five taro entries tested across the centres, RNCA-1 produced the highest cormel yield

at Dholi, Faizabad and Rajendranagar. In yam bean, BCYB-1 emerged as the most suitable variety for West Bengal conditions and performed well in terms of tuber yield and harvest index. BCYB-1 may be promoted in West Bengal for releasing as variety.

- Experiments on the 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 an additional net income of Rs 41895 when sericulture component was included. Site specific nutrient management studies in cassava and elephant foot yam indicated that maximum yield was recorded with standard fertilizer dose followed by soil test based application of nutrients. 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 91192 ha^{-1}, whereas production of rice alone was 3584 kg with net return of Rs 36680 ha^{-1}.
- Planting sweet potato with garlic or coriander in 1:1 ratio could reduce the weevil infestation and resulted in higher marketable tuber yield at Kalyani and Dholi. The results of the fourth 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.

GENERAL

TRAINING AND OTHER RELATED PROGRAMMES

- 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.

Demonstration of mobile starch extraction

- 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.

Demonstration of cassava chipping machine

- 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 colla-borative RKVY project.
- 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 Marang-phung village on December 5, 2013 and in Riha village, Manipur 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.
- 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.

IMPORTANT EVENTS

13th Annual Group Meeting of the AICRP on tuber crops at Assam Agricultural University, Jorhat, Assam under the auspices of the Horticulture Department	:	26 – 28 April, 2013

Annual Group Meeting of the AICRP on Tuber Crops

39th Institute Research Council meeting of CTCRI	:	16 - 18 April, 2013
Cassava brainstorming at CTCRI under the chairmanship of Dr. N. K. Krishnakumar, DDG (HS)	:	17 May, 2013
Fourth H. H. Sree VisakhamThirunal 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)	:	18 May, 2013

Harvest Festival at Pallichal to celebrate the success of the validation of biopesticide developed by CTCRI against pseudo-stem weevil in banana at the farmer's field. : 15 June, 2013

Foundation stone laid out for Internationl Training Hostel at CTCRI by Dr. S. Ayyappan, Secretary, DARE and DG, ICAR : 9 July, 2013

International Conference on Tropical Roots and Tubers for Sustainable Livelihood under Changing Agro-Climate (ICTRT 2013) organized by the Indian Society for Root Crops (ISRC) in association with Central Tuber Crops Research Institute (CTCRI) at Hotel Mascot, Thiruvananthapuram, Kerala, India. : 9-12 July, 2013

Inaugural function of ICTRT 2013

Banana harvest festival and celebration of successful validation of efficacy of cassava based biopesticide against pseudostem weevil of banana at Periya Community Hall in Kasaragod.	:	27 July, 2013

Banana harvest festival at Kasaragode

Foundation stone laid out for the Techno-Incubation Centre funded by the Govt. of Kerala at CTCRI by Dr. S. K. Chakrabarti, Director, CTCRI.	:	17 August, 2013
Annual Project Review and Planning Workshop of Food Security Through Roots & Tubers (FoodSTART) at Mayfair Lagoon Hotel, Bhubaneswar.	:	28 -31, August 2013
National Symposium on "Pathogenomics for diagnosis and management of plant diseases" by CTCRI & Indian Phytopathological Society (South Zone) at CTCRI	:	24-25, October 2013
Consultation meeting under the project CIP- IFAD-FoodSTART- Food Security through Asian Roots and Tubers at CTCRI RC, Bhubaneswar	:	6-7 November, 2013.
Tuber Crops Day	:	13 December, 2013

Tuber Crops Day

The consultation meeting of the stakeholders of the cassava value chain in Tamil Nadu, India under FoodSTART project on Root and Tuber Crops for Food Security undertaken by CTCRI, Trivandrum at Hotel Grand Estancia, Salem, Tamil Nadu, India	:	11 December, 2013
The consultation meeting of the stakeholders of the Cassava value chain in Kerala, India under FoodSTART project on Root and Tuber Crops for Food Security undertaken by CTCRI, Trivandrum at Hotel Wyte Fort, Adoor	:	16 December, 2013.
IMC meeting	:	20 December, 2013
Third meeting of 6th Research Advisory Committee	:	9 January, 2014
QRT : First meeting at Head quarters	:	7 and 8 January, 2014
QRT: Second meeting at Regional centre	:	22 and 24 January, 2014
National Science Day Celebration	:	25 and 26 February, 2014

PARTICIPATION IN EXHIBITIONS

CTCRI participated in 23 exhibitions in Assam, Kerala, Maharashtra and Manipur states in India

VISITS ABROAD

Seven scientists have visited abroad for consultancy, to attend training, as invited speakers and to attend international symposium, workshops and conferences.

PUBLICATIONS

- Papers in research journals: 41
- Books : 5
- Book chapters:19
- Popular articles: 26
- Folders/leaflets/pamphlets: 5
- Papers in conferences/proceedings/seminars: 119
- Technical bulletin:5
- Annual reports (CTCRI and AICRPTC): 2
- CTCRI News: 2
- Other Publications : 10

AWARDS AND 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.
- 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.

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.
- 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.

Dr. S. Chandrababu and Mrs. K.S. Sudha Devi receiving institute awards

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. 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.

Ph.D Degree

- 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.

DISTINGUISHED VISITORS

- Princess Gouri Parvathi Bayi, Member of Royal Family of erstwhile Travancore
- Dr. S. Ayyappan, Secretary, DARE and DG, ICAR
- Dr. N. K.Krishnakumar, DDG (HS), ICAR
- Dr. P. K. Chakarbarti, ADG (Plant Prot ection)
- Dr. S. K. Malhotra, ADG (HS)
- Dr. K. Ramasamy, Vice Chancellor, TNAU
- Dr. Abraham Varghese, Director, NBAII, Bengaluru
- Dr. K. Veluthampi, MKU,Madurai
- 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

- 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

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

LIBRARY SERVICES

Information support was provided to all the Research and Training activities of the Institute. During the period, 71 books and 22 journals were added to the stock. Library has provided services like Ready reference , circulation of books, CD searches, CeRA and photocopying to the users.

INSTITUTE TECHNOLOGY MANAGEMENT UNIT (ITMU)

Institute Technology Management Unit (ITMU) has been active in carrying out following IP activities during the period 2013-2014.

The unit had engaged with public/private parties for the commercialization of technologies. Technology of value added fried products and fried chips from cassava have been transferred to Ms. Beena, Manikanteswaram, Thiruvananthapuram on a consultancy mode. A collaborative (contractual) agreement was made with M/s Boosters International, Tamil Nadu for preparing gelatinized dough for making tapioca papad. License Agreement for

Collaborative agreement with M/s Boosters International, Tamil Nadu

Planting Material Production of Tuber Crops on consultancy mode was given to M/s Natura Nursery & Agro products, Meppayur, Kozhikode. A sensitization programme on Intellectual property rights was organized on March 25, 2014 at CTCRI.

The ITMU has taken initiative in filing one provisional patent application "Electronic Crop"- an electronic device for providing realistic agro advisory to the farmers and three copyright applications, MADHURAM, SPOTCOMS and SIMCAS.

Agriculture Knowledge Management Unit (AKMU)

The unit 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 facilit, VPN connectivity for Global Access to the servers (under implementation) & New touch screen information kiosk (to be installed soon).

Planting material production (2013- 2014)

Crop	Quantity produced (Kg)
Elephant foot yam (kg)	35000
Greater yam (kg)	25000
White yam (kg)	1500
Lesser yam (kg)	850
Tapioca stems (nos)	60000
Sweet potato vines (nos)	50000
Arrowroot (kg)	1000
Taro (kg)	6000
Coleus cuttings (nos)	2500
Yam bean (kg)	100

"CTCRI achieved the prestigious ISO 9001: 2008 Certification"
31 March 2014 to 30 March 2017


VEXIL BUSINESS PROCESS SERVICES

Certificate

Central Tuber Crops Research Institute
(Indian Council of Agricultural Research)
Sreekariyam
Thiruvananthapuram 695 017
Kerala
INDIA

Development of elite varieties of tropical tuber crops (cassava, sweet potato, yams, aroids and minor tubers), sustainable crop production, protection, post harvest and value addition technologies suited for different agro-climatic regions of the country and transfer of technologies to user systems

Original Issue : 31 March 2014
Latest Issue : 31 March 2014
Valid Till : 30 March 2017

ISO 9001:2008

RETIREMENT

The following scientific, technical and skilled support staff retired from service during 2013- 2014.

Dr. Lila Babu, Principal Scientist, Division of Crop Utilization

Shri. S. Divakaran, Technical Officer

Shri.Yudhistra Sahoo, Technical officer, RC

Smt. K. V. P. Sarada, Assistant, Administration

Shri. A. R. Bhaskaran, Smt. S. Thankamani Amma, Shri. G. Ravindran, Shri. V. G.Sankaran, Shri. M. Krishnan, Smt. P. Sarojini: Skilled support staff

PROMOTION /NEW JOINING/TRANSFER

Dr. A. N. Jyothi, Dr. C. Mohan, Dr. T. Srinivas, Dr. K. Rajasekhara Rao and Dr. K. Laxminarayana were promoted as Principal Scientist.

Dr. Sheela Immanuel (Extension) joined as Principal Scientist in the Section of Extension and Social Sciences.

Shri. P. J. Davis transferred to CIFT, Kochi

Shri. Davis Joseph joined as Administrative Officer.

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

Agr*e*search with a h*u*man touch

Akshara Offset, Tvm. Ph : 2471174