CTCRI/QSF/RP/424

अनुसंधान की मुख्य विशेषताएं

RESEARCH HIGHLIGHTS

2018–2019

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
श्रीकारियम तिरूवनंतपुरम 695 017 केरल भारत

ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
Sreekariyam Thiruvananthapuram 695 017 Kerala India

CTCRI/QSF/RP/424

अनुसंधान की मुख्य विशेषताएं
RESEARCH HIGHLIGHTS
2018–2019

भाकृअनुप-केन्द्रीय कंद फसल अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद्)
श्रीकारियम तिरुवनन्तपुरम 695 017 केरल भारत
ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
SREEKARIYAM THIRUVANANTHAPURAM 695 017 KERALA INDIA

ICAR–Central Tuber Crops Research Institute
Sreekariyam, Thiruvananthapuram 695 017
Kerala, India

Tel.No. (91) (471) 2598551 to 2598554
Fax: (91) (471) 2590063
E-mail: director.ctcri@icar.gov.in
Website: http://www.ctcri.org

Published by
Dr. Archana Mukherjee
Director

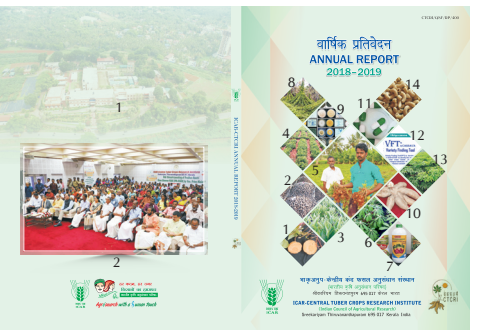
Compiled and Edited by
Dr. G. Suja
Dr. M.L. Jeeva
Dr. A.N. Jyothi
Dr. V. Ramesh
Dr. A. Asha Devi
Dr. D. Jaganathan
Dr. Sanket J. More
Shri. K. Hanume Gowda
Dr. S. Karthikeyan
Shri. B.S. Prakash Krishnan

Design & Printing
Directorate of Knowledge Management in Agriculture, ICAR, New Delhi

Cover Illustrations

Front

1. Orange-fleshed sweet potato
2. Chinese potato tubers
3. Arrowroot germplasm
4. Chinese potato field
5. FLD on Chinese potato
6. Field of Sree Suvarna, CMD resistant variety of cassava
7. Micronutrient formulations
8. Validation of organic greater yam in coconut garden
9. Pathogens causing corm rot in elephant foot yam
10. Tubers of Sree Sakthi, CMD resistant variety of cassava
11. Sweet potato anthocyanin capsules
12. VFT: Variety Finding Tool
13. Demonstration of SSNM in elephant foot yam
14. Sweet potato pasta



Back

1. ICAR-CTCRI aerial view
2. PM-KISAN-cum-live web telecast at ICAR-CTCRI

Correct Citation

ICAR-CTCRI 2019, Research Highlights 2018-2019, ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, 58 p

Laser typeset at M/s Dot & Design, 208, Reshabshree House, Ranjeet Nagar Comm. Complex, New Delhi 110008 and printed at M/s Chandu Press, 469 Patparganj Industrial Estate, Delhi 110092

CONTENTS

PREFACE

The ICAR-Central Tuber Crops Research Institute (CTCRI), in its 56th year of service, is spearheading with 67 improved varieties, besides farmer-friendly production, protection and value addition technologies in tropical tuber crops, a group of climate-ready crops that can sustain food, nutritional and environmental security. Termed as 'cheap energy capsules' and rich in dietary fibres, minerals, vitamins and anti-oxidants, roots and tubers are no more 'orphaned' or 'poor-man's crop', but have been raised to the status of 'nutraceutical-rich health foods and future smart crops'. In this background, I take pride to present the research accomplishments, technological advancements and development activities for the year 2018-2019 documented concisely in the form of 'Research Highlights of ICAR-CTCRI'.

The genetic wealth constituting 5579 accessions, continued to be enriched and conserved with valued traits. Two cassava mosaic disease (CMD) resistant varieties, Sree Sakthi and Sree Suvarna, were recommended for Central release for cultivation in Tamil Nadu, Andhra Pradesh, Maharashtra and Kerala for industrial use. Four early maturing, high yielding and drought tolerant sweet potato genotypes; two greater yam lines resistant to anthracnose, Da-110 and JAS-2; high yielding white yam hybrids, DrH-1180 and DrH-1157 and two high yielding white yam bushy hybrids, Drd-1095 and Drd-1142 and protocol for short term storage of cassava synthetic seed were developed.

The sustainable resource management technologies like feasible cropping systems involving tuber crops and pulses, water saving techniques in elephant foot yam, water scheduling for taro, drip fertigation for greater yam + maize system, soil test based INM and nutrient use efficient cassava genotypes for saving NPK fertilizers will help to enable 'Doubling of Farmers Income by 2022', the most important mission-mode programme of the Govt. of India. *Sree Poshini*, a mobile app developed for SSNM of tropical tuber crops is made available in Google play store.

IDM package for postharvest rot in elephant foot yam and anthracnose in yam, CMD resistant lines through OFTs at Salem and LAMP based diagnosis of *Sri Lankan cassava mosaic virus* were the other major research highlights. A few notable value addition technologies/products comprise sweet potato anthocyanin capsules, cassava flour based pasta, rice analogue, noodles from cassava–millet based composite flour, particle boards from cassava stem, functional sago using sweet potato leaf powder and beet root powder, thermoplastic starch sheets and wax coating of cassava tubers for prolonged shelf life. Technology commercialisation strategies assessment model, modified methodology for assessing the sustainable livelihood analysis of tuber crop farmers using DFID methodology, R-package for Soil Quality Index and two Mobile Apps, VFT-Cassava and VFT-Taro were developed.

Further, Corporate Social Responsibility initiatives were taken up by ICAR-CTCRI staff that included cleaning of flood affected areas and financial contribution.

'The Techno-Incubation Centre' is extending hand holding support to young entrepreneurs. Eight technologies on production and value addition were commercialized. The Institute

is moving forward with the twin flagship programme of the Govt. of India, '*Mera Gaon Mera Gaurav* and 'Swachh Bharath Mission'. The Institute bagged the 'Best Annual Report Award' for 2017-18. The quality research publications numbering to 260, including those in high impact national and international journals have improved the scientific credibility. A Video entitled 'Produce tuber Reduce hunger' was prepared and released by Shri. Radha Mohan Singh, Hon'ble Union Minister for Agriculture & Farmers' Welfare at New Delhi. Another significant event was the interactions held with Smt. Krishna Raj, Hon'ble Minister of State for Agriculture & Farmers' Welfare.

The Institute hosted the Hon'ble Prime Minister Shri. Narendra Modi Ji's interactions with Kerala farmers through video conferencing on the occasion of *"Pradhan Mantri Kisan SAmman Nidhi" (PM-KISAN)* scheme. For strengthening the R&D activities of the institute, RAC and IMC meetings were also convened. Besides, ICAR-CTCRI participated in 29 exhibitions and organized 80 trainings with the mission to reach the unreached. The Institute also observed World Environment Day, International Yoga Day, 150th Birth Anniversary of Mahatma Gandhi, World Soil Day, National Science Day and Tuber Crops Day.

I express my deep sense of gratitude to Dr. Trilochan Mohapatra, Hon'ble Secretary, DARE and Director General, ICAR for his invaluable guidance and support. I sincerely acknowledge the timely guidance provided by Dr. Anand Kumar Singh, DDG (Horticulture Science). I also thank Dr. T. Janakiram, ADG (HS-I), Dr. V. Pandey, Dr. B.K. Pandey, Dr. M. Das, Dr. S. Kant and Shri. P.K. Srivastava for their cooperation.

The support extended by PPV&FRA, Indo-Swiss collaboration, RKVY-Govt. of Kerala & Govt. of Odisha, KSCSTE, Kerala State Planning Board, Coconut Development Board, MANAGE, KVKs and other R&D Institutes and consortia research platforms of ICAR are duly acknowledged. The unstinted support from ICAR and the concerted efforts and hard work of the entire ICAR-CTCRI family enabled the Institute to make this year commendable. My sincere thanks to all our staff. I also appreciate and congratulate the editorial team for bringing out this publication on time.

25 July 2019

(Archana Mukherjee)
Director

RESEARCH ACHIEVEMENTS

The highlights of the genetic wealth conserved with newer collections, varieties released, processes, protocols, technologies, methods, high value compounds and postharvest machineries developed under eight Institute projects, two flagship projects as well as 27 external funded projects are given below:

CROP IMPROVEMENT

- A total of 5579 accessions, comprising 1324 cassava, 1497 sweet potato, 1161 yams, 1235 edible aroids and 362 minor tuber crops were maintained and conserved in the field gene bank of headquarters (HQ) and Regional Centre, Bhubaneswar.
- Sixty eight new collections of tuber crops, cassava (5), sweet potato (5); yams (13); edible aroids (11) and minor tuber crops (34) were added to the germplasm.
- Of the 1211 cassava accessions maintained at HQ, 375 indigenous accessions were characterized for 51 traits. The characters such as stem perimeter, total fresh tuber yield plant^{-1} and total stem and foliage weight plant^{-1} showed maximum variation.
- Cluster analysis divided the accessions into 25 morphotypes based on morphology. Detailed morphological and molecular characterization in 20 indigenous accessions of cassava, 10 each from two different morphotypes revealed that variability existed at the genetic level among accessions that were found similar morphologically.

Some of the morphotypes identified in the cassava germplasm based on morphological clustering

- Biochemical characterization for total starch, sugar, crude fibre, ash and dry matter contents in 100 cassava accessions showed that total starch content was highest for CI-187 (69.20%), while total sugars was highest for CI-260 (4%). Ash content ranged from 0.88% in CI-186 to 2% in CI-241 and crude fibre content ranged from 0.68% in CI-273 to 1.36% in CI-190.

- Morphological and molecular characterization of 85 sweet potato accessions from the eastern states of India including three wild species, *I. triloba*, *I. pes-tigridis* and *I. aquatica* showed that there were no duplicates. High intra-clusteral variability was noticed, indicating good amount of variability within this set. S-1408 and S-1572, which were collections from Chhattisgarh and West Bengal, respectively showed the least similarity (37%).

- In another set of 56 sweet potato accessions, storage root yield ranged from 0.011 to 0.458 kg per plant (0.8 t ha^{-1} to 38 t ha^{-1}). Tuber skin colour ranged between purplish pink (10) through pink (12) and light pink (10) to white colour (13). The tuber flesh colour varied from white to orange with some accessions showing purple or purplish tinge. Cooking quality was assessed based on IPGRI descriptors. Among the white or cream flesh type, S-1751, S-809, S-625, S-823, S-643, S-620 and S-691 were rated as having very good taste. Among the purple flesh type, S-1638 and S-1648 were tasty. Among the orange-flesh type, S-618 was having good taste. Based on organoleptic evaluation, 13 were having high starch, 17 medium starch and the rest were low starch lines. Apart from that, one accession (S-1710) had high fibre, eight had medium fibre and the remaining one had very low fibre as assessed by mouth-feel. Sweetness of storage root was highest in accessions S-1751, S-632, S-809, S-613, S-823, S-643, S-620 and lowest in S-1641 and S-1646.

Promising sweet potato accession S-1638

Accession No. S-87

- At the Regional Centre, 100 accessions of sweet potato germplasm were characterized for yield and flesh colour and four accessions (S-87, S-78, S-72 and S-100) were identified as having high yield. Among them, accession S-87 (1.20 kg $plant^{-1}$) was the highest yielder. Out of these, 27 were light yellow-

fleshed, 13 light orange-fleshed, 26 cream-fleshed and 34 were white-fleshed accessions.

- A total of 1110 accessions of yams comprising greater yam (591), white yam (158), lesser yam (220), potato yam (6) and wild yams (135) are being maintained in the field gene bank at the HQ.
- In greater yam, anthracnose resistant lines were identified through field screening and under lab conditions. Da-110 and JAS-2 were highly resistant, while Da-200, Da-340, Da-374, Da-489, TCR 308, TCR 319, TCR 264 and TCR 113 were resistant to anthracnose disease. In the pre-breeding lines, three hybrids viz., DaH-9/196, DaH-22-2-3 and DaH-58FG showed high field tolerance/ resistance to anthracnose disease.
- Cryopreservation was attempted using greater yam and white yam pollen. Cryo-stored pollen of white yam showed 30.29% staining and 20.01% *in vitro* germination, while 37.08% staining and 27.51% *in vitro* germination was observed in cryo-preserved pollens of greater yam. After hand pollination, a total of 2.26% fruit set in white yam and 11.42% in greater yam was observed using cryo-stored pollens.
- A total of 683 edible aroid germplasm comprising 429 taro, 203 elephant foot yam, 48 tannia and 3 *Alocasia* are being maintained in the field gene bank at HQ. IC numbers were obtained from ICAR-NBPGR for 59 taro accessions received from NEH region.
- Field screening for resistance against taro leaf blight identified 10 lines moderately tolerant to TLB viz., C-292, C-465, C-621, TCR 368, TCR 947 A, TCR 961, E-14, H-9, I-17 and HOB T2-1. Flowering was observed in seven taro accessions viz., C-66, C-292, C-485, C-621, H-45-75, HOB T2-1 and TTr17-7.
- Preliminary yield data of 28 accessions of taro showed that cormel yield ranged from 1.36 (H-12) to 16.11 t ha^{-1} (MNMS/14-2) and total yield from 1.98 (H-12) to 19.63 t ha^{-1} (Line 4).
- Molecular characterization of 36 taro accessions based on its reaction to taro leaf blight (TLB) showed that the primers gave high polymorphism as explained by average number of alleles per locus and Polymorphism Information Content (PIC). All the accessions showed good diversity as explained by high heterozygosity values. Few divergent lines could be identified using three marker systems viz., C-276 and C-679 (RAPD); IC012294 (SSR) and Muktakeshi (ISSR) and no duplicates were identified.

- Fifty taro accessions were evaluated for their acridity level in the leaf and petiole, where, 36 accessions had very high acridity level, eight medium acrid and six with low acridity.
- A total of 209 accessions of various minor tuber crops are being maintained in the field gene bank at the HQ.
- Fifteen accessions belonging to eight species of *Curcuma* were characterized using morphological as well as molecular markers to study the genetic variation existing in them. Wide variability was observed among the accessions. PCA showed that the characters such as leaf midrib colour, rhizome flesh colour, leaf texture and aroma of rhizome contributed mostly to the variability among the accessions of *Curcuma*. Morphologically, the highest intra-specific similarity was observed between the two *C. raktakanta* accessions (94%), while maximum inter-specific similarity was observed between *C. amada*-2 and *C. aromatica*-1. Clustering based on molecular markers also showed high variability and Mantels' test showed high correlation between the morphological and molecular systems.
- At the Regional Centre, 100 accessions of yam bean were evaluated for yield and ten lines were identified (Y-71, Y-77, Y-39, Y-54, Y-70, Y-10, Y-35, Y-57, Y-12 and Y-56) for high yield. Accession 71 (1.9 kg plant^{-1}) was the highest yielder.
- Two CMD resistant cassava varieties were recommended for Central release for cultivation in Tamil Nadu, Andhra Pradesh, Maharashtra and Kerala under irrigated/rainfed upland for industrial use. Sree Sakthi had an average tuber yield of 43 t ha^{-1}, whereas, Sree Suvarna had an average yield of 38 t ha^{-1}. Both are non-branching varieties.

Sree Sakthi

Sree Suvarna

- Cassava lines having desirable traits were identified viz., 15S-436 with CMD resistance, good culinary properties and high yield (48.10 t ha^{-1}); 15S-406 with high dry matter content (48.4%) and tuber yield (55 t ha^{-1}); 15S-156 with maximum dry matter (51.79%) and CMD resistance as well as seven lines rich in β carotene (17S-135, 15S-139, 17S-154, 17S-191, 17S-259, 17S-255 and

17S-52). The cassava varieties, CO-1, Sree Reksha, Sree Sahya, Kalpaka and CR-43-2 were identified for tolerance to postharvest physiological deterioration. Hybridisation was attempted between the genotypes contrasting for PPD tolerance and 250 hybrid seeds were collected.

- For identification of drought tolerant lines in cassava, 25 genotypes were screened in the field conditions. H-226 had the highest per cent of sprouting (94.44%), followed by Vellayani Hraswa (83.33%), 8S-501 (66.67%), 9S-127 (58.89%) and CI-126B (51.10%) under water deficit stress conditions. For molecular profiling, EST-Microsatellite markers derived from the drought transcriptome of cassava showed that six out of eight loci attempted, amplified. MeESSR 47 (Thylakoid membrane phosphoprotein 14 kDa, chloroplast precursor) was a highly heterozygous locus with a Polymorphism Information Content of 0.416 and Shannon's Information Index of 0.607.
- In the experiment on pyramiding of genes for cassava mosaic disease (CMD) resistance, 50 CMD resistant clonal hybrid with high yield, high starch and good plant types were evaluated.
- For identification of markers linked to high starch, 150 hybrid seedling progenies obtained between high starch line 9S-127 and Sree Padmanabha were phenotyped at harvest, and tuber yield of up to 5 kg was recorded. 9S-127 and Sree Padmanabha contained 43.82 and 37.96% starch, respectively, whereas in the progenies, starch content ranged from 27.32 (MS-79) to 49.88% (MS-120). Out of a total of 145 F_1 progenies, 37 progenies had < 38% DM, while, 53 progenies had DM ranging between 38-44% and 55 progenies had > 44% DM content.
- In the experiment on genetic modifications for quality improvement in cassava, CMD resistant cassava accession, 9S-127 was multiplied and maintained and FECs of 9S-127 were also maintained.
- Guide RNAs were synthesized *in silico* for developing *gbss* construct using gene editing tools.
- For characterization of abiotic stress responsive genes in cassava, spatio-temporal and abiotic stress-specific expression patterns in normalized RNA seq datasets was done, which revealed constitutive as well as inductive responses of *MeHSP20* and *MeSnRK* family members in different tissues and developmental stages of cassava. 37 out of 67 *MeHSP20* and 22 out of 41 *MeSnRK* gene expression were induced in either drought/cold stress conditions.
- Using bioinformatics tools, a set of 1919 immunity related protein domains were identified in cassava whole genome database (Phytozome), out of which,

22 were found to confer virus resistance and their gene annotation were carried out using Blast2GO.

- Protein-protein interactions were predicted for genes involved in bacterial blight diseases of cassava and network constructed using STRING.

- Evaluation of OP lines revealed maturity of 75 days in 12 sweet potato lines (two orange-fleshed, five white-fleshed and five purple-fleshed) having yields ranging from 20.40 to 22.80 t ha^{-1} and 17 lines (five purple-fleshed, three white-fleshed and nine orange-fleshed) having 90-100 days maturity and yield ranging from 24.20 to 30.60 t ha^{-1}.

- Evaluation of clonal generation of hybrids raised during 2014-15 resulted in the identification of 15 lines (white-5, orange-4 and purple-6), of which, 75 days maturity was recorded in 3 white, 3 orange and 6 purple-fleshed lines. The remaining were of 90 days maturity. Weevil infestation of less than 5% was recorded beyond 75 days. The clonal lines of 2015-16 cross revealed higher yield in 11 lines (white-5, orange-5 and purple-1). Maturity was recorded as 75 days in orange (4) and white (5) lines. No weevil infestation was observed till 90 days. The clonal generation of hybrids raised during 2016-17 revealed 7 lines (white-4, orange-2 and purple-1) with the targeted traits. Among these, 75 days maturity was recorded in 3 white-fleshed, 2 orange-fleshed and 1 purple-fleshed lines with yields ranging from 18.60 to 21.50 t ha^{-1} and the remaining white line matured in 90 days with yield of 23.90 to 27.30 t ha^{-1}. In all the early maturing (75 days duration) lines, no weevil infestation was seen. Starch content ranged from 14.80 to 23.30%; β-carotene, 8.60 to 16 mg $100g^{-1}$ and anthocyanin, 58.60 to 99.20 mg $100g^{-1}$. Inheritance of valued traits indicated both dominance as well as interactions.

Clonal lines of F_1s having 75 days maturity: purple flesh (A), orange flesh (B) and white flesh (C) sweet potato

- Four early maturing sweet potato accessions, No.15, S30/16, Baster-45 and No. 527 with high yield ranging from 18-21.40 t ha^{-1}; crop duration of 75 to 80 days and responding well to lower nutrient doses were identified. Four genotypes viz., 84 x 14, Dhenkanal local-2, Howrah and SB21/57 were identified as drought

tolerant. Three lines viz., 84 x 14 (8.55 t ha^{-1}), S-783 (7.75 t ha^{-1}) and 84 x 1 (7.6 t ha^{-1}) were identified as high yielders under drought stress conditions. Five sweet potato genotypes viz., S-1712, S-1652, S-27, Bhu Krishna and 526/7 were found best for processing.

Fried chips of sweet potato

- Using bioinformatics tools, 13 novel potential miRNAs and 81 target genes in sweet potato were predicted and functionally characterized using Blast2GO. Predicted 9215 long non coding RNAs (lncRNAs) and 8665 protein coding genes in sweet potato using an intelligent tool RNAplonc.
- In the advanced yield trial of greater yam hybrids, DaH-10-1-2 (65.42 tha^{-1}) yielded the highest, followed by DaH-23-2-1 (59.26 t ha^{-1}). Among the yellow-fleshed greater yam hybrids, DaH-8-39 produced the highest tuber yield (45.67 t ha^{-1}). In the evaluation of anthracnose resistant lines for yield, DaH-9/196 yielded the highest (44.03 t ha^{-1}).
- In the study for identification of molecular markers linked to anthracnose resistance, the association of three ISSR markers (UBC 807, UBC 836 and $(GA)_9AT$) with anthracnose resistance in greater yam was noted.
- Evaluation of white yam germplasm showed that tuber yield ranged from 0.40 kg $plant^{-1}$ (DR-353) to 6.45 kg $plant^{-1}$ (DR-44). Seven accessions viz., DR-2, DR-43, DR-44, DR-46, DR-170, DR-313 and DR-128 were high yielding (>5 kg $plant^{-1}$). DR-59 produced high yield coupled with compact tuber shape. DR-80, DR-57 and DR-113 had excellent cooking quality.
- In AYT of white yam, DrH-1180 produced the highest yield (59.67 t ha^{-1}), followed by DrH-1157 (47.32 t ha^{-1}). The white yam hybrid clone DrH-1150 had the highest dry matter (46%), followed by DrH-187 and DrH-1157 (42%). One white yam genotype (DrH-1181) was identified with yellow flesh colour.
- Two white yam bushy hybrids with high yield (>30 t ha^{-1}), Drd-1095 and Drd-1142, were developed. Drd-1060 was identified as having the highest dry

matter (40.68%). Among the non-trailing white yam, SD-15 was identified as the highest yielder (64.60 t ha^{-1}), out-performing Sree Dhanya (23.87 t ha^{-1}), the present popular dwarf variety.

Tubers of white yam pre-release variety, SD-15

- Promising lesser yam accessions were identified, CTDE-64 (2.6 kg $plant^{-1}$) and CTDE-39 (2.5 kg $plant^{-1}$) having high yield.
- Using bioinformatics tools, 1789 SNPs and 1002 SSRs were predicted *in silico* for anthracnose resistance in yams.
- Twelve TLB resistant genotypes (C-84, C-370, C-388, C-565, C-679, C-690(v), C-717, TCR 267, TCR 326, IC310104, IC087153 and Colocasia Nicobar Chukchukia village) were identified through screening. Biochemical studies showed that the dasheen taro, VHAK/2017-4 had a total starch of 18.43%.
- OP seedlings derived from TLB resistant and susceptible lines showed good morphological variability. Maximum number of cormels was observed in the line 690(v)-24 (8 nos).
- For identification of molecular markers associated with TLB, one ISSR primer, UBC 811, produced a unique band in seven out of the 18 resistant genotypes. Similarity searches revealed the presence of five genes associated with resistance in *Arabidopsis.*
- Nutritionally rich lines of taro viz., for antioxidant (TRC-369), phenolics (Tripura local-2), sugar (TRC-868), starch (Andaman), crude protein (Tripura local-2), phosphorus (NBPGR-37), potassium (Tripura local-2), iron

(NBPGR-37), copper (NBPGR-37), zinc (NBPGR-37) and manganese (Nycle) were identified at Bhubaneswar.

- Using bioinformatic tools, 562 SNPs and 3034 SSRs were predicted *in silico* for blight resistance in taro.
- A promising arrowroot accession, M-6, having high yield (57.12 t ha^{-1}), dry matter (34.44%), total starch (22.50%), ash (1.14%) and lowest sugars (0.76%) was identified.
- In yam bean breeding experiment conducted at the Regional Centre, the inheritance of flower colour in yam bean was studied and it was confirmed for the first time that purple flower colour was dominant over white flower colour and it is governed by monogenic dominant gene and the distribution fitted the expected Mendelian ratio of 3 (purple) : 1 (white).
- For developing breeder seed standards in yam bean, harvested fresh seeds of 53 accessions were subjected to evaluation for varietal purity and germination potential. Under varietal purity, the qualitative characters namely, flower color, seed colour and seed shape were evaluated. Good variability was seen in all these characters. For the evaluation of different seed quality attributes viz., 100 seed weight and other germination attributes, fresh seeds of ten genotypes namely, Rajendra Local, Nepal, EC100550, IC25112, IC25117, DL-14, DL-16, DL-17, DL-20 and DPH-5 were studied. Among them, DPH-5 showed significantly higher seed quality attributes. The stable qualitative characters will be studied further with large numbers of varieties and genotypes including released varieties for developing seed standards for breeders seed.
- In attempts on bio-prospecting for novel traits in tuber crops, 500 µg dose of ethanolic extract of *Coleus aromaticus* leaf produced a clear zone of inhibition indicating its antibacterial effect against *Staphylococcus aureus.*
- *In ovo* screening of angiogenic effects of tuber crops showed that ethanol extracts of sweet potato variety Bhu Krishna and *D. alata* (Da-340) had anti-angiogenic effects as evidenced by reduced number of micro-blood vessels around the disc as well as breakage of major blood vessels.

CROP PRODUCTION

- Five technologies for the production of liquid foliar micronutrient formulations for SSNM of cassava (2 products), sweet potato, elephant foot yam and yams were commercialized. *Sree Poshini*, a mobile app developed for SSNM of tropical tuber crops is made available in google play store.

Five liquid foliar micronutrient formulations commercialized for different tuber crops

- Planting material of cassava varieties, Sree Vijaya, Sree Jaya, Sree Swarna and Sree Pavithra were soaked in hot water, which resulted in zero cassava mosaic virus infection up to two months. The infection was 4, 6, 8 and 10% at 3rd month and 47, 43, 34 and 36% at 8th month after planting.

- The sustainability yield index (SYI) of package of practices (POP: FYM @ 12.5 t ha^{-1} + NPK @ 100:50:100 kg ha^{-1}) (0.665) was established over absolute control (0.385) with mean values of 0.738 and 0.389 after 13 years of continuous experimentation in cassava.

- The cassava genotypes viz., CI-905, 7III E3-5, Sree Pavithra and CI-906 were identified as nutrient-use efficient as the application of NPK fertilizers could be reduced to 25%, saving 75% of the recommended dose. Demonstration-cum-field validation trials in 24 farmers' fields of Kerala have shown that the average yield of CI-906, CI-905, 7III E3-5 and Sree Pavithra without NPK fertilizers/25% NPK were 45.80, 43.20, 42.90 and 38.60 t ha^{-1} respectively.

- Sree Reksha responded well to organic farming. Of the 12 cassava varieties tested, Sree Reksha produced significantly higher yield (40.69 t ha^{-1}), higher profit (₹ 4,42,062 ha^{-1}) and B:C ratio (3.63), followed by Sree Pavithra (29.49 t ha^{-1}; ₹ 2,74,070 ha^{-1} profit and 2.63 B:C ratio).

CI-905 CI-906

7III E3-5 Sree Pavithra

On-farm trials on NUE genotypes of cassava

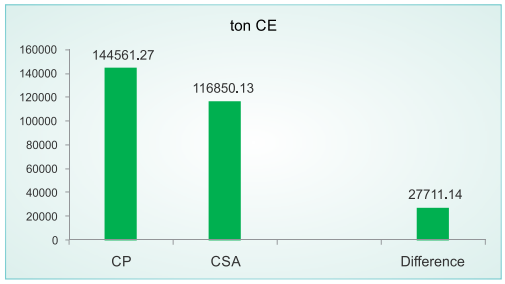
First crop of cassava Cassava followed by vegetable cowpea

Organic farming of cassava based croping system

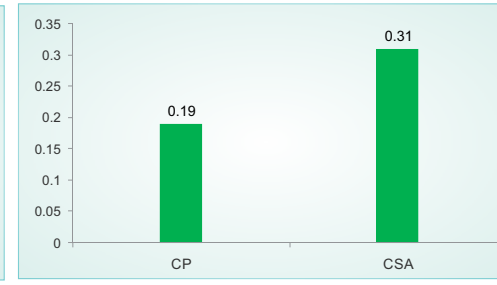
- Developed organic techniques involving innovative practices of 3% *Panchagavya* and 10% vermiwash for cassava-vegetable cowpea and cassava-groundnut systems, which was profitable.
- The maximum net photosynthetic rate *(Pn)* of 15 cassava genotypes increased due to short-term (ten minutes) exposure at eCO_2 concentrations between 400 and 1000 ppm. Maximum increment in *Pn* was recorded at CO_2 between 400-600 ppm relative to 400 ppm in varieties Sree Jaya (23%) and H-226 (21%).
- Under irrigated and WDS conditions, cassava genotypes had the average net photosynthetic rate (P_n) of 28.40 and 15.75 µmol CO2 m^{-2} s^{-1} (44% reduction in stressed plants over control), respectively, while, under irrigated and WDS conditions, cassava genotypes had the average stomatal conductance (g_s) of

0.30 and 0.15 mol H_2O m^{-2} s^{-1} (50% reduction in stressed plants over control) respectively. In irrigated condition, transpiration varied from 7.90-13.63 mmol H_2O m^{-2} s^{-1}, whereas it ranged from 3.76-7.66 mmol H_2O m^{-2} s^{-1} in stressed plants. Among the tested varieties, Sree Reksha was the top performing variety under irrigated as well as water deficit stress conditions.

- The total carbon emissions from major inputs of cassava cultivation in climate smart agriculture (CSA) was estimated to be 116850.13 ton carbon equivalent (CE) as compared to conventional practice (CP), which was 144561.27 ton CE, thereby showing the higher carbon efficiency of CSA (0.31) over CP (0.19) by reducing GHG emission.



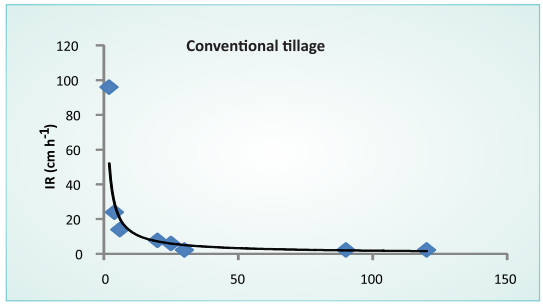
Total carbon emission from major inputs of cassava cultivation under CP and CSA



The carbon efficiency of climate smart agriculture and conventional practice of cassava cultivation

- The cassava tuber yield of 29.90, 29 and 23.60 t ha^{-1} was obtained under conventional (CT), deep (DT) and minimum tillage (MT) practices, respectively, in the fourth year of study. The interactions among conventional tillage and ground cover (GC) mulch showed improved values of sorptivity (0.046 cm $min^{-1/2}$) as compared to first year (0.023 cm $min^{-1/2}$). Soil surface infiltration rate was 2.24 cm h^{-1} under CT, whereas it was 1.16 cm h^{-1} for MT plots during the current year of study. Correlation studies showed that bulk density had a significant negative relationship with soil sorptivity in conventional tilled and GC sheet applied plots (-0.742* and -0.623*; P=0.05 respectively).

- The content of easily extractable glomalin (EEG) in major cassava growing soils (Alfisols) of Pachamalai hills, Tamil Nadu varied from 3.40-5.12 mg g^{-1} soil and highest content was observed in forest soils. The average number of fungal spores per gram of dry soil was higher (42.9) in sub surface soil (0.1-0.2 m depth) as compared to surface soils (20.7) and varied from 3 to 50 among the soil and forest land uses, respectively. Correlation studies showed that significant correlations existed among the soil properties viz., pH and Ca (0.73*, P=0.05), SOC and Ca (0.81*,P=0.05), among others.



Infiltration pattern in Ultisols under conventional tillage

Geospatial soil sampling at Pachamalai Hills, Tamil Nadu

- To induce tolerance to high temperature stress through chemical treatments in sweet potato under field conditions, foliar spraying of $CaCl_2$ (0.2%), Salicylic acid (0.2%) and BA (1000 ppm) during 4th to 8th month was done, and higher tuber yield was recorded due to spraying of $CaCl_2$ (0.2%) under polychamber with humidification (16.80 t ha^{-1}), open field (13.24 t ha^{-1}) and polychamber without humidification (11.45 t ha^{-1}) conditions. Foliar spraying of $CaCl_2$ resulted in 20.86-43.18% higher tuber yield relative to control plants with water spray. Photosynthetic rate was the maximum in plants under polychamber with humidification (21.83-26.93 µmol m^{-2} s^{-1}).
- In sweet potato, 64 and 84 days after planting (DAP) and in elephant foot yam, 4 and 5.5 months after planting (MAP) were identified as the critical growth stages for foliar nutrition.
- Treatment of elephant foot yam corms with carbon disulphide @ 80 ml 100 kg^{-1} resulted in maximum uniform sprouting, better growth and significantly higher corm yield.
- Productive-profitable-energy efficient-nutrient saving cropping systems involving tuber crops and pulses were evolved. These include, elephant foot yam + soybean, taro + green gram/black gram, dwarf white yam + green gram systems.
- The elephant foot yam var. Gajendra intercropped with soybean under full fertility level (FYM @ 25 t ha^{-1}, NPK @ 100:50:150 kg ha^{-1}) resulted in higher net income (₹ 10, 07, 356 ha^{-1}), B:C ratio (3.18) and added profit of ₹ 2,33,164 ha^{-1} over sole crop.
- Water saving techniques were developed in elephant foot yam. Highest corm yield and B:C ratio (2.91) was obtained by providing 50% CPE irrigation along with plastic ground cover mulching (37.46 t ha^{-1}), followed by application of Pusa hydrogel (35.72 t ha^{-1}; 2.77) and with 100% irrigation (32.03 t ha^{-1}; 2.67).
- On-farm validation experiments of customized fertilizers developed for elephant foot yam in seven farmers' fields of Kerala have shown that site specific nutrient

management (SSNM) resulted in significantly higher corm yield (44 t ha^{-1}) than farmer fertilizer practice (FFP) (34.50 t ha^{-1}), which was 27.50% higher over FFP.

- Site specific nutrient management (SSNM) strategies were developed for sustainable production of elephant foot yam–black gram cropping system.
- Significantly highest corm yield of elephant foot yam (26.34 t ha^{-1}) and grain yield of black gram (708 kg ha^{-1}) were obtained due to integrated application of lime + FYM + NPK + $MgSO_4$ with highest yield response of 159% over that of control apart from improvement in soil enzyme activities and soil microbial count.
- In elephant foot yam-black gram cropping system studies, integrated use of lime + FYM + NPK + $MgSO_4$ in Alfisols resulted in highest acid and alkaline phosphatases activities (32.18 and 30.87 µg PNP g^{-1} h^{-1}, respectively). Studies also indicated that soil bacteria and actinomycetes had significant impact on soil enzyme activities (DHA, FDA, urease and phosphatase) and contributed to higher crop yields of elephant foot yam.
- Irrigation of taro crop up to 24 weeks @ IW/CPE ratio of 1.0 resulted in maximum cormel yield (19.91 t ha^{-1}), which was on par with irrigation for 24 weeks under different irrigation levels of 0.75, 1.25 and 1.50 and also furrow irrigation. The water requirement of upland taro was worked out to be approximately 3 mm per day for producing optimum cormel yield. Water productivity was estimated at 3.4 kg m^{-3}.
- The taro variety, Sree Kiran intercropped with green gram or black gram at the reduced fertility level (half FYM and N, full K ie., FYM @ 6 t ha^{-1} & NPK @ 40:25:100 kg ha^{-1}) produced higher tuber equivalent yield (12.34 and 11.89 t ha^{-1}), production efficiency (68.55 and 66.03 kg ha^{-1} day^{-1}) and equivalent energy (45.66 and 44.69 x 10^3 MJ ha^{-1} respectively) over sole taro.
- In yet another intercropping study in taro, the land equivalent ratio (LER) of taro + maize (5:1), taro + maize (5:2), taro + pigeon pea (5:1) and taro + pigeon pea (5:2) were found to be >1, indicating that they were biologically efficient system. Sole taro produced maximum cormel equivalent yield (16.61 t ha^{-1}). The gross and net returns of taro + maize (5:1) and taro + pigeon pea (5:1) were statistically on par and were next best to the sole taro. Greater B:C ratio of 2.35 was noticed in taro + pigeon pea (5:1) followed by sole taro (2.24) and taro + maize (5:1) (2.23).
- In greater yam + maize intercropping system, fertigation of N-P_2O_5-K_2O @ 140-90-140 kg ha^{-1} in 60 splits at 3 days interval resulted in higher greater yam equivalent yield (39.70 t ha^{-1}), gross (₹ 5,96,000 ha^{-1}) and net returns (₹ 3,84,200 ha^{-1}) as well as B: C ratio (2.81).

- Yield reduction of dwarf white yam (var. Sree Dhanya) due to intercropping with pulses was comparatively less (-9.55%). Under full fertility level (full FYM, N and K ie., FYM @ 10 t ha^{-1} & NPK @ 80:60:80 kg ha^{-1}), the dwarf white yam intercropped with green gram was the most productive (tuber yield 28.96 t ha^{-1}, tuber equivalent yield 31.17 t ha^{-1}, production efficiency 115.45 kg ha^{-1} day^{-1}), energy efficient (119.14 x 10^3 MJ ha^{-1}), profitable (net returns of ₹ 8,02,399 ha^{-1}; B:C ratio of 3.68) and better than sole dwarf white yam (added profit of ₹ 91,811 ha^{-1} over sole crop).

Field view of dwarf white yam after harvest of pulses

Tuber yield under dwarf white yam + green gram under full fertility level

- The maximum *Pn* of seven yam varieties viz., four white yam (*Dioscorea rotundata*) varieties viz., Sree Priya and Sree Haritha and two dwarf white yams namely Sree Dhanya, Sree Swetha and three greater yam (*D. alata*) varieties namely Sree Shilpa, Sree Karthika, Sree Nidhi was recorded at photosynthetic photon flux densities (PPFDs) of 1500 µmol $m^{-2}s^{-1}$. Maximum increase of *Pn* was observed between 400-600 ppm in the varieties, Sree Dhanya (33.26%), Sree Karthika (33.05%) and Sree Haritha (32.93%). In all varieties, *Ci* steadily increased between 400 and 1000 ppm CO_2. With exceptions like the variety Sree Dhanya, the *gs* declined between 400-1000 ppm CO_2. The average *Pn* rate of seven yam varieties were 18.99, 26.35, 29.54 and 31.95 µmol CO_2 $m^{-2}s^{-1}$ at 400, 600, 800 and 1000 ppm CO_2 respectively.
- Among the treatments studied to assess the impact of nutrients on soil microbes, enzyme activities and yield of *Colocasia* in Alfisols of eastern India, incorporation of FYM @ 10 t ha^{-1} resulted in an yield response of 35.40% over control and higher yield response in comparison to single application of N, P and K @ 40, 15 and 40 kg ha^{-1}, respectively. Combined application of lower doses of NPK @ 40, 15 and 40 kg ha^{-1} along with incorporation of FYM @ 10 t ha^{-1} resulted in significantly highest cormel yield (19.28 t ha^{-1}), with an increase of 4% yield over that of $N_{80}P_{30}K_{80}$.

- The maximum *Pn* of yam bean variety, Rajendra Misrikand-1 (RM-1) was recorded at PPFD of 1500 µmol $m^{-2}s^{-1}$. The *Pn* steadily increased at CO_2 concentrations between 400 ppm and 800 ppm, but decreased at 1000 ppm. The *Pn* rate was 34.45, 39.60, 36.16 and 34.54 µmol CO_2 $m^{-2}s^{-1}$ at 400, 600, 800 and 1000 ppm CO_2 respectively. The *Pn* had a significant positive correlation with external CO_2 and *Ci*, but a weak positive correlation with *gs*. The *Ci* steadily increased at eCO_2 concentrations between 400 ppm and 1000 ppm. The *Ci* steadily increased from 324.15 µmol CO_2 mol^{-1} to 909.69 15 µmol CO_2 mol^{-1} between 400 and 1000 ppm CO_2 respectively. The *gs* increased little between 400 and 800 ppm external CO_2 but decreased at 1000 ppm. The differences in *Ci* were statistically significant across CO_2 concentrations (P>0.001).

- Soil fertility status was assessed for profile soils (surface (0-0.3 m) and sub surface (0.3-1.0 m) soils representing 6237 Gram Panchayats from 314 blocks in 30 districts of Odisha. GIS based soil fertility maps were prepared for physico-chemical properties and soil nutrient contents, with the support of Odisha Space Applications Centre, Bhubaneswar.

- A total number of 150 micro plants of different cassava varieties against cassava mosaic virus and 120 numbers of elephant foot yam variety Gajendra were indexed. Quality planting materials of tuber crops viz., 80,000 cassava stems, 13 tonnes of elephant foot yam, 18 tonnes of greater yam, 1 ton of taro, 4.12 lakhs vine cuttings of sweet potato and 50 kg of yam bean seeds were produced at ICAR-CTCRI and distributed to the farmers' of different states.

- A total quantity of 7875 cassava stems, 1325 kg of yams, 7700 kg of elephant foot yam and 1225 kg of taro were supplied to 63 contact ST farmers in Tribal settlements of Thiruvananthapuram, Kottayam and Idukki districts of Kerala identified with the assistance from the State Department of Agriculture.

- Planting material of tuber crops like, sweet potato 2,00,000 vine cuttings, cassava 5000 stems, greater yam tubers 3000 kg, maize 10 kg, red gram 10 kg and yam bean seeds 100 kg were distributed to 200 tribal farmers of Mohan and R. Udayagiri blocks of Gajapati district, Odisha, for demonstrating tuber crops based farming system in an area of 0.2 ha model. Vegetable kits, 300 numbers and 2000 poultry birds (Vanaraja) were also distributed to tribal farmers to supplement the farm income.

CROP PROTECTION

- The whiteflies attacking tuber crops were identified as *Bemisia tabaci* (cassava, sweet potato), *Aleurodicus rugioperculatus* (arrowroot) and *Aleurodicus disperses* (cassava) through molecular characterization. All the samples of cassava whitefly (*Bemisia tabaci*) from the different AICRP centres belonged to Asia II5 biotype (having up to 2% sequence variation).
- Fungi, *Beauveria bassiana, Metarhizium anisopliae, Penicillium citrinum* and bacteria *Bacillus cereus* and *Bacillus pumilus* isolated from the rhizosphere of tuber crops were effective in whitefly (*Bemisia tabaci*) management, which showed 68, 80, 77, 65 and 61% mortality respectively.
- Residue analysis (using LCMS and GCMS) of promising insecticides used for whitefly management showed significant reduction in their concentration in different cassava plant parts 48 hours after field application.
- Bioinformatics analysis (QIIME and MG-RAST) of endosymbionts in whitefly population showed that there were variations in *Enterobacteriaceae* (important bacteria in endosymbiont-virus interaction studies) based on samples from different agro-ecological zones (85.01% in plains and 8.34% in hilly zones).
- Imidacloprid (0.001%) and biopesticide *Nanma* (5.0%) reduced the sweet potato weevil population significantly. Out of the 25 sweet potato genotypes, five, viz., S-1661, Howrah, Bhu Sona, Bhu Krishna and Kanhangad showed the expression of proteinase inhibitor and cysteine proteinase inhibitor genes.
- Among the six synthetic insecticides viz., Imidacloprid, Chlorpyrifos, Fenvalerate, Ekalux, Dimethoate and Dichlorvos tested, Imidacloprid (0.001%) and Fenvalerate were most toxic to oviposition of sweet potato weevils (SPW). Regarding ovicidal activity and hatching, Imidacloprid ranked first, followed by Ekalux and Dimethoate. In the case of biopesticides, *Nanma* and Nimbicidine showed low hatching and no hatching was noticed in the treatment with *Nanma* at 3 and 5%. Tuber treatment with biopesticide indicated that Agro bioplus at 1, 3 and 5% had no feeding until 20 DAT, and all the exposed weevils died. Thus, Imidacloprid and biopesticides *Nanma* and Agro bioplus could be utilized for managing SPW.
- Validation of gene expression showed that out of 24, the proteinase inhibitor and the cysteine proteinase inhibitor gene could be amplified from 15 and six genotypes respectively. The protease inhibitor genes were expressed in sweet potato varieties such as Sree Kanaka, Sree Vardhini, Howrah, Bhu Sona, Bhu

Krishna and Kanhangad. The cysteine proteinase inhibitor gene was amplified in sweet potato genotypes S-1661, Howrah, Bhu Sona, Bhu Krishna and Kanhangad.

- A new strain of entomopathogenic nematode (EPN) was isolated from soil samples collected from Kattakada, Thiruvananthapuram and identified as *Steinernema siamkayai*.

Steinernema siamkayai infective juveniles emerging from insect cadaver

- In elephant foot yam fields, plant parasitic nematodes, *Pratylenchus coffeae* and *Meloidogyne incognita* were the predominant species at ICAR-CTCRI, Thiruvananthapuram and *M. incognita* and *Pratylenchus* sp. in Wayanad, Kerala, whereas in Chettiyampalayam, Gobi, Erode, Tamil Nadu, *Pratylenchus* sp. and *Hemicycliophora* sp. were the predominant. In Chinese potato fields of Ambasamudhram, Tamil Nadu, *Meloidogyne incognita* was the most predominant nematode with a population density of 1.5 nematodes per gram of soil.

- In soil solarisation experiment, the recovered infective juveniles of *M. incognita* were significantly lower in the treated soil (80 nematodes per 100 g of soil) as compared to control (120 per 100 g soil), which showed its effect in reducing the nematode population.

- A natural infection of bacterial parasite, *Pasteuria* sp. was observed on *Meloidogyne incognita* from a soil sample in Thiruvananthapuram. Both Rhabditid and Tylenchid nematodes were infested with this bacterium.

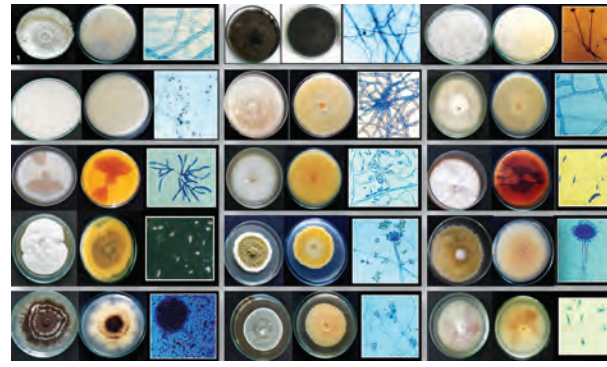
- Corm treatment either with *Trichoderma asperellum* or *Bacillus amyloliquefaciens* showed lowest collar rot disease incidence in elephant foot yam. The maximum yield was recorded in corm treatment with *T. asperellum* + application of vermicompost fortified with *T. asperellum* followed by corm treatment with *T. asperellum* + drenching the collar region with fungicide (Mancozeb + Carbendazim) 0.2%.

Elephant foot yam sett preparation

Field preparation

Field trial on collar rot management in elephant foot yam

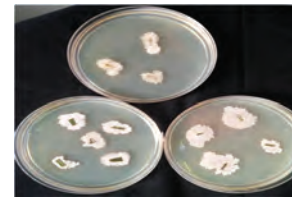
- LAMP technique for the detection of *S. rolfsii* causing collar rot of elephant foot yam was standardised by designing specific primers.
- The etiology of postharvest rot in elephant foot yam showed that brown lesions turning into powdery mass of tissue in later stages was the most common symptom among the nine symptoms observed. Major symptoms produced by 15 isolates were discolouration, rotting and softening of tubers for which the pathogenecity was proved. The pathogens were identified as *Athelia rolfsii*, *Lasiodiplodia theobromae*, *Rhizopus oryzae*, *Cunninghamella elegans*, *Rhizoctonia solani*, *Ceratobasidium* sp., *Fusarium brachygibbosum*, *Fusarium solani*, *Fusarium oxysporum*, *Colletotrichum gloeosporioides*, *Aspergillus tamarii*, *Aspergillus nomius*, *Aspergillus niger* and *Penicillium citrinum* through amplification of ITS and TEF region.



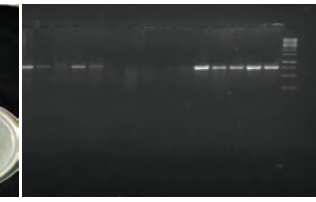
Pathogens causing postharvest rot in elephant foot yam

- Pre-storage treatment of elephant foot yam corms with *Trichoderma*/ Mancozeb 0.15%/Carbendazim 0.05%/combination fungicide (Mancozeb and Carbendazim 0.2%) could effectively mitigate the postharvest loss in elephant foot yam, in which the latter one was highly effective.
- The initiation of the taro blight infection was delayed by almost 45 days compared to previous years and the highest PDI (Percent Disease Index) was observed during December-January period. The susceptibility score value was calculated for the released varieties, Muktakeshi and Sree Rashmi based on AUDPC (Area Under the Disease Progress Curve) and these were rated as resistant (score 0.96) and highly susceptible (score 6) respectively.
- Secondary metabolites responsible for antifungal activity in the most efficient endophytes against taro leaf blight causing *Phytophthora colocasiae* viz., *Nigrospora oryzae* and *Bacillus subtilis* were characterized. In the case of *B. subtilis*, the peptides obtained upon MALDI–TOF analysis showed 100% identity to fragments of the spore coat protein. The partially purified secondary metabolite from *N. oryzae* was identified as oxaspiro compound through TLC and GC-MS.
- In field, spraying a mixture of 0.025% Carbendazim and *Nanma* (0.7%) seven times showed highest reduction in the intensity of greater yam anthracnose (75%). Soil and tuber treatment with *Menma* and spraying *Nanma* weekly resulted in maximum increase in yield (34.71%). The finding showed that the usage of Carbendazim could be reduced up to 50%.
- Two bacterial endophytes, *Bacillus cereus* (SrS1) and *Bacillus subtilis* (MaL1) from arrowroot leaf and Chinese potato stem, reduced 87.07% and 64% of anthracnose intensity in greater yam respectively, which showed their potential in managing the disease as well as promoting the growth.
- In another experiment, altogether 197 bacterial and 157 fungal endophytes were isolated from 10 commonly available medicinal plants, viz., *Sida acuta, Andrographis paniculata, Asparagus racemosus, Tridax procumbens, Aloe vera, Eclipta alba, Solanum torvum, Piper longum, Phyllanthus niruri, Boerhavia diffusa* and among them 8 and 3 showed more than 80 and 75 per cent inhibition respectively, which will be utilized further for managing the disease.

Greater yam tissue cultured plants sprayed with *Bacillus subtilis*



Confirmation of colonization by isolation from leaves



Confirmation of colonization by PCR amplification using specific primers

- The greater yam anthracnose disease severity was observed at weekly intervals till 9th month of planting in three released varieties of greater yam, viz., Orissa Elite (Highly susceptible), Sree Karthika and Sree Keerthi (Resistant) in the field. The susceptibility score value based on AUDPC were 5.0, 0.13 and 0.33 respectively, which indicated that Sree Karthika and Sree Keerthi were resistant to anthracnose.

Anthracnose resistant var. Sree Karthika at 6 MAP

Anthracnose susceptible var. Orissa Elite at 6 MAP

- Hot water treatment of elephant foot yam for 45 minutes resulted in maximum reduction (33%) of *Dasheen Mosaic Virus* (DsMV) followed by both 30 and 15 min. (28%) compared to control.

Pot trial on the effect of hot water treatment of elephant foot yam tubers on *Dasheen mosaic virus*

Elephant foot yam plants infected by *Dasheen mosaic virus*

- Sequence analysis of partial genome of *Taro bacilliform virus* showed 100% similarity with *Taro bacilliform* China isolates.
- Rolling Circular Amplification (RCA) was carried out to obtain whole genome sequence of *Sweet potato leaf curl virus*. Sequencing was done with PW285.2, SPG1, SPG4 and M13 primers, which showed 90% similarity with *Sweet potato leaf curl virus* Greece isolate (KF697069.1)
- The sequence of pSLCMV A (Genbank accession No. MK404225) showed maximum similarity of 99% with SLCMV-[TVM1] and SLCMV B (Genbank accession No. MK404226) showed maximum similarity of 99% with SLCMV-[Ker20] sequence. The sequence of ICMV A showed maximum similarity of 95% with ICMV-[Mah] sequence.
- Infectious clones of SLCMV and ICMV were developed using bitmer strategy and tested for their infectivity with tobacco (*Nicotiana benthamiana*), which showed infectious nature of these clones.
- Using next generation sequencing (NGS) technology, small RNA sequencing was done with healthy and CMD infected cassava plants. Using this sequence data, siRNA, known miRNA and novel miRNA aligning with cassava genome sequence as well as virus genome database were identified.
- Physiological and biochemical changes due to CMD infection showed maximum net photosynthetic rate (Pn) in healthy leaves of cassava genotypes. Chlorophyll a & b contents decreased with increasing severity of CMD infection in all the genotypes and the total carotenoids content decreased significantly in diseased leaves compared to healthy ones.

- Association of SSRY28 and SSRY44 with CMD resistance in 39 resistant and 21 susceptible cassava genotypes was demonstrated.
- In transcriptome dataset analysis of cassava infected with *Cassava mosaic virus*, out of 19 SNAC genes, eight genes (*MeNAC22*, *MeNAC28*, *MeNAC61*, *MeNAC62*, *MeNAC63*, *MeNAC75*, *MeNAC79*, and *MeNAC121)* displayed more than two fold inductions during virus infection.
- The pyramiding of different sources of CMD resistance genes was undertaken through marker assisted breeding. The second clonal progeny were evaluated for agronomic traits. The dry matter content of the resistant lines ranged from 8.06% (17S-97) to 47.70 % (17S-2).
- Field experiment on the effect of micronutrients on cassava mosaic disease in cassava variety Mulluvadi depicted significant reduction in CMD symptom expression from 70.50% at sprouting to 39% at 6 MAP with nutrients in the order as Phosphorus (P)<Boron (B)<Zinc (Zn)<Silicon (Si)<Calcium(Ca).
- The synthetic seeds developed were subjected to short/medium-term storage studies at room temperature (25±2°C). It can be stored up to 42 days at room temperature.

Cassava synthetic seeds

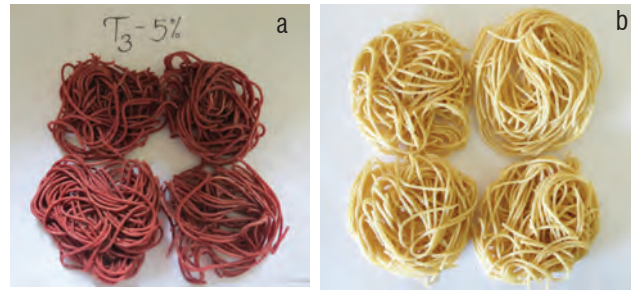
In vitro sprouting of cassava synthetic seeds

CROP UTILIZATION

- Functional pasta was developed from the composite flour containing cassava flour, maida, soy flour and resistant cassava starch. The optimum conditions were as follows: 62.47% cassava flour, 19.76% maida, 5% resistant starch and 7.75% soy flour.
- Process was optimized for producing sweet potato pasta enriched with protein from low cost sources such as green peas, Bengal gram flour and casein and the protein content in the pasta varied from 7.50 to 15.10%.

Sweet potato based composite flour pasta with low cost protein sources
(a) green peas (b) Bengal gram (c) casein

- Functional pasta was developed from the composite flour containing cassava, maida, beetroot powder, whey protein concentrate and pre-gelatinized starch.
- Noodles enriched with soy flour and beetroot powder were prepared from the composite flour containing cassava and maida. There was a significant increase in fibre content (1.07 - 2.31%), when compared to control (0.76%).



Noodles from cassava-beetroot based composite flour (a) along with control (b)

- Resistant starch (RS4 type) of cassava and sweet potato were prepared by chemical modification with citric acid and the physicochemical and digestibility properties were compared with resistant starches of potato, banana and lentil prepared under the same conditions. The modified starches showed high resistant starch and slowly digestible starch and medium glycemic index.

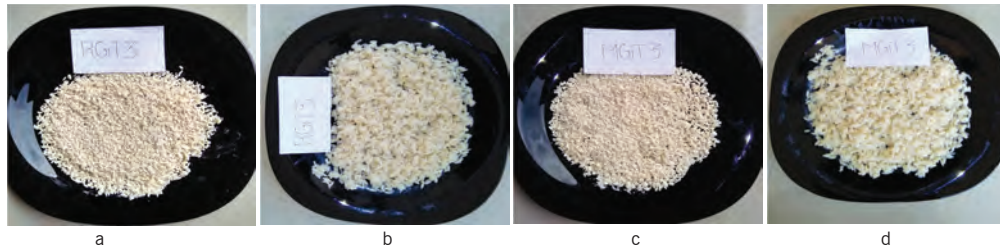
- Functional pasta was prepared from elephant foot yam flour, suji and finger millet flour and the process conditions were optimized using response surface methodology. The proximate composition of pasta was analysed. The protein content ranged from 10.33 to 15.62%, fat content from 1.92 to 2.30%, starch content from 33 to 40% and sugar content from 1.95 to 3.32%. The iron and calcium contents were 3.15 to 5.80 mg $100g^{-1}$ and 320 to 390 mg $100g^{-1}$, respectively.
- The process for production of pasta from sweet potato-pseudo millet based composite flour was standardized. The flours used were sweet potato flour (55%), millet flour (15%), maida (30%) and starch (5%) along with quinoa and buckwheat flour.

Pasta from sweet potato-pseudo millet based composite flour; (a to c) pasta made from sweet potato-quinoa based composite flour; (d to f) pasta made from sweet potato-buckwheat based composite flour

- The recipe for ready-to-use paratha mix from sweet potato flour was standardized. The optimized composition was sweet potato flour-50%, millet flour-15%, multigrain flour-30% and dried spices-5%. Sensory evaluation for colour, texture, aroma, taste and overall acceptability of paratha was carried out.

Sweet potato flour based paratha mix

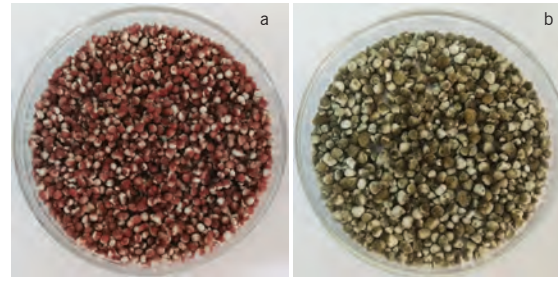
- Rice analogue was prepared from cassava flour by extrusion technique and their quality parameters were estimated. The rice analogue prepared from the composite flour containing cassava-maida-whey protein concentrate-guar gum was more acceptable by sensory evaluation.



a b c d

Rice analogue from cassava based composite flour with rice and guar gum [(a) raw and (b) cooked] and maida and guar gum [(c) raw and (d) cooked]

- Functional sago was developed from reconstituted dry cassava starch, wet starch and combination of dry and wet starches by incorporation of beetroot powder and sweet potato leaf powder as functional ingredients to impart dietary fibre and antioxidant properties. The maximum incorporation level of the selected functional ingredients was 6%. The dietary fibre content and *in vitro* antioxidant activity were comparatively higher in the functional sago made using sweet potato leaf powder. The slowly digestible starch (SDS) and resistant starch (RS) contents were more in the sago prepared using beetroot powder.



Functional sago incorporated with beetroot powder (a) and sweet potato leaf powder (b)

- High quality cassava flour (HQCF) was produced by static pressing method and the process conditions such as pressure, pressing time and loading weight were optimized. The optimized conditions for the production of HQCF were as follows: pressure-44.63 bar, pressing time-24.13 s, loading weight-1312 g. The starch loss due to pressing was very less and was in the range of 0.98 to 2.58%.
- Thermoplastic starch sheets with improved physical properties were developed from oxidized cassava starch as well as from cassava starch-wax composites by adding glycerol as plasticizer and the process conditions were optimized. The optimum conditions were as follows: starch-5%, glycerol-5%, wax-6% and pressure-120 bar.
- Cassava stem based particle boards were made with cassava starch and wax as well as with cross-linked cassava starch as binder. The optimum conditions for the production of particle boards which have properties in accordance with the approved BIS standards were as follows: starch-15%, glycerol-12.44% and pressure-46.86 bar.
- Wax coating of cassava tubers have been standardized for extending the shelf life. Cassava tubers of twelve different cassava varieties/genotypes, in which proximal and distal ends were cut in order to simulate the wounding in actual harvesting, were used for the study. Among the different waxes used, paraffin and microcrystalline waxes were found to be more suitable for coating the tubers. The tubers could be stored without any PPD symptoms up to 2 weeks by this treatment and no significant effect of genotypes/varieties was observed.
- The effect of biochar on soil fertility and tuber yield of two sweet potato varieties, Sree Arun and Sree Kanaka, which were grown in pots was investigated under well irrigated and water deficit (WDS) conditions. There was a dramatic increase in soil microbial activity, organic carbon content and mineral content due to biochar application at 2% and 5% concentrations. Net photosynthetic rate increased significantly with 2% biochar application in both the varieties. Tuber fresh and dry weights markedly increased with biochar application in both WDS and well irrigated conditions.

- The flours prepared from sweet potato and greater yam tuber residues after anthocyanin extraction were successfully used to replace up to three fourth of the maida in bakery products such as cookies. This enables the simultaneous utilization of purple sweet potato and greater yams tubers for colorant extraction as well as for flour production.

Sweet potato flour (a) prepared from left over tuber residues after anthocyanin extraction and cookies (b) made from it

- The MTT assay of anthocyanins from sweet potato tubers (var. Bhu Krishna), purple sweet potato leaves (Acc. S-1467) and tubers of greater yam (Acc. Da-340) on three different human cancer cells viz., cervical cancer (HeLa), breast cancer (MCF-7) and colon cancer (DLD1) cells showed that comparatively higher activity was obtained with breast cancer cells.
- Gelatin capsules of purified anthocyanins from the purple tubers of greater yam (*D. alata*, Acc. Da-340) and sweet potato (var. Bhu Krishna) were prepared as nutrient supplement. The concentration of anthocyanins was 5 mg per capsule.

Sweet potato anthocyanin capsules

- The techno-incubation centres at headquarters and regional centre were actively involved in imparting hands-on-trainings and also providing incubation facilities for preparing various tuber crops based food products.

EXTENSION & SOCIAL SCIENCES

- Demonstrations on improved varieties of cassava, sweet potato, taro and Chinese Potato; Integrated management of pseudostem weevil of banana and mealybug in cassava using cassava based bio-formulations were established in Tamil Nadu, Kerala, Meghalaya and Arunachal Pradesh in 35 farmers' fields for proving the technical feasibility and economic viability of the improved technologies.
- Fifteen frontline demonstrations on improved varieties of cassava viz., Sree Jaya, Sree Vijaya, Sree Swarna, Sree Pavithra, Sree Athulya and Sree Apoorva were established in Kanyakumari, Salem and Namakkal districts of Tamil Nadu.
- Frontline demonstrations on improved varieties of cassava conducted at Kanyakumari district, Tamil Nadu revealed that Sree Pavithra produced the highest yield (36.50 t ha^{-1}), followed by Sree Swarna (34.50 t ha^{-1}), Sree Jaya (33 t ha^{-1}) and Sree Vijaya (29.75 t ha^{-1}). Productivity of cassava from improved varieties was 32.70 t ha^{-1}, which was higher (14.70%) than that of local varieties (28.50 t ha^{-1}).
- In Salem district, Sree Athulya yielded maximum (38 t ha^{-1}), followed by Sree Apoorva (36.50 t ha^{-1}), Sree Pavithra (35 t ha^{-1}), Sree Jaya (34 t ha^{-1}) and Sree Vijaya (32.50 t ha^{-1}). Yield of improved varieties of cassava was 35.20 t ha^{-1}, which was higher (14.70%) than the yield of local varieties (30.70 t ha^{-1}).
- Demonstrations in Namakkal district showed that Sree Athulya produced maximum yield of 40.50 t ha^{-1}, followed by Sree Pavithra (38 t ha^{-1}), Sree Apoorva (36 t ha^{-1}), Sree Vijaya (34 t ha^{-1}) and Sree Jaya (33.50 t ha^{-1}). Yield of improved varieties of cassava was 36.40 t ha^{-1}, which was higher (17 %) than the yield of local varieties (31.10 t ha^{-1}).
- Gross income realized from improved varieties of cassava in Kanyakumari, Salem and Namakkal districts were ₹ 2.62 lakhs, ₹ 2.20 lakhs and ₹ 2.29 lakhs in comparison to income obtained from local varieties ₹ 2.14 lakhs, ₹ 1.92 lakhs and ₹ 1.96 lakhs respectively.
- On an average, the yield of improved varieties of cassava was higher by 15.45% over that of the local varieties. The net income realized from improved varieties of cassava in the above districts was ₹ 1.28 lakhs, which was 28% higher over that obtained from local varieties (₹ 1.0 lakh).
- Demonstrations on improved variety of Chinese potato viz., Sree Dhara conducted in Tirunelveli district, Tamil Nadu, indicated that the yield of Sree Dhara (26.70 t ha^{-1}) was higher by 16.60% over that of the local varieties (22.90 t ha^{-1}). Net income realized from Sree Dhara was ₹ 1.79 lakhs ha^{-1} (B:C ratio: 2.77) in comparison to local varieties, which was ₹ 1.43 lakhs ha^{-1} (B:C ratio: 2.46).

Demonstration on improved cassava varieties

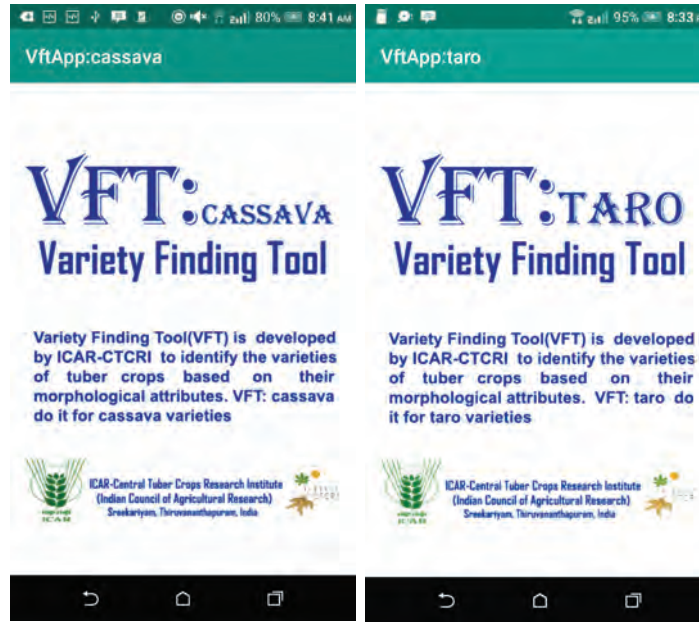
Demonstration on Chinese potato (var. Sree Dhara)

Distribution of Chinese potato (var. Sree Dhara) to farmers

- A sample of 50 farmers was selected from Kanyakumari district for analyzing the consumption pattern of tuber crops among farmers. Majority of the farmers (70%) were in the old age group (> 50 years), 100% of the respondents were literates, 72% were having nuclear family type, majority (74%) were small and marginal farmers, 56% of the respondents were cultivating tuber crops viz., cassava, elephant foot yam and yam. It was found that rice grain, rice flour and wheat flour were frequently consumed by the respondents in Kanyakumari district of Tamil Nadu. With respect to per capita consumption of food items (kg/month), rice was consumed to the tune of 5.77, followed by wheat flour (0.92), rice flour (0.72), semia (0.4), rava (0.35), bread (0.23), noodles and pasta (0.19), millet flour (0.08), oats (0.08) and corn flakes (0.05). Tuber crop viz., potato was frequently (5-6 per week) consumed by the respondents followed by cassava, sweet potato, greater yam, elephant foot yam and taro. Per capita consumption (kg/month) of potato was 0.56, followed by cassava (0.54), sweet potato (0.26), elephant foot yam (0.22), taro (0.16) and greater yam (0.10).

- Sustainable livelihood analysis of tuber crop farmers was conducted among 60 elephant foot yam growers and 60 banana growers from two districts viz., East Godavari and West Godavari. The Rural livelihood sustainability index for banana growers was slightly higher (69) than that of the elephant foot yam growers (66). Physical and natural indices were more in both the cases. In the order of merit, human capital index was less among all the capitals. Major sources of livelihood as reported by both the farmers were agriculture, employment in government/private sector and small business. The vulnerability factors were price fluctuation, crop failure due to weather aberrations and increased labour cost. The trends observed were price rise (input cost), climate change and labour shortage.

- Self-learning sweet potato crop growth model was developed using neural networks algorithm of artificial intelligence. Developed two mobile apps VFT:cassava and VFT:taro for identifying varieties of cassava and taro respectively from the images of leaves. Convolutional Neural Network (CNN) image classification model was developed for cassava using the pictures of emerging leaves (top view) of four cassava varieties, Vellayani Hraswa, Sree Vijaya, Sree Pavithra and Sree Sakthi. CNN image classification model was developed using leaf images of Muktakeshi and Sree Pallavi varieties of taro.



a b

Mobile apps a) VFT:cassava and b)VFT:taro

- Developed R-package for Soil Quality Index (SQI) by integrating ANOVA, Principal Component Analysis and computation of SQI. Deep learning methods were compared for classification based on soil types and prediction of SQI.
- A survey of Agricultural startups in India indicated the presence of five categories of agristartups in India viz., Upstream (input) marketplace startups, Downstream (output) farm-to-fork supply chain startups, IoT and Big data led innovation startups, engineering-led innovation startups and Farming as a Service (FaaS) startups. Among the entrepreneurial ecosystem domains, about half of the papers (51.43%) focused on cultural domain, followed by support (25.71%).
- There was significant growth in productivity and production of cassava during 1961-2017, while declining trend in area during the same period was observed. In case of sweet potato, both area and production showed declining trend while productivity showed significant growth trend during the same period.
- Cassava starch showed significant decline in quantity of exports while in value terms, there was non-significant growth during 1994-2018. Significant growth in cassava starch imports both in terms of the quantity (32.5%) and value (43.9%) was observed during 2003-2018.
- Revealed Symmetric Comparative Advantage (RSCA) indicated that India has comparative advantage in SAARC region for exporting cassava starch; sweet potato; roots and tubers nes and flour roots and tubers nes; in case of ASEAN region for sweet potato exports and roots and tubers nes; in case of BRICS region for cassava dried exports and in case of IOR-ARC, for sweet potato, flour roots and tubers nes and roots and tubers nes exports during 1995 to 2016.
- An entrepreneurial ecosystem survey conducted in Maharashtra, Uttar Pradesh, Kerala and Tamil Nadu indicated that obtaining finance was the critical component, which influences venture formation by AC&ABC trainees.
- Eight technologies including five micronutrient foliar formulations for site-specific nutrient management in tropical tuber crops and three for the production of cassava fried snacks were transferred to four entrepreneurs in Tamil Nadu and Kerala. Value added fried products and fried chips from cassava and sweet potato on a technology licensing and consultancy mode were given to three firms/individuals. A total of ₹ 130.69 lakhs was generated as revenue through technology commercialization, farm sales, students' fee, analytical charges and other professional service functions.

ICAR-ALL INDIA CO-ORDINATED RESEARCH PROJECT ON TUBER CROPS

- A total of 118 new germplasm collections were made by different centres during 2018-19. Altogether 4386 different accessions of root and tuber crops were maintained as gene bank for improvement of major crops, including cassava, sweet potato, aroids and yams and also in minor tuber crops at 21 centres. A total of 5579 accessions of different tuber crops were maintained in the National Repository for Tuber Crops at ICAR-CTCRI, which included 1242 accessions maintained at Regional Centre of ICAR-CTCRI, Bhubaneswar. Among the AICRP centres, maximum accessions of 12 tuber crops (1338) were maintained at RPCAU, Dholi. IC numbers were obtained for a total of 2020 germplasm collections at different centres.
- In IET on cassava mosaic resistant lines, the entry TCa16-4 performed best at Yethapur (44.58 t ha^{-1}), TCa 16-5 at Peddapuram (53.37 t ha^{-1}) and TCa 16-2 at Jagdalpur (32.38 t ha^{-1}), with no incidence of cassava mosaic disease.
- First year MLT on K-efficient cassava lines indicated the superiority of TCa14-6 at Yethapur and Sree Athulya at Peddapuram. Among the five entries under MLT on cassava for culinary uses, TCa 13-4 yielded maximum in Chhattisgarh and TCa 13-7 in Manipur.
- In IET on orange-fleshed sweet potato, TSp 16-2 produced maximum marketable tuber yield at Ranchi, TSp 16-5 at Kalyani, TSp 16-9 at Peddapuram, TSp 16-7 at Jagdalpur, Navsari and Rajendranagar. In MLT on sweet potato, maximum marketable tuber yield was recorded from Sree Bhadra in West Bengal and TSp12-12 in Meghalaya based on the pooled data analysis.
- Under MLT on sweet potato weevil resistance, TSp 12-6 performed well coupled with less weevil infestation in Bihar, TSp 12-4 in West Bengal and Telangana with more total and marketable tuber yield.
- Among the 14 entries evaluated under IET on taro, TTr 17-4 produced the highest cormel yield at Kalyani, Rajendranagar and Coimbatore, TTr17-1 at Barapani and Kovvur, TTr 17-7 at Jorhat, TTr 17-12 at Dapoli, Tripura and Dholi, TTr 17-5 at Jagdalpur, TTr 17-8 at Imphal and Coimbatore, TTr 17-9 at Ranchi.
- In the first year of MLT on taro, TTr 12-4 was superior in yield at West Bengal and Tamil Nadu. The entry TTr 12-8 yielded maximum in Jharkhand, Bihar and Andaman & Nicobar islands. The evaluation of taro entries against *Phytophthora* leaf blight in MLT indicated that TCbl 12-3 and TCbl 12-4 were field resistant

to leaf blight and yielded highest in West Bengal, TCbl 12-4 in Bihar, whereas TCbl 12-5 was superior in Maharashtra and Telangana.

- Under IET on bunda, pooled analysis of yield data showed that TBd 17-1 was superior at Jagdalpur, TBd 17-2 at Barapani, TBd 17-3 at Kalyani, TBd 17-4 at Dholi and Ranchi.
- Under URT on swamp taro, the highest stolon yield was recorded in BCST-3 (24.19 t ha^{-1}) at Kalyani, AAUST-2 at Jorhat and BCST-1 at Imphal.
- Under URT on tannia, among the six entries, TTn 14-6 performed well and produced maximum tuber yield at Rajendranagar and Jagdalpur and TTn 14-1 at Kalyani.
- Under IET on elephant foot yam, based on two years pooled data, TEy 17-1 produced significantly higher corm yield (32.30 t ha^{-1}) at Dholi, TEy 17-5 at Kovvur, and the national check Gajendra yielded maximum at the other centres.
- Under the IET on greater yam, TGy 17-6 produced the highest tuber yield at Kalyani (30.97 t ha^{-1}), national check Sree Karthika at Dapoli, local variety at Kovvur, TGy 17-3 at Jagdalpur (52.41 t ha^{-1}), Jorhat and Udaipur based on pooled means.
- Under URT on greater yam, TGy 14-7 produced maximum yield at Dapoli (25.43 t ha^{-1}), TGy 14-11 at Udaipur, Imphal and Kovvur (46.07 t ha^{-1}), TGy 14-3 at Jagdalpur, TGy 14-9 at Jorhat. Under MLT on greater yam, TGy12-3 produced maximum tuber yield at Bhubaneswar and Kovvur, TGy 12-1 at Jagdalpur (27.02 t ha^{-1}) and local variety at Udaipur. Highest organoleptic score was recorded in Sree Karthika (7.8) followed by TGy 12-3 (7.7) at Bhubaneswar, TGy 12-3 at Jagdalpur and Kovvur. Maximum bulbil yield and total yield was recorded in TDb 13-6 at Jagdalpur, TDb 13-5 at Ranchi, TDb 13-1 at Dapoli under MLT on aerial yam based on pooled data analysis.
- In the first year MLT on yam bean, highest tuber yield was recorded in TYb 14-5 (17.37 t ha^{-1}) at Bhubaneswar, TYb14-9 at Dholi and TYb 14-8 at Kalyani. Arrowroot tuber yield varied widely among the centres in the new IET initiated with 15 entries. TAr18-3 produced maximum yield at Kalyani, TAr 18-8 at Coimbatore, TAr 18-14 at Jagdalpur, Ranchi and Thiruvananthapuram and TAr 18-13 at Imphal.
- The farming system studies involving tuber crops introduced in Narangi (village), Gajapati (District), Odisha state generated a gross income of

₹1,87,025 ha^{-1} with B:C ratio of 3.16 and employment generation of 365 man-days ha^{-1} in the place of the gross income of ₹ 49,125 ha^{-1} with B:C ratio of 1.93 and employment generation of 235 man-days ha^{-1} before intervention. The gross and net income, B:C ratio and employment generation increased after interventions of different components under tuber crops based farming system in Semra village of Ranchi district of Jharkhand, Jorhat district of Assam, Khweng and Mawbri village of Ribhoi district, Meghalaya.

- Validation of organic farming technologies in elephant foot yam indicated positive response of organic farming over conventional method, however highest B:C ratio was recorded in the conventional method at Dholi, Dapoli and Kalyani. Organic farming practices produced maximum corm yield at Navsari, Ranchi and Kovvur.

- In greater yam, organic package resulted in the highest tuber yield and net income in all the centres, except Jorhat and Coimbatore, where conventional package resulted in highest yield. Organic farming resulted in superior performance of taro in most of the centres. At Rajendranagar, conventional method resulted in higher cormel yield.

- Studies on integrated weed management in elephant foot yam showed that weed control ground cover was the most effective with maximum growth and corm yield at Coimbatore (42.98 t ha^{-1}), Kovvur (41.44 t ha^{-1}), Kalyani (46.98 t ha^{-1}), Port Blair (23.50 t ha^{-1}) and Navsari. Hand weeding thrice, 30, 60 and 90 DAP was effective at Tripura and Ranchi.

- Under the new trial on 'Management of sucking pests in taro', there was a significant reduction in aphid population in all the insecticidal treatments, whereas botanical insecticides were less effective in reducing the population as compared to chemical insecticidal treatments.

- For anthracnose management in greater yam, soil application and tuber treatment with *Trichoderma* followed by Carbendazim spray seven times showed minimum disease intensity and maximum tuber yield at Jagdalpur, Rajendranagar and Udaipur. The *Trichoderma* treatment along with Carbendazim spray thrice resulted in maximum tuber yield at Jagdalpur.

- Seed corm treatment with Fungicide I (Carbendazim 25% + Mancozeb 50%) before storing the corms, corm treatment in cow dung slurry + *Trichoderma* @ 5g kg^{-1} corm 3 days before planting followed by drenching twice with 0.2% Carbendazim 25% + Mancozeb 50% gave very good control of collar rot of elephant foot yam in most of the centres. Chemical control gave best results

at Ranchi and Fungicide II, 0.1% (Mancozeb 63% + Carbendazim 12%) was effective at Coimbatore. Both the chemicals were effective at Palampur and Lembucherra centres.

- The centres produced a total of 1,46,441 stems of cassava, 95,72,730 vine cuttings of sweet potato, 36.40 tons of elephant foot yam, 8.62 tons of taro, 2.16 tons of bunda, 30.20 tons of greater yam, 0.96 tons of lesser yam, 9 tons of Tikhur, and 166 kg of yam bean and distributed to farmers.
- MPUAT, Udaipur organized two farmers training programme under Scheduled Caste Sub-Plan (SCSP) on 14 and 18 March 2019. The Regional Centre of ICAR-CTCRI organized 'Tuber Day' on 09 January 2019 at Chandragiri (Village), Mohana (Block), Gajapati (District), Odisha. About 500 tribal farmers and farm women from 30 villages attended the programme. A field day on 'Tuber Crops: Future Smart Crops' was conducted on 04 October 2018 at ICAR Research Complex for NEH Region, Umiam. Value added tuber products were displayed in Kisan Mela held at Zeeradai and Motihari.

TECHNOLOGIES ASSESSED, TRANSFERRED, CONSULTANCY AND PATENT SERVICES

- Eight technologies including five micronutrient foliar formulations for site-specific nutrient management in tropical tuber crops and three for the production of cassava fried snacks were transferred to four entrepreneurs in Tamil Nadu and Kerala. Value added fried products and fried chips from cassava and sweet potato on a technology licensing and consultancy mode were given to three firms/individuals 1) Dora Food Industries, Kozhikode, Kerala; 2) JSJ Food Products, Thondernad P.O., Korome, Wayanad and 3) Saji Varkey, Nirappil House, Ramapuram Bazar P.O., Marangad, Kottayam. A special paid programme on social science research methodology was also organised.

Exchange of MoU with M/s Linga Chemicals, Madurai

MoU with Dora Food Industries, Kozhikode

A total of ₹ 30,51,283 was generated as revenue through various activities as indicated below.

Revenue generated through technology commercialisation and other professional service functions

Sl. No.	Activity	Revenue generated (₹)
1.	Technology licensing	2,50,000*
2.	Sale of technological products	11,500
3.	Professional training	2,24,423
4.	Consultancy	75,000*
5.	Students fees	24,90,360
	Total	**30,51,283**

*Excluding GST

Technologies/varieties developed

Varieties and potential genotypes

- Sree Sakthi: The cassava mosaic disease resistant variety 'Sree Sakthi' (IC625794) has been recommended for central release for cultivation in Tamil Nadu, Andhra Pradhesh, Maharashtra and Kerala under irrigated/rainfed upland for industrial use. It is a non branching variety with a duration of 9-10 months and is completely resistant to cassava mosaic disease caused by the *Indian cassava mosaic virus* and *Sri Lankan cassava mosaic virus*. It has cylindrical tubers with brown skin, cream rind and white flesh colour. It has high starch content of 29% (Range: 26-32%). It has an average tuber yield of 43 t ha^{-1} with a potential yield of 80 t ha^{-1}.
- Sree Suvarna: The cassava mosaic disease resistant variety 'Sree Suvarna' (IC6267768) has been recommended for central release for cultivation in Tamil Nadu, Andhra Pradesh, Maharashtra and Kerala under irrigated/ rainfed upland for industrial use. It is a non branching/top branching variety with brown stem, dark purple petiole, light brown emerging leaves, conical to cylindrical tubers with brown skin, cream rind and white flesh colour. It has a duration of seven months and is completely resistant to cassava mosaic disease caused by the *Indian cassava mosaic virus* and *Sri Lankan cassava mosaic virus*. It has medium starch, 25-27% (Range: 24-29.8%) and low cyanogen (45.01 ppm). It has an average tuber yield of 38 t ha^{-1} with a potential yield of 48 t ha^{-1}.
- Identified 10 high yielding yam bean lines.
- Identified 4 high yielding sweet potato lines.

Production technologies

- Production technology for rice-black gram-short-duration cassava.
- Production technology for rice-short-duration cassava + black gram system.
- Production technology for elephant foot yam + pulse system.
- Drip irrigation along with plastic ground cover mulching or soil application of super absorbent polymers like Pusa hydrogel for reducing the water requirement of elephant foot yam to 50% without adversely affecting the corm yield.
- For upland taro, drip irrigation @ 75% of the CPE for 24 weeks required for proper germination, growth, tuber initiation, tuber development and optimum cormel yield in taro.

- Soil test based application of NPK, Mg, Zn and B.
- Green manuring *in situ* with cowpea, coirpith compost, vermicompost as alternate organic sources to farmyard manure.
- Need based soil application of secondary nutrient, Mg and micronutrients, Zn and B based on soil test.
- Four NUE cassava genotypes, 7III E3-5, CI-905, Sree Pavithra and CI-906 for saving NPK fertilizers to the extent of 75-100%.

Protection technologies

- Tuber treatment with Mancozeb 0.2%/Carbendazim+Mancozeb 0.2%, application of *Trichoderma* @ 5g kg^{-1} tuber for the management of postharvest rot in elephant foot yam.
- IDM package for greater yam anthracnose.
- Optimized techniques on behavioural study of *Bemisia tabaci* in cassava plants.
- Protocol for short term storage of cassava synthetic seed.
- Reliable protocols for genetic transformation of farmer and industry preferred cassava cultivars from India (in particular southern India).
- Fifty five lines of transgenic cassava plants having *SLCMV* RNAi constructs established in ICAR-CTCRI tissue culture facility.
- Standardisation of conditions and medium for hardening of transgenic lines imported from ETH, Zurich.
- Virus resistance assessment of CMD resistant transgenic cassava plants in green house through grafting and particle bombardment.
- Hardened ten transgenic lines (seventy plants) ready to be challenged by particle bombardment.
- Agroclones of *SLCMV* and *ICMV* for rapid screening of transgenics for their resistance against virus infection.
- Four CMD resistant lines through field trial in farmers' fields at Salem.
- LAMP based diagnosis of *Sri Lankan cassava mosaic virus* (*SLCMV*).

Technologies for value added food products

- Cassava flour based pasta using low cost protein rich ingredients viz., green peas, Bengal gram, casein, beetroot, soy flour etc.
- Rice analogue from the composite flour containing cassava-maida-whey protein concentrate-guar gum.
- Noodles from cassava–millet based composite flour.

Technologies for industrial products

- Particle board from cassava stem using cross linked cassava starch as binder.
- Particle board from cassava stem using cassava starch-wax as binder.
- Continuous wet pressing screw press for making high quality cassava flour.
- Functional sago using sweet potato leaf powder and beetroot powder.
- Thermoplastic sheet from oxidized cassava starch and cassava starch-wax composites.
- RS4 type resistant starch of cassava and sweet potato of medium glycemic index (55-70), by modification with citric acid.

Models/Packages/ICT tools

- Technology commercialisation strategies assessment framework model for assessing the effectiveness of technology commercialisation strategies of ICAR Institutes/SAU.
- Modified methodology for assessing the sustainable livelihood analysis of tuber crop farmers using DFID methodology.
- R-package for Soil Quality Index.
- Three Mobile Apps: VFT-Cassava, VFT-Taro and *Sree Poshini*.

GENERAL INFORMATION

EDUCATION AND TRAINING

Education

- ICAR-CTCRI is recognized as an approved Research Centre by the University of Kerala, Kannur University, Manonmaniam Sundaranar University, Utkal University and Orissa University of Agriculture & Technology, Bhubaneswar, Odisha for undertaking Ph. D. programme on tuber crops. During the period, the Institute has offered exposure training to students, imparted technical guidance for Ph.D. programme and project work of M.Sc. students. Besides, the scientists of ICAR–CTCRI have handled courses at College of Agriculture, Vellayani for the students of M.Sc. Course on Integrated Biotechnology.

Particulars of the programme	Number of students
B.Sc. project work	118
B.Sc./B.Tech. internship	78
M.Sc. project work	48
M.Sc. Integrated Biotechnology	8
Ph.D.	30
PDF	3

Training programme

On-campus training programmes

- A total of 874 farmers, 426 students and 114 officials from different parts of the country were imparted training by ICAR-CTCRI. They were trained on the improved technologies of tuber crops for enhancing productivity and profitability in tuber crops farming.
- Inter-state ATMA training programme on 'Improved technologies of tuber crops' were organized for 316 progressive farmers from the states of Tamil Nadu, Maharashtra and Bihar.

Participants of the training from Pune, Maharashtra

Participants of the training on Soil Analysis

- Entrepreneurship Development Programme (EDP) for agricultural students jointly organized by ICAR-CTCRI and College of Agriculture, KAU, Vellayani during 24-26 September 2018.
- On-job training on 'Improved technologies of tuber crops' for VHSS students, Thiruvallam, Thiruvananthapuram during 27-29 September 2018.
- RAWE programme for 11 B.Sc. (Ag.) students of College of Agriculture, Padanakkad, Kasaragod during 26-30 October 2018.
- Stakeholders Interface Programme in connection with Tuber Crops Day and Farmers' Fair during 22-23 November 2018 at ICAR-CTCRI for the benefit of more than 150 farmers and other stakeholders.
- Farmers day (Kisan Diwas) was celebrated on 23 December 2018 at ICAR-CTCRI for the benefit of more than 50 farmers and other stakeholders.
- Training on Priority Setting, Monitoring and Evaluation of Agricultural Research Projects was jointly organized by ICAR-CTCRI and College of Agriculture, KAU, Vellayani on 19 January 2019 for PG and Ph.D. students (122 nos.) from College of Agriculture, Vellayani.
- Training on Soil Analysis was conducted during 04-08 February 2019 for 20 officials of Soil Testing Laboratories of Kerala state. The participants included Scientific Assistants, Agricultural Officers and Assistant Soil Chemists of District and Mobile Soil Testing Laboratories in different districts of Kerala. The programme was conducted under the Soil Health Card Scheme 2018-2019 of National Mission for Sustainable Agriculture.
- Stakeholders Interface in connection with *"Pradhan Mantri Kisan Samman Nidhi"* (PM-KISAN)-cum-Live-web telecast on 24 February 2019 for the benefit of more than 500 farmers and other stakeholders.
- Refresher training on 'Improved technologies of tuber crops' was organized for 28 technical personnel of ICAR-CTCRI during 08 to 10 January 2019.
- Training on 'Enhancing personal efficiency in job performance' was organized for 23 skilled support staff of ICAR-CTCRI during 04 to 06 February 2019.
- Two professional attachment training of newly recruited ARS Scientists were organized.
- Apart from these, fourteen training programmes were organized at ICAR-CTCRI, Regional Centre, Bhubaneswar, Odisha.

Off-campus training programme

- Seven Stakeholder Meet and Entrepreneurship Development Programme on Tuber Crop Technologies were organized during the period in Andhra Pradesh, Tamil Nadu, Meghalaya and Kerala.

Trainings organized by Techno-Incubation Centre, ICAR-CTCRI

- Thirty six on-campus and six off-campus training programme were organized on practical demonstration of value added products and entrepreneurship development in tuber crops by the Techno-incubation centre of ICAR-CTCRI, Thiruvananthapuram.
- A one day seminar on 'Technological Empowerment of Women for Entrepreneurship Development in Tuber Crops based Value Added Products' was organized on 26 July 2018 at ICAR-CTCRI, Thiruvananthapuram.
- Five on-campus and one off-campus trainings were organized at the Techno-Incubation Centre, Regional Centre, Bhubaneswar.

Resource person in training programme

- More than 200 classes on production, protection, processing and value addition aspects were handled by scientists of various divisions under different programme within and outside the Institute beneficial to department officials, subject matter specialists, students and farmers all over the country. The specific topics covered were improved varieties, tissue culture, agro-techniques with special focus on organic management, INM, IPM, vermi-composting, bio-pesticides and bio-control strategies, post harvest management and value addition.

Exposure visit-cum-training programme

- One day exposure visit-cum-training on 'Improved technologies of tuber crops' was organized for the benefit of 1223 farmers, 1464 students and 100 officials across the nation at ICAR-CTCRI, Thiruvananthapuram.

Farmers from Thiruvarur, Tamil Nadu

Farmers from West Godavari, Andhra Pradesh

National Training undergone by ICAR-CTCRI staff

- Twenty two scientists, four technical staff and three administrative staff attended 12, four and three training programme respectively at the National level.

AWARDS

A total of 19 awards were received during the period by the Scientists /Staff members/Students of ICAR-CTCRI. These included three 'Best Exhibition Stall Awards'. A few important ones are detailed below:

- ICAR-Central Tuber Crops Research Institute, Sreekariyam, Thiruvananthapuram bagged the 'Best Annual Report Award' for the year 2017-18 under Small Institutes category.

Dr. Archana Mukherjee, Director, ICAR-CTCRI, receiving the Best Annual Report Award from Shri. Radha Mohan Singh, Hon'ble Union Minister for Agriculture & Farmers' Welfare in the presence of Dr. T. Mohapatra, DG, ICAR & other dignitaries

The Certificate of the Award

- Dr. G. Suja received the 'Indian Society of Agronomy (ISA) Fellow Award 2015' from the Indian Society of Agronomy, New Delhi in the 'National Symposium on Doubling Farmers' Income through Agronomic Interventions under Changing Scenario', held during 24-26 October 2018 at the Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan.
- Dr. P. Murugesan was conferred as Fellow of the Indian Society of Seed Technology during the valedictory function of 'National Seminar on Strengthening of Seed Systems in the North-Eastern and Unreached Regions– Problems, Prospects and Policies' on 05 February 2019 at ICAR-Research Complex for NEH Region, Manipur Centre, Lamphelpat, Imphal. He was also awarded the Best Poster Award for the research paper entitled 'Integration of digital image analysis for seed quality evaluation in sweet potato' in this Seminar.
- Dr. K. Susan John secured the first place and won the 'International Plant Nutrition Institute (IPNI) Photo Contest Award 2018' in the category of micronutrient deficiency of crops for B deficiency in sweet potato. The award

carried a cash award of USD 150, certificate and a USB flash drive collection of nutrient disorder images.

- Dr. Vivek Hegde was awarded the Best Poster Award for the presentation on 'Long term pollen storage studies in cassava and greater yam' in the 8th Indian Horticulture Congress held during 17-21 January 2019 at Indira Gandhi Krishi Viswavidyalaya, Raipur, Chhattisgarh.
- Dr. Sanket J. More received the Best Ph.D. Thesis Award from Gujarat Association for Agricultural Sciences, Ahmedabad, Gujarat for the academic year 2014-2015.
- Dr. S.S. Veena won the Best Oral Presentation Award for the research paper entitled 'Progress and prospects of leaf blight management in taro (*Colocasia esculenta* (L.) Schott)' in the 'National Symposium on Cutting Edge Approaches for Sustainable Plant Disease Management and Ensuring Farmers Profit' held during 21-23 December 2018 at ICAR-National Research Centre for Banana, Tiruchirappalli, Tamil Nadu.
- Mr. P. Prakash received Dr. N.A. Mujumdar Prize Award for Best Oral Research Paper titled 'Does APMC market increase farmers income? Evidence from value chain analysis of sweet potato in Karnataka' in the 78th Annual Conference of Indian Society of Agricultural Economics held during 01-03 November 2018, organized by the Institute of Economic Growth and International Food Policy Research Institute, New Delhi.

ICAR-CTCRI bagged second prize in the category of 'Best Exhibition Stall Award' in VAIGA & Krishi Unnati Mela

ICAR-CTCRI bagged first prize in the category of 'Best Exhibition Stall Award' in Krishidham Expo

- ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, bagged the second prize in the category of 'Best Exhibition Stall Award' in VAIGA & Krishi

Unnati Mela - International Workshop and Exhibition on Agro-processing and Value Addition held during 27-30 December 2018 at Thekkinkadu Maidanam, Thrissur, Kerala.

- ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, bagged the first prize in the category of 'Best Exhibition Stall Award' in the National Horticultural Fair held during 23-25 January 2019 at ICAR-Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru.
- ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, bagged the first prize in the category of 'Best Exhibition Stall Award' in Krishidham Expo held during 15-17 February 2019 at ICAR-Central Potato Research Institute, Regional Station, Modipuram, Meerut, Uttar Pradesh.

Award of Ph.D.

- Mrs. Chithra S. was awarded Ph.D. in Environmental Sciences from University of Kerala for the thesis entitled 'Cassava starch factory solid waste (Thippi): Prospects on utilization for nutrient recycling in cassava cultivation' under the guidance of Dr. K. Susan John.
- Mrs. Seena Radhakrishnan A.R. was awarded Ph.D. in Environmental Sciences from University of Kerala for the thesis entitled 'Evaluation of agronomic, nutritional and socio-economic impacts of organic production of cassava (*Manihot esculenta* Crantz)' under the guidance of Dr. Suja G.
- Mrs. Pravi Vidyadharan was awarded Ph.D. in Biotechnology from University of Kerala, for the thesis entitled 'Molecular diagnosis and characterization of *Sclerotium rolfsii* causing collar rot disease in *Amorphophallus paeoniifolius'* under the guidance of Dr. M.L. Jeeva.
- Mrs. Archana P.V. was awarded Ph.D. in Biotechnology from University of Kerala, for the thesis entitled 'Molecular diagnosis and characterization of *Phytophthora colocasiae* causing leaf blight disease of taro' under the guidance of Dr. M.L. Jeeva.
- Mrs. Pooja N.S. was awarded Ph.D. in Biotechnology from University of Kerala, for the thesis entitled 'Utilization of agricultural residues from cassava for lignocellulosic ethanol production' under the guidance of Dr. M.L. Jeeva and co-guidance of Dr. G. Padmaja.
- Twenty five students were awarded M.Sc. Biotechnology/Biochemistry/ B.Sc.-M.Sc. (Integrated) Biotechnology which were undertaken under the guidance of Scientists of ICAR-CTCRI.

PUBLICATIONS

- The Institute had a total of 260 publications; Radio talks: 8; TV talks: 5; Video: 1

Publication	Number
Research papers	70
Symposia	84
Books	4
Book chapters	13
Technical bulletins	3
Popular articles	56
Folders/leaflets/pamphlets	14
Course/training manuals	8
Institute publications	7
e-publication	1
Total	**260**

ONGOING PROJECTS

- **Institute projects : 8**
- **Flagship projects : 2**
- **Externally aided projects: 27**

VISITS ABROAD

Name of the scientist	Period	Place of visit	Purpose
Dr. M.N. Sheela	17-21 September 2018	Phnom Penh city, Cambodia	As Invited speaker presented a paper titled 'Control of cassava mosaic disease in India' at Regional CMD Control Plan Meeting organized by Global Cassava Partnership for the 21st Century
Dr. C. A. Jayaprakas	04-28 June 2018	Hainan Province, China	Attended training course on 'Integrated pest management of tropical crops for developing countries'
	07-11 October 2018	Berlin, Germany	Participated in the 12th International Working Conference on Stored Product Protection (IWCSPP) and presented a poster on 'Management of major coleopteran pests of stored-products using the insecticidal principles isolated from cassava, *Manihot esculenta* Crantz'
	11-14 November 2018	Vancouver British Columbia, Canada	Participated in the Entomological Society of America (ESA) Joint Annual Meeting 2018 at the Vancouver convention, and presented the paper entitled 'Cassava, *Manihot esculenta* Crantz, a befitting source for the isolation of green molecules against red palm weevil'
Dr. K. Susan John	05-07 September 2018	KU Leuven, Belgium	Attended the 5th International Zinc Symposium at Irish College, and presented an oral research paper titled 'Recent advances in the zinc nutrition of tropical tuber crops in different soil types of Kerala, India'.
Dr. T. Makeshkumar	17-21 September 2018	Phnom Penh city, Cambodia	Participated in the Regional CMD Control Plan Meeting and presented 'Status report of cassava mosaic disease in India'
	06-16 December 2018	Braunschweig, Germany	Undertaken short-term research visit at DSMZ Plant Virus Department
Mr. P. Prakash	28 July-02 August 2018	Vancouver, Canada	30th International Conference of Agricultural Economists

DISTINGUISHED VISITORS

- Shri. Alphons Kannanthanam, Hon'ble Minister of State for Tourism (Independent Charge), New Delhi.
- Dr. Abhilaksh Likhi, Joint Secretary (Cooperation), Ministry of Agriculture and Farmers Welfare, Govt. of India.
- Dr. G. Kalloo, Former DDG (Hort. Sci.), ICAR, New Delhi.
- Dr. N.K. Krishnakumar, Regional Representative in South & Central Asia, Bioversity International & Former DDG (Hort. Sci.), ICAR, New Delhi.
- Shri. Devendra Kumar Singh IAS, Agricultural Production Commissioner, Govt. of Kerala.
- Dr. P.K. Jayasree, Director, Department of Agriculture & Farmers' Welfare, Govt. of Kerala.
- Smt. Shardha Sampath, Chief Post Master General, Kerala Circle, Thiruvananthapuram.
- Dr. Purnachandra Rao, Director, National Centre for Earth Science Studies, Thiruvananthapuram.
- Shri. S. Harikishore IAS, Executive Director, Kudumbasree Mission, Govt. of Kerala.
- Shri. A. Somadethan, Assistant Director (Retd.), Income Tax Office, Thiruvananthapuram.
- Dr. T.N. Seema, Vice Chairperson, Haritha Keralam Mission, Government of Kerala.
- Dr. Simon Heck, CIP Program leader, Uganda.
- Dr. Maria Andrade, World Food Prize Laureate 2016, CIP, Mozambique.
- Dr. T. Janakiram, ADG (Hort. Sci.), ICAR, New Delhi.
- Dr. C. Devakumar, Former ADG (EP&D), ICAR, New Delhi.

- Dr. M. Anandaraj, Former Director, ICAR-Indian Institute of Spices Research, Kozhikode.
- Dr. S.K. Nanda, Former Project Coordinator, AICRP on PHT, ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana.
- Dr. S. Arulraj, Former Director, ICAR-Indian Institute of Oil Palm Research, Pedavegi, Andhra Pradesh.
- Dr. P. Kalia, Emeritus Scientist & Former Head, Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, Pusa, New Delhi.
- Prof. (Dr.) P.M. Rajan Gurukkal, Vice Chairman, Kerala State Higher Education Council, Thiruvananthapuram.
- Prof. (Dr.) V.K. Ramachandran, Vice Chairman, Kerala State Planning Board, Thiruvananthapuram.
- Advocate Smt. Rakhi Ravikumar, Deputy Mayor, Thiruvananthapuram Corporation, Thiruvananthapuram.
- Dr. S.P. Verma, Former Project Coordinator, AICRP (TC), ICAR-CTCRI, Thiruvananthapuram.
- Dr. M.S. Palaniswami, Former Project Coordinator, AICRP (TC), ICAR-CTCRI, Thiruvananthapuram.
- Dr. Saji Gopinath, Chief Executive Officer, Kerala Startup Mission, Thiruvananthapuram.
- Shri. Alathara Anil Kumar, Ward Councillor, Thiruvananthapuram Corporation, Thiruvananthapuram.

Distinguished RAC experts on the occasion of the First Meeting of RAC VIII

OTHER INFORMATION

Hon'ble Prime Minister's interaction with Kerala Farmers during the *PM-KISAN* Launch through Video Conference at ICAR-CTCRI, Thiruvananthapuram

The ICAR-CTCRI, Thiruvananthapuram hosted the Hon'ble Prime Minister Shri. Narendra Modi Ji's interactions with Kerala farmers through video conferencing on the occasion of *"Pradhan Mantri Kisan SAmman Nidhi" (PM-KISAN)* scheme launching at Gorakhpur, Uttar Pradesh on 24 February 2019. The ICAR-CTCRI was one of the five Institutes chosen by the Ministry of Agriculture and Farmers' Welfare, Government of India, wherein the farmers could interact with the Hon'ble Prime Minister regarding *PM-KISAN* Scheme. Shri. Alphons Kannanthanam, Hon'ble Minister of State for Tourism (Independent Charge) graced the occasion and shared about the agricultural policy and various schemes designed for the 'farmers welfare' in the country. Dr. Abhilaksh Likhi, Joint Secretary (Cooperation), Ministry of Agriculture and Farmers' Welfare, Government of India provided an overview of *PM-KISAN* scheme and stated that *PM-KISAN* is a revolutionary scheme for providing income support for farming and other needs. Dr. Archana Mukherjee, Director, ICAR-CTCRI welcomed the dignitaries, farmers and other invited guests and media. About 500 farmers and other stakeholders participated in the event.

PM-KISAN launch through video conference at ICAR-CTCRI

Participation in Exhibitions

- ICAR-CTCRI participated in 29 exhibitions for the benefit of stakeholders and bagged three "Best Stall Awards". Large number of farmers, college and school students, industrialists and other general public acquired knowledge on improved technologies of tuber crops.

VAIGA & Krishi Unnati Mela at Thrissur

National Horticultural Fair at Bengaluru

Tuber crops food festival at Namsai

Krishidham Expo at Meerut

Library Corner

Library continued information support services to the research and training activities of the Institute. In addition to the routine services, the major activities undertaken were: Maintenance of more than 18300 documents including books, bound back volumes of journals. A total of 211 books were issued to the users on loan. About 20 Document Delivery Request (DDR) of various State Agricultural Universities and ICAR Institutes of CeRA were satisfied by sending soft copy/ hard copy of library materials. Ready assistance and solutions to the various queries of the users were provided. These included enquiries in person or over the phone regarding any matter related to information sources like URLS of websites related to our work, downloading of files, common plant names, phone numbers, geographical information etc. More than 1500 users availed the facility of reference services from the library. Services were extended to the students from Colleges

and University Departments, who undertook their B.Sc., M.Sc., Ph.D. and PDF under the guidance of the Institute Scientists. They were given necessary guidance in the use of reference resources and also photocopying facility. Library continued to provide photocopying service to the Institute staff and other library users on official/payment basis. Ten new scientific books, eight Ph.D. and 13 B.Sc.-M.Sc. (Integrated Biotechnology) theses were added during this year. Six journals, two in Hindi and four in English, five newspapers, three in English and two in Malayalam were subscribed.

Hindi Corner

Three Hindi Workshops were held during this year on 29 June 2018, 15 December 2018 and 28 February 2019 by the Official Language Implementation Committee (OLIC). In the first two workshops, classes were taken by Shri. A. Somadethan, Assistant Director (Retd.), Income Tax Office, Thiruvananthapuram on the topic, 'Noting, Drafting/Official Language Awareness Programme' and 'Official Language Policy/Official Language Awareness Programme', respectively. The third workshop was conducted by Smt. P.A. Usha, Asst. Director (OL), All India Radio, Thiruvananthapuram on the topic, 'Noting and drafting'. Four OLIC meetings were also conducted during this period on 29 June, 29 September, 31 December 2018 and 26 March 2019. The Hindi Fortnight 2018 was celebrated during 14-28 September 2018, where, various competitions were held for the staff and children. Thirty three participants actively participated and bagged various prizes, which were distributed during the valedictory function on 15 December 2018, in which, Shri. A. Somadethan, Retd. Assistant Director (OL), Income Tax Office, Thiruvananthapuram was the Chief Guest and Dr. Archana Mukherjee, Director, ICAR-CTCRI, presided over. During this period, six staff members viz., Dr. H. Kesava Kumar, Dr. D. Jaganathan, Dr. T. Krishnakumar, Dr. K.M. Senthilkumar, Shri. S. Radhakrishnan Nair and Shri. K. Sarathchandra Kumar were awarded certificates for completing Hindi correspondence course 'Prabodh' conducted by the Central Hindi Training Institute, New Delhi. Nine staff members had enrolled for 2018-19 course in Prabodh/Praveen.

State of art of *Mera Gaon Mera Gaurav* (MGMG)

ICAR-CTCRI, Thiruvananthapuram and its Regional Centre implemented the MGMG programme in collaboration with other stakeholders viz., Department of Agriculture, Krishi Vigyan Kendra, grama panchayat, input dealers, progressive farmers, SHGs etc. During 2018-19, interface meetings, training programmes, demonstration of improved practices, farm advisory visits, mobile advisory services were organized in the selected villages for the benefit of farming community. A

total of 46 scientists adopted 51 villages for the overall development of the villages through 498 activities that benefitted 4223 farmers as given below:

Sl. No.	Name of the activity	No. of activities conducted	No. of farmers participated & benefitted
1.	Visit to village by teams	75	274
2.	Interface meetings/ *Goshthis*	61	949
3.	Trainings organized	25	405
4.	Demonstrations conducted	32	133
5.	Mobile-based advisories	135	212
6.	Literature support provided	119	588
7.	Awareness created	51	1662
	Total	**498**	**4223**

Swaccha Bharat Abhiyan

ICAR-CTCRI is involved in various activities related to 'Swachha Bharat Mission', the nation-wide cleanliness programme conceptualised by the Hon'ble Prime Minister of India. Since its inception in 2014 at ICAR-CTCRI, various cleanliness initiatives were being implemented such as:

- Swaccha Bharat Abhiyan was conducted weekly on every last day of the week for half an hour and all the staff members were instructed to clean their respective labs and sitting areas.
- On the last working day of the month, Swaccha Bharat Abhiyan was conducted for one hour, during which all the staff members were involved in cleaning the campus as a whole.

Swachhata Hi Seva–2018

The Swachhata Hi Seva-2018 fortnight was observed at ICAR-CTCRI Headquarters (HQ) and at Regional Centre (RC), Bhubaneswar from 15 September to 02 October 2018. It was inaugurated with the administration of the 'Swachhata Shapath' by Dr. Archana Mukherjee, Director. To uphold and disseminate the message of swachhata campaign, awareness programs were organised at schools in Thiruvananthapuram and Bhubaneswar and tourist places. A Swachhata awareness lecture highlighting the importance of Swachhata, pollution free environment and conservation of the nature was conducted at ICAR-CTCRI, Thiruvananthapuram. Dr. T.N. Seema, Vice Chairperson, Haritha Keralam Mission, Government of Kerala delivered the lecture and Dr. Archana Mukherjee presided over the

function. All the staff and students of ICAR-CTCRI and Students Police Cadets from Government High School, Chavadimukku attended the lecture. To emphasize the significance of solid waste management and conserving nature, compost pit was constructed to compost the waste generated on site. The valedictory function was conducted on 02 October 2018. Dr. Archana Mukherjee, Director, ICAR-CTCRI and Dr. M. Nedunchezhiyan, Head (i/c), presided over the programmes at HQ and RC, respectively.

150th Birth Anniversary of Mahatma Gandhiji, Father of Nation

A floral tribute to the Father of Nation, Mahatma Gandhiji was offered to celebrate his 150th Birth Anniversary. Prizes were distributed to the winners of several competitions held in connection with Swachhata Hi Seva-2018.

Swachhata Pakhwada-2018

The Swachhata Pakhwada-2018 was observed at ICAR-CTCRI, Thiruvananthapuram during 16-31 December 2018. Swachhata Pakhwada 2018 was inaugurated with the administration of 'Swachhata Pledge' by Dr. Archana Mukherjee, Director, ICAR-CTCRI. The Swachhata awareness banner was displayed at prominent places for creating awareness among public. Planting among trees was done by the Director and staff of ICAR-CTCRI. Swachha Bharat awareness placards were installed around the campus for preventing the general public from throwing wastes on streets. Under 'Swachhata Pakhwada' cleaning activities in the premises of Cheruvikkal Government Primary School, Thiruvananthapuram was done to create awareness among the school children. As a concluding event, a special programme on the theme 'Wealth from Waste' was conducted in the Bio-pesticide laboratory, where cassava leaves were utilised as a source of biogas. Shri. M. Unnikrishnan, Principal Scientist (Retd.), ICAR-CTCRI and Shri. Suresh Muthukulam, Principal Information Officer (Rtd.), Farm Information Bureau graced the occasion. Swachhata Pakhwada was observed at ICAR-CTCRI, RC, Bhubaneswar during 16-31 December 2018 including Kisan Diwas on 23 December 2018.

Quality planting material production of tuber crops during the crop season 2018-19

Sl.No.	Name of the crops	Varieties	Quantity of planting material produced
1.	Cassava (No. of stems)	Sree Vijaya	30,000
		Sree Jaya	23,000
		Sree Pavithra	14,000
		Sree Swarna	13,000
		Total	**80,000**
2.	Elephant foot yam (ton)	Gajendra	12.00
		Sree Padma	1.00
		Total	**13.00**
3.	Greater yam (ton)	Sree Keerthi	5.5
		Sree Karthika	3.5
		Sree Shilpa	4.5
		Sree Roopa	2.5
		Orissa Elite	2.0
		Total	**18.00**
4.	Taro (ton)	Sree Rashmi	0.5
		Muktakeshi	0.5
		Total	**1.0**
5.	Sweet potato (No. of vine cuttings)	Bhu Sona	2,25,000
		Bhu Krishna	1,87,000
		Total	**4,12,000**
6.	Chinese potato (No. of cuttings)	Sree Dhara	4,000
7.	Yam bean (kg)	RM-1	50

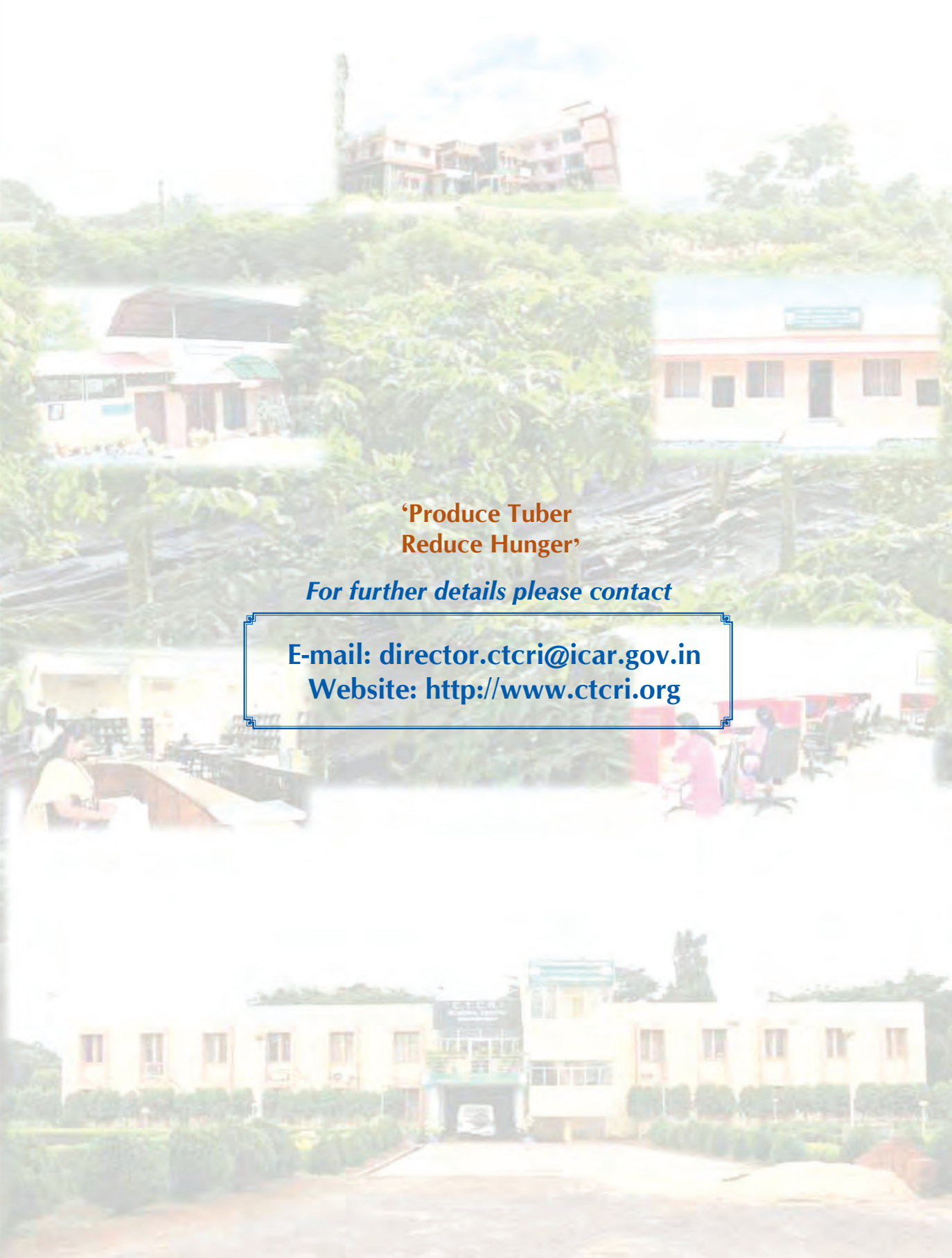
IMPORTANT EVENTS AND ACHIEVEMENTS

Events

Events	Date
44th Annual Institute Research Council Meeting	03-05 April 2018
18th Annual Group Meeting and Golden Jubilee Celebrations of the All India Coordinated Research Project on Tuber Crops	26-28 April 2018
H.H. Sree Visakham Thirunal Endowment Lecture	19 May 2018
Annual Asia Sweet potato Breeders and Seed System Meeting 2018	28-31 May 2018
International Yoga Day	21 June 2018
National Workshop on e-Crop : an IoT Solution in Agriculture	05-07 September 2018
Hindi Fortnight Celebrations	14-28 September 2018
Entrepreneurship Orientation Programme for Agricultural Students	24-26 September 2018
Swachhata Hi Seva	15 September-02 October 2018
150th Anniversary of Mahatma Gandhi	02 October 2018
Vigilance Awareness Week	29 October-03 November 2018
National Workshop on Advances in Social and Behavioural Science Research	12-17 November 2018
Research Advisory Committee Meeting	16-17 November 2018
Tuber Crops Day and Farmers Fair celebrations	22-23 November 2018
Stakeholders Meet and Tuber Crops Entrepreneurship Development Programme at Tura, Meghalaya	01 December 2018
Stakeholders Meet and Tuber Crops Entrepreneurship Development Programme at Namsai, Arunachal Pradesh	05 December 2018
World Soil Day 2018	05 December 2018
Farmers Day (Kisan Diwas) Celebrations	23 December 2018
Swachhata Pakhwada 2018	16 -31 December 2018
Value Addition for Income Generation in Agriculture (VAIGA) and Krishi Unnati Mela	27-30 December 2018
Refresher Training on 'Improved Technologies of Tuber Crops' for Technical Personnel of ICAR-CTCRI	08-10 January 2019
Field Day-cum-Agripreneur Meet on Chinese potato at Tirunelveli	11 January 2019
Release of video entitled 'Produce tuber Reduce hunger' at New Delhi	31 January 2019
Training on Enhancing Personal Efficiency in Job Performance for Skilled Support Staff of ICAR-CTCRI	04-06 February 2019
National Productivity Week Celebrations at ICAR-CTCRI, Thiruvananthapuram	12-18 February 2019
National Science Day Celebrations	19-22 February 2019
Pradhan Mantri Kisan SAmman Nidhi (PM-KISAN)-cum-Live Web Telecast	24 February 2019
Stakeholders Interface in connection with International Women's day	08 March 2019
Institute Management Committee Meeting	18 March 2019
Workshop on Intellectual Property Valuation of Agricultural Technologies	22 March 2019

Achievements

Particulars	Nos.
Institute projects	8
Flagship projects	2
External aided projects	27
Tuber crops germplasm maintained in the field gene bank	5579
Tuber crops varieties released	2
Technologies commercialized	8
ICT Apps developed	3
External fund mobilised (₹ lakhs)	2359.73
Revenue generated (₹ lakhs)	130.69
B.Sc. students guided	196
M.Sc. students guided	56
Ph.D. scholars guided	30
Ph.D. awarded	5
PDF guided	3
Farmers visited the Institute	1223
Students visited the Institute	1464
Officers visited the Institute	100
Trainings conducted	80
Institute staff members trained	83
Awards received	19
Publications in peer reviewed journals	70
Papers presented in conferences/seminars/symposia/ workshops etc.	84
Books	4
Book chapters	13
Technical bulletins	3
Popular articles	56
Folders, leaflets	14
e-Publication	1
Radio talks	8
TV programme	5
Scientists visited abroad	5
Dignitaries visited the Institute	21
Exhibitions organized	29
FLDs conducted	35



'Produce Tuber
Reduce Hunger'

For further details please contact

E-mail: director.ctcri@icar.gov.in
Website: http://www.ctcri.org

भाकृअनुप
ICAR

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

Agrisearch with a human touch