



अनुसंधान की मुख्य विशेषताएँ
Research Highlights
2016 - 2017



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

ICAR-CENTRAL TUBER CROPS RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
An ISO 9001-2008 Certified Institute
Sreekariyam Thiruvananthapuram 695 017 Kerala India

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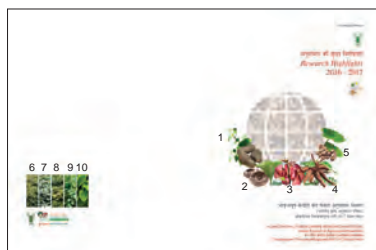
Cover Illustration

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1. White yam shoot and tubers
2. Elephant foot yam plant and corms
3. Sweet potato shoot and tubers
4. Cassava shoot and tubers
5. Taro leaves and cormels

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16 July 2017



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Preface

ICAR-Central Tuber Crops Research Institute with its headquarters at Thiruvananthapuram and Regional Centre at Bhubaneswar has delivered several farmer/consumer-friendly production, protection and value addition technologies in tropical tuber crops ensuring food-cum-nutritional-cum-livelihood security in the back ground of severe threat due to climate change. We proudly present a concise document on Highlights of Research for 2016-2017, another eventful year with notable scientific contributions and developments for the use of farmers, industrialists, entrepreneurs, extension personnel and policy makers. For detailed description of the achievements, readers may access the Annual Report 2016-2017 available in our website (<http://www.ctcri.org>).

Eight varieties, including 5 sweet potato, 1 greater yam and 2 taro varieties, were released by Regional Centre, ICAR-CTCRI, Bhubaneswar. Among the sweet potato varieties, anthocyanin rich, Bhu Krishna and β carotene rich, Bhu Sona are nutritionally important. Besides, CMD resistant hybrids with short-duration, PPD tolerant cassava genotypes, early maturing sweet potato rich in β -carotene and anthocyanin, hybrids of greater yam with tolerance to anthracnose, high yielding dwarf and semi-dwarf white yam hybrids with excellent cooking quality and taro accessions moderately resistant to TLB were identified. Protocol for synthetic seed production in cassava was also developed.


Sustainable resource management technologies especially to address some of the government flagship programmes such as 'more crop per drop', safeguarding soil health, enhancing production of pulses and climate smart agriculture were developed. The major research highlights were water and nutrient saving techniques through drip irrigation, drip fertigation for elephant foot yam, cassava and greater yam + maize system and nutrient efficient cassava genotypes. Methodologies were developed for climate suitability studies of cassava. The nutrient requirement of sweet potato for Island eco-system, elephant foot yam + black gram system, site specific nutrient management schedules, customized fertilizers for cassava, sweet potato and elephant foot yam, weed management for elephant foot yam and organic production technologies for tuber crop based system were evolved.

Exploitation of cassava based bio-formulation for pest management, especially thrips in vegetables, management of sweet potato weevil using sex pheromones, repellents and EPNs, bio-intensive management of taro leaf blight, collar rot of elephant foot yam and yam anthracnose were few notable crop protection technologies. Production of sweet potato based gluten free cookies, sweet potato flour fortified nutri bar, vacuum fried orange-fleshed and purple-fleshed sweet potato chips, sweet potato based functional bars enriched with resistant starch, *jimikand* papad, *jimikand* shorts, PPD management in cassava, particle boards from cassava stems, encapsulated anthocyanin pigments with improved colour stability from sweet potato and greater yam, protein rich, calcium rich and fibre rich functional cookies containing *Curcuma angustifolia* starch and lacto-pickling of greater yam were the significant value addition technologies.

The real-time advisories sent as SMS to the farmers through the electronic device (E-Crop) and a nutrient decision support system in CD, CASSNUM version 1.1, released for site specific nutrient management of cassava, were important contributions. The Tribal Sub Plan programme at Regional Centre, Bhubaneswar, the Techno-Incubation Centre at the headquarters and the special programmes of Hon'ble Prime Minister, "Mera Gaon Mera Gaurav" and "Swachh Bharath Mission", continued in a big way. Hon'ble Union Agriculture Minister and Minister of State for Agriculture visited our Institute and graced a couple of programmes.

I am extremely grateful to Dr. Trilochan Mohapatra, Secretary, DARE and Director General, ICAR for his valuable guidance and support. I place on record my gratitude to Dr. N. K. Krishna Kumar, former DDG and Dr. A. K. Singh, DDG (Horticulture Science). I express sincere thanks to Dr. T. Janakiram, ADG (HS I), Dr. B.K. Pandey, Dr. Manish Das, Dr. V. Pandey and other Officers and Staff of the SMD for their suggestions and timely help. I express my sincere gratitude to Dr. James George, the former Director (Acting), ICAR-CTCRI, for his dynamic leadership and valuable contributions. I am also thankful to PPV & FRA, EU aided INEA, Indo-Swiss collaboration, the network projects and consortia research platforms of ICAR for the financial support. The constant support from ICAR and the commitment of the Scientists are also sincerely acknowledged. I congratulate the editorial team for bringing out this publication on time.

16 July 2017



Archana Mukherjee
Director

Research Achievements

There were 10 ongoing projects, including two flagship projects and 27 externally aided projects during 2016-2017. The salient achievements of the projects are highlighted here.

CROP IMPROVEMENT

- A total of 5558 accessions comprising 1211 cassava, 1124 sweet potato, 1110 yams, 672 edible aroids, 200 minor tuber crops and 1241 collections from regional centre were maintained and conserved in the field gene bank.
- Three exploration trips were carried out in Chhattisgarh, Assam and Karnataka and a total of 164 accessions of major and minor tuber crops were collected. Sixty accessions were collected from the Bastar region of Chhattisgarh, 89 from Assam and 15 accessions from Joida, Sirsi and Siddapura areas of Uttara Kannada district of Karnataka. A wide variability in tubers were recorded in the collections.



Tuber variability in the new collections

- A total of 1211 accessions of cassava comprising of the indigenous, exotic, landraces and breeding lines were planted in the field for maintenance, characterization and evaluation. Morphological characterization of 500 accessions of cassava for 12 above ground vegetative plant characteristics using a combination of IPGRI/NBPGR descriptors was completed with digitization of indigenous accessions.
- Evaluation of 280 accessions of cassava for 42 yield and tuber traits viz., tuber rind, cortex and pulp colour, shape of tuber, presence of constriction and roots on tuber, tuber taste, tuber rind and cortex texture, ease of peeling, tuber length, tuber diameter, tail and neck length and tuber yield per plant was done. Of the 280 accessions, 173 showed high tuber yield per plant.



- Twenty exotic accessions of cassava were analysed for genetic diversity using six SSR markers. The polymorphic primers SSRY-105 and SSRY-28 produced the highest number of four fragments. The primers SSRY-45, SSRY-100 and SSRY-181 showed 100% polymorphism and the similarity coefficient based on SSR markers ranged from 0.45 to 0.90. The accessions CE-56 and CE-84 were 100% similar.
- A total of 1124 sweet potato accessions is being maintained in the field gene bank. Characterization of germplasm of sweet potato based on morphological descriptors was done for 500 accessions.
- Evaluation of tuber traits and yield were performed for 55 accessions from germplasm in three trials. The accession 526/7 was the highest yielder with a per plant yield of 0.49-1.07 kg. Twenty new accessions of sweet potato were evaluated in augmented design with five released varieties as control. Out of these, RSM-2015-5 from Joida, Karnataka was the highest yielder (0.58 kg plant⁻¹).



Sweet potato accession 526/7

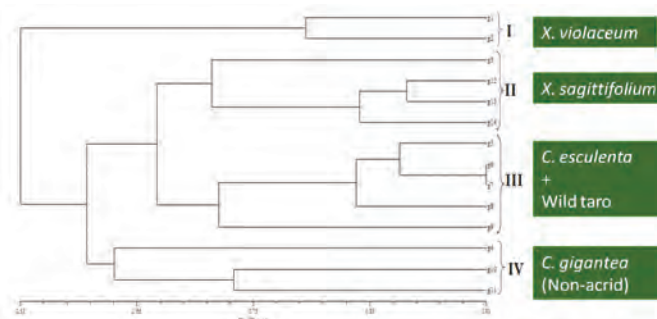
- One thousand one hundred and ten accessions of yams comprising of greater yam (591), white yam (158), lesser yam (220), potato yam (6) and wild yams (135) were replanted and conserved in the field gene bank.
- Sixty accessions of greater yam were characterized based on 25 qualitative and 13 quantitative traits including the major yield components and three biochemical characteristics. No duplicate accessions were identified. Principal component analysis showed that the total variance among accessions was contributed mainly by young vein colour, colour of young leaves, leaf shape, petiole length, young leaf vein colour, tuber shape, tuber cortex colour and starch content. The distribution of accessions in the scatter plot revealed high divergence of Da-340, Da-331 and Da-390.
- Forty five greater yam accessions were evaluated for biochemical traits and crude protein content on fresh weight basis, which varied from 2.28% (Da-390) to 5.23%

(Da-331). Da-391 had the highest dry matter (48.24%), starch (26.41%) and sugar (3.66%). The sugar content on fresh weight basis ranged from 0.84% (Da-308) to 3.66% (Da-391). Among the accessions, Da-331, Da-391 and Da-69 had the highest protein content on fresh weight basis (>5.10%).

- Twenty seven accessions of wild yams were characterized using 22 morphological traits comprising of 18 qualitative and four quantitative traits. The biochemical studies of 27 accessions of 18 *Dioscorea* species was done to identify wild yam accessions with better nutritive value. Among the accessions, *D. floribunda* (CTDf-1) had the highest protein content on dry weight basis (14%) followed by *D. hispida*, CTDh-1 (12.46%), while, *D. vexans* (1.29%) and *D. floribunda* (9.31) had the highest fibre and fat contents, respectively.
- Molecular characterization of 45 accessions of greater yam and 27 accessions of wild yams was carried out using 15 ISSR and 10 SSR primers. The Polymorphism Information Content (PIC) of the primers ranged from 0.6918 (UBC817) to 0.88 (UBC807). The studied primers showed PIC value > 0.8. Dendrogram based on ISSR markers showed that Da-340 and Da-331 had maximum genetic divergence from other landraces.
- Six hundred and seventy two edible aroid germplasm comprising 429 taro, 203 elephant foot yam and 40 tannia are being maintained in the field gene bank. DNA of 8 taro, 30 elephant foot yam and 6 tannia lines were deposited in the DNA bank.
- ISSR markers were successfully used to differentiate between different aroid species, which were morphologically different. When nine ISSR markers were used in an experiment comprising *Xanthosoma sagittifolium*, *X. violaceum*, a non-acrid *Colocasia* spp., *C. esculenta* and a wild *Colocasia*, all of them grouped separately, except the *C. esculenta* and the wild *Colocasia*, which grouped together, with the wild one as an outlier in the group. The non-acrid *Colocasia* grouped separately suggesting that it is a different species. Its appearance resembles that of *C. gigantea*, which is to be confirmed at flowering stage.



The non-acrid *Colocasia* spp.

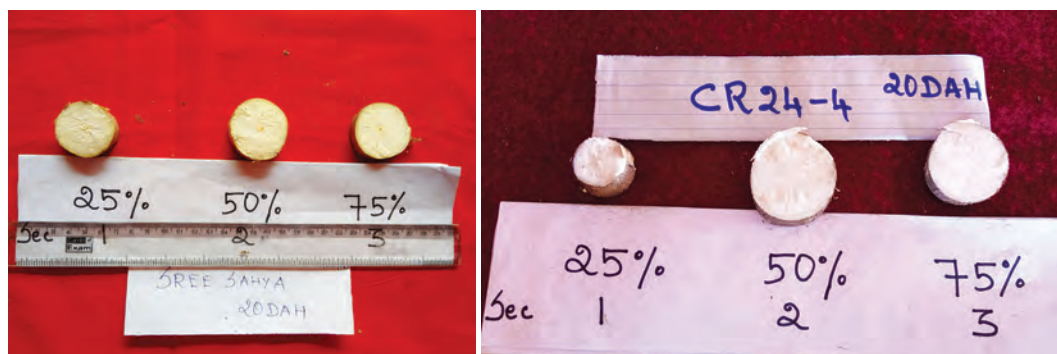


Dendrogram showing the grouping of the different aroid species using nine ISSR markers



- Morphological characterization of 28 elephant foot yam accessions was done using 32 traits (NBPGR minimum descriptors), including aboveground traits and tuber characters. Eighteen quantitative characters were included in this. Weight of the corm was a major contributing factor responsible for separating the accessions in PCA. Based on the coefficient of variation, the degree of variability was found to be high for fresh weight of corm, height of corm, length of cormels, number of leaflets (primary partition), number of corms, number of tertiary partitions, weight of cormels and number of cormels. Molecular characterization of these accessions was also done using 15 ISSR primers and as in the case of morphological data, no duplicates were present in this set.
- A total of 200 accessions comprising Chinese potato, yam bean, arrowroot, *Canna* sp., *Costus* spp., *Tacca* sp., *Arisaema* sp., *Curcuma* spp., *Zingiber* spp. and *Coleus aromaticus* are being maintained in the field gene bank. DNA samples of 20 accessions of Chinese potato accessions were deposited in the DNA bank.
- At the Regional Centre, ICAR-CTCRI, Bhubaneswar, different tuber crops comprising 1241 germplasm accessions are being maintained in the field gene bank. It includes taro (506), sweet potato (373), cassava (113), yams (51), elephant foot yam (41), yam bean (146), Chinese potato (5), arrowroot (2), tannia (1) and *Alocasia* (3).
- Under the *in vitro* conservation of germplasm of tuber crops, a total of 11 accessions of *Dioscorea rotundata*, 101 accessions of *D. alata* and 192 accessions of sweet potato received from NBPGR are being maintained. Twenty new accessions of sweet potato, 20 taro, 18 cassava accessions from germplasm were brought *in vitro* during this year. Besides, the existing cultures of sweet potato were sub-cultured and maintained in the IVAG.
- Hexane and ethanol extract of sweet potato leaf and Chinese potato tuber was prepared in the experiment on gene bioprospecting for novel traits in tuber crops. *In ovo* screening of different extracts of purple leaf of sweet potato Acc. No. 1467 was done. The ethanol extract of sweet potato leaf extract showed pro-angiogenic effect as indicated with many blood vessels growing towards the discs, similar to VEGF control. Hexane extract did not promote the growth of blood vessels, neither did it prevent the blood vessel growth.
- The CMD resistance of the CMD resistant cassava seedlings screened through grafting and multiplex PCR using ICMV and SLCM specific primers showed that resistance segregated in the ratio 3:1 indicating a dominant gene. Maximum number of CMD resistant hybrids was obtained in the cross 9S-75 x CI-273. Among the CMD resistant hybrids with short-duration, 16S-203 produced the highest tuber yield (7.81 kg plant⁻¹) at the sixth month. Of the CMD resistant hybrids, 15S-57 had the highest dry matter (44.80%). For culinary purpose, the genotypes, 11S-30, 11S-7, 15S-57, 11S-53 and 11S-4, with high yield (>40 t ha⁻¹), CMD resistance and cooking quality were selected.

- Among the triploid cassava evaluated for yield and starch content (>30%), Tr44-7 produced the highest yield (64.20 t ha⁻¹). Highest starch content was in Tr44-4 (33.70%).
- In the trial for identifying cassava lines with good fried chips quality, CMR-100, 8W-5 and CR-21/10 yielded good quality chips, crispy and soft.
- In an experiment on pyramiding of genes for cassava mosaic disease (CMD) resistance, the identified 150 true hybrid seedlings having both genes showed 100 per cent field resistance to CMD disease.
- For post-harvest physiological deterioration (PPD) tolerance in cassava, among the 72 cassava genotypes evaluated, Sree Sahya, Kalpaka, CO-1, CR-43-2, CR-20A (2) and CR-24-4 were free of PPD symptoms even at 20 days after harvest (DAH). Tubers with neck showed less PPD symptoms than the ones without neck. Tuber length, dry matter content and total starch had significant positive correlation with PPD response. Tuber girth, tuber weight and total sugar had significant negative correlation with PPD response.



Sree Sahya after 20 days of harvest (left); CR24-4 after 20 days of harvest (right)

- Among the 159 accessions of cassava screened for drought tolerance on the basis of leaf retention capacity, 31 genotypes had poor, 61 had below average, 53 had average and 14 had above average leaf retention capacity.
- During 2016-2017, five varieties of sweet potato for various traits, especially with nutritional attributes and salinity tolerance, were released by Regional Centre, ICAR-CTCRI, Bhubaneswar. ST-13 (Bhu Krishna) is an anthocyanin rich variety (85-90 mg 100g⁻¹); ST-14 (Bhu Sona) is a β carotene rich variety (14 mg 100g⁻¹); ST-10 (Bhu Swami) is a white-fleshed variety suitable for food and processing industries having tolerance to mid-season drought. CIP-440127 (Bhu Kanti) and CIPSWA-2 (Bhu Ja) are the other released varieties.



Bhu Sona (ST-14)



Bhu Krishna (ST-13)



Bhu Kanti (CIP-440127)



Bhu Ja (CIPSWA-2)



Bhu Swami (ST-10)

- In sweet potato breeding, progressive evaluation of 265 genetic resources resulted in the selection of 16 lines having more than 18 t ha⁻¹ yield, four of which was observed to have 75 days maturity. The accession nos. S30/15, S30/16, Baster-45 and Acc. No. 527 with 75 days maturity also responded to half doses of N and K (37.5: 37.5).
- Progressive evaluation of previously selected 29 sweet potato breeding lines generated through open pollination for high starch, β-carotene, anthocyanin and weevil resistance showed 75 days maturity in seven lines, two of which were having white flesh, two orange flesh and three purple flesh. Of the rest, 90 days maturity was recorded in six white, three purple and five orange flesh sweet potato lines. Yield ranged from 18.70 to 20.80 t ha⁻¹ for lines with 75 days maturity and 24.90 to 35.50 t ha⁻¹ for lines with 90 days maturity, respectively.
- Evaluation of the clonal generation of F₁ (C₁F₁ 2015-16 and C₂F₁ 2016-17) generated through reciprocal crosses in sweet potato, revealed 75 days maturity in eight hybrids, of which four were white, one orange and three purple-fleshed. Starch content ranged from 15-18%, β-carotene 10-16 mg 100g⁻¹ and anthocyanin 65-100 mg 100g⁻¹ in these lines.
- One short-duration greater yam variety (6-7 months), Bhu Swar (Da-25) was

released by Regional Centre, ICAR-CTCRI, Bhubaneswar, with good cooking quality and yield of 20-25 t ha⁻¹.



Bhu Swar (Da-25)

- Among the 9th clonal white yam hybrids evaluated, Drh-1150 produced the highest tuber yield (46.90 t ha⁻¹) followed by Drh-1125 (43.21 t ha⁻¹). Among the dwarf white yam hybrids (9th clonal) evaluated under irrigated condition, Drd-1157 produced the highest tuber yield (73.20 t ha⁻¹) followed by Drd-1038 (51.70 t ha⁻¹), Drd-1118 (51.10 t ha⁻¹) and Drd-1095 (39.5 t ha⁻¹). The dwarf clones, Drd-9495 and Drd-1060 had better cooking quality than the released dwarf white yam variety Sree Dhanya. Among the semi-dwarf varieties of white yam, SD-15 produced high yield coupled with excellent culinary quality.



Drd-1157

- *In vitro* screening of 71 accessions of greater yam using highly virulent isolate of *Colletotrichum gloeosporioides* for anthracnose showed that eight accessions did not show any infection and 14 showed resistance with a disease scale of 1-2 including the released varieties, Sree Karthika and Sree Keerthi.
- Two taro varieties viz., Bhu Kripa (Jhankri) and Bhu Sree (Sonajuli) were released



by Regional Centre, ICAR-CTCRI, Bhubaneswar, with good cooking quality and yield of 15-20 t ha⁻¹.



Bhu Kripa (Jhankri)



Bhu Sree (Sonajuli)

- Of the fifteen taro accessions screened artificially, four showed moderate resistance to taro leaf blight in the first season, whereas, nine and seven accessions screened earlier showed tolerance in the second and third seasons, respectively. Flowering was noted in few taro lines. Crossing was attempted with two accessions as female parent (C-157 and C-688) with TLB tolerant lines, Muktakeshi, C-565 and C-203 as male parents. The seeds were collected, dried and stored for further germination studies.
- In elephant foot yam, a total of 240 corms were selected from the hybrid progeny of the six crosses from previous two years, the corm weight of which ranged from 5 g - 550 g. Most of the corms had numerous cormels. Six genotypes with smooth petiole and reasonably higher yield were identified during the second year.
- In PYT 1 in tannia, the total yield ranged between 9.61 (Xa-12) to 19.88 t ha⁻¹ (Xa-AD/2014-15).
- In the AYT for arrowroot, M-1 produced the highest per plant yield (0.64 kg), number of tubers per plant (16) and biggest tuber length (22.11cm).
- Biochemical analysis done in seven arrowroot genotypes showed that the highest dry matter content of 32.35% was recorded in M-7, while the total starch and sugar content were highest for M-1. The total starch content on dry weight basis ranged from 54.15% (M-1) to 50.43% (M-7). Total sugar varied from 2.40% (M-1) to 1.98% (M-5). The total ash content was highest in M-4 (4.23%) and the lowest in M-2 (3.18%). The total crude fibre content was lowest for the accession M-1 (1.71%) and highest for the accession M-7 (2.19%).

- In yam bean, the tuber yield in F₂ generation of the five best F₁ hybrids ranged from 30.55 t ha⁻¹ (3x9) to 36.11 t ha⁻¹ (3x10) as compared to 24.99 t ha⁻¹ in RM-1 as a check variety. Starch content ranged from 9.34% (3x8) to 15.33% (3x9) and sugar content ranged from 3.88% (3x8) to 7.55% (3x9). The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity determination showed that 3x10 had the highest ability (40.11%), while 3x8 had the lowest scavenging ability (28.13%). Lignin content ranged from 1.23% (3x8) to 2.85% (3x9).
- In the experiment on genetic modifications for quality improvement in cassava, 9S-127 and CR-4311 (CMD resistant cassava lines) were multiplied *in vitro*. TMS60444 FEC transformed with glgC gene maintained in maturation media was transferred to regeneration media. New embryogenic callus was initiated from 9S-127 and callusing was initiated in CR-4311.
- Using cassava transcript sequences retrieved from the Phytozome website, NovoMIR predicted a total of 29 novel miRNAs from 41,381 cassava transcript sequences. The predicted miRNAs targeting transcript sequences of cassava were subjected to functional annotation by BlastX. The major functions were ADP binding property, ATP binding, ion transport, ATP hydrolysis coupled proton transport, lipid binding and hydrogen ion transmembrane transporter. RNA Hairpin Figure draws hairpin-like text figure from RNA sequence and its secondary structure in dot-bracket notation.
- A total of 219 SNP markers and 10,307 SSR markers in *A. paeoniifolius* associated with dasheen mosaic virus were predicted using bioinformatics tools. SNP748 could differentiate the resistant and susceptible varieties. About 374 novel microRNAs in *Amorphophallus* and 29 novel microRNAs in cassava and its secondary structure were predicted using bioinformatics tools. A database of predicted SNPs and SSRs of cassava and predicted miRNA for *Amorphophallus* was developed.



CROP PRODUCTION

- Drip fertigation studies in cassava during the third year as well as pooled analysis of data of three years confirmed that N and K₂O @ 75 and 100 kg ha⁻¹ was optimum for obtaining maximum tuber yield in short-duration cassava var. Sree Vijaya raised through minisetts.
- On-farm validation experiments of customised fertilizers developed for cassava based on SSNM technology were conducted in 35 farmers' fields spread across five agro-ecological units (AEU) zonations of Kerala (Malappuram, Palakkad, Idukki, Alappuzha and Pathanamthitta). In Idukki, Malappuram and Palakkad districts, the customized fertilizer treatment resulted in significantly higher tuber yield (42.50, 62.50 and 48.60 t ha⁻¹ respectively) than farmer fertilizer practice (FFP) (35.30, 50.30 and 38.40 t ha⁻¹ respectively). On an average, the customized fertilizer treatment resulted in 24% higher yield over FFP in these agro-ecological units. The decision support system for SSNM of cassava, CASSNUM version 1.1 was released.



On-farm validation experiments of customised fertilizers for cassava based on SSNM technology at Malappuram, Kerala

- Sustainability of cassava for continuous cultivation was established after 12th season crop with a tuber yield of 14.27 t ha⁻¹, without manures and fertilizers. Soil test based application of NPK @ 84:0:106 kg ha⁻¹ along with FYM @ 5 t ha⁻¹ produced tuber yield (23.18 t ha⁻¹) on par with the recommended POP (FYM @ 12.5 t ha⁻¹ + NPK @ 100:50:100 kg ha⁻¹ +) (23.06 t ha⁻¹). Continuous application of NPK @ 125:50:125 (25.61 t ha⁻¹), 100:50:100 (23.06 t ha⁻¹), 50:25:100 (28.91 t ha⁻¹), 50:25:50 (21.40 t ha⁻¹) and soil test based @ 84:0:106 kg ha⁻¹ (23.18 t ha⁻¹) were on par with respect to tuber yield.
- Different organic manures tried viz., green manuring with cowpea (28.91 t ha⁻¹), coir pith compost (20.09 t ha⁻¹) and vermicompost (21.69 t ha⁻¹) served as alternatives to FYM (23.06 t ha⁻¹). Organics alone applied as combination of crop residue, coir pith compost, vermicompost and ash without any chemical fertilizers

(18.99 t ha⁻¹) resulted in a significantly lower yield than the other organic sources along with chemical fertilizers. Green manuring with cowpea (32.57 t ha⁻¹) resulted in a significantly higher yield compared to FYM (23.88 t ha⁻¹).

- Soil test based application of Mg (0.270 meq 100g⁻¹) as MgSO₄ alone @ 15 kg ha⁻¹ (32.89 t ha⁻¹) and along with Zn (2.830 ppm) as ZnSO₄ @ 2.5 kg ha⁻¹ (39.180 t ha⁻¹) were on par and significantly higher in tuber yield than POP (23.06 t ha⁻¹). Soil test based application of single, two nutrient and three nutrient combinations of Mg, Zn and B were on par to POP.
- Among the NUE genotypes evaluated for reduction/substitution of NPK fertilizers, 7 III E3-5 produced significantly highest tuber yield (49.44 t ha⁻¹), on par with Acc. No. 905 (43.10 t ha⁻¹). Sree Pavithra (39.47 t ha⁻¹) and Acc. No. 906 (39.87 t ha⁻¹) produced yield on par with Acc. No. 905. The four different levels viz., 25 (39.77 t ha⁻¹), 50 (41.58 t ha⁻¹), 75 (44.34 t ha⁻¹), 100% (46.20 t ha⁻¹) did not significantly influence the tuber yield indicating that when NPK efficient genotypes were used, the NPK levels could be reduced up to 25%. Apparent recovery efficiency (ARE) and utilization efficiency (UE) were significantly influenced by interaction effect of genotypes and NPK levels. The genotype 7 III E3-5 at 25% NPK had significantly the highest ARE (13.05) and UE (0.77).



7 III E3-5 at 25% NPK

7 III E3-5 at 50% NPK

7 III E3-5 at 100% NPK

- Response of cassava to different soil tillage and mulching practices in laterite soils revealed that cassava tuber yield was highest under deep tillage (DT) (31.60 t ha⁻¹) followed by conventional (CT) (27.80 t ha⁻¹) and minimum tillage (MT) practices (26.20 t ha⁻¹). The different types of mulches influenced the yield in the order porous ground cover (GC)>crop residue (CR)>no mulch (NM).
- The average volumetric surface soil moisture were 8.20, 9.10 and 9.80% (v/v) and the soil temperature were 36.20, 35.90 and 35.50°C respectively under CT, DT and MT practices. Among the mulch practices, GC had high moisture content (10.30%, v/v) when compared to no mulch (7.80%, v/v). Saturated hydraulic



conductivity and sorptivity of CT was 10 and 22% higher than minimum tillage, whereas 16% increase in matric potential was observed under GC as compared to NM. The interaction between minimum tillage and GC mulch showed improved values of sorptivity ($0.032 \text{ cm min}^{-1/2}$) as compared to the first year ($0.023 \text{ cm min}^{-1/2}$), but significantly less than deep tillage treatment. Soil properties viz., soil moisture, bulk density and available P and K had significant positive relationship ($r=0.72^{**}$) with tuber yield in conventional tilled soils.

- On-station developed (at ICAR-CTCRI) organic production technologies for cassava and yams were validated in an organically raised 48 year old coconut plantation at ICAR-CPCRI, Kasaragod, for the second season. Yield under organic mode (0.76 and 0.98 respectively of conventional) was on par with chemical system in both cassava (8.14 and 10.71 t ha^{-1}) and yams (*Dioscorea* spp.) (6.81 and 6.91 t ha^{-1}) intercropped in coconut garden based on average yield data of two years.



Validation trials on organic farming of cassava (left) and dwarf white yam (right) in coconut gardens at ICAR-CPCRI, Kasaragod

- Kernel based Possibilistic *c*-means approach developed for cassava acreage estimation was validated for area estimation in Namakkal and Dharmapuri districts. Ground truth data were collected and the area was estimated. The total estimated area was 17125 ha and 19263 ha for Dharmapuri and Namakkal districts respectively.
- Future changes in climate and climate suitability over major cassava growing regions of India by 2050 were studied using geoinformatics tools (DivaGIS) and AR5 data of IPCC. The model predicted that by 2050, the mean temperature of cassava growing areas in India will increase on an average by 1.86°C ($0 - 2^{\circ}\text{C}$). The total precipitation of cassava growing areas in India will increase on an average by 231.60 mm ($0-366 \text{ mm}$). The results showed that in the cassava growing environments of India, the climate suitability will increase by 42.30% ($-57-100\%$) in 2050.

- On-farm validation experiments of customised fertilizers developed for sweet potato based on SSNM technology were conducted in seven farmers' fields in Denkanal district, Odisha for two consecutive seasons. The tuber yield in SSNM treatment (11.50 t ha^{-1}), was on par with that of FFP (11.80 t ha^{-1}). Secondary-and micronutrient-inclusive customised plant nutrient formulations were developed for major yams and sweet potato growing areas of India.



On-farm validation experiments of customised fertilizers for sweet potato based on SSNM technology at Denkanal, Odisha

- Application of N, P_2O_5 and K_2O @ $50:25:50 \text{ kg ha}^{-1}$ was found optimum to realize higher tuber yields of sweet potato with good quality tubers in the natural saline soils under island ecosystem of Andaman.
- In sweet potato, dolomite followed by gypsum along with foliar application of CaNO_3 was the best liming practice. INM along with dolomite and foliar application of $19:19:19 + \text{Zn EDTA}$ during the peak vegetative growth stage and KNO_3 along with solubor twice at tuber bulking stage at an interval of one month was effective for sweet potato.
- In greater yam + maize intercropping system, drip irrigation at 100% CPE (cumulative pan evaporation) resulted in higher maize yield. However, greater yam yield (33.8 t ha^{-1}) and tuber equivalent yield (36.5 t ha^{-1}) were higher at 100% CPE 1-90 DAP (days after planting) + 80% CPE 91-270 DAP. Drip fertigation of $\text{N:P}_2\text{O}_5:\text{K}_2\text{O}$ @ $160:90:160 \text{ kg ha}^{-1}$ resulted in higher maize, greater yam and tuber equivalent yield. However, it was on par with $\text{N:P}_2\text{O}_5:\text{K}_2\text{O}$ @ $140:90:140 \text{ kg ha}^{-1}$. Drip irrigation at 100% CPE 1-90 DAP (days after planting) + 80% CPE 91-270 DAP along with fertigation of $\text{N:P}_2\text{O}_5:\text{K}_2\text{O}$ @ $140:90:140 \text{ kg ha}^{-1}$ resulted in higher use efficiency of water ($50.30 \text{ kg ha-mm}^{-1}$) and nutrient ($107.80 \text{ kg kg}^{-1}$) as well as B:C ratio (2.85).
- Elephant foot yam corms fumigated with carbon disulphide @ $80 \text{ ml } 100 \text{ kg}^{-1}$ led to higher uniform sprouting (85.49 and 98.45% at 15 and 30 days after planting respectively), canopy growth and significantly higher yield (19.50 t ha^{-1}).

- Different water saving techniques were tried along with micro irrigation in elephant foot yam to ascertain the possibility of reducing the water requirement. Significant difference in corm yield was obtained among the treatments. Significantly highest corm yield (27.81 t ha⁻¹) was obtained by providing drip irrigation at 50% CPE, along with weed control ground cover mulching compared to all the other water saving techniques. Studies on water management in upland taro is underway



Elephant foot yam + black gram



Drip irrigation in taro

- In elephant foot yam + pulses intercropping system, the yield of elephant foot yam under intercropping with pulses (14.16 t ha⁻¹) was on par (-8.82%) with sole cropping (15.53 t ha⁻¹). Among the elephant foot yam varieties, Gajendra (18.78 t ha⁻¹) proved superior to Sree Padma (13.16 t ha⁻¹) and Sree Athira (10.54 t ha⁻¹). Black gram was the most suitable pulse crop (228.58 kg ha⁻¹) for intercropping in elephant foot yam. Among the treatment combinations, elephant foot yam var. Gajendra + black gram under full fertility level resulted in yield (21.60 t ha⁻¹), equivalent energy (79.82 x 10³ MJ ha⁻¹), production efficiency (122.80 kg ha⁻¹ day⁻¹) and tuber equivalent yield (22.10 t ha⁻¹) on par with sole cropping of elephant foot yam var. Gajendra (22.53 t ha⁻¹, 81.11 x 10³ MJ ha⁻¹, 125.16 kg ha⁻¹ day⁻¹, 22.53 t ha⁻¹).
- Among the various weed management practices in elephant foot yam, use of weed control ground cover resulted in higher weed control efficiency (96.40%), corm yield (36.0 t ha⁻¹) and gross returns (Rs. 5,39,700 ha⁻¹). Higher benefit:cost ratio (2.42) was obtained in two rounds of manual weeding (30 and 60 DAP) + Glyphosate (90 DAP) treatment due to low cost of cultivation.
- Dolomite @ 1.5 t ha⁻¹ was the best liming material for elephant foot yam. Soil + foliar application of B, Ca and Mg were beneficial for elephant foot yam.
- Field trials conducted at three locations in AEU 3 and four locations in AEU 9 each for cassava and elephant foot yam under intercropping in coconut to develop best management practices (BMP) taking into account the subsoil acidity revealed no



Field trials to develop BMP (left) and custom mixed fertilizer grades in elephant foot yam (right)

significant effect of BMP comprising of organic manures, NPK fertilizers, liming materials (lime, gypsum and dolomite) and secondary and micronutrients (Zn and B) on corm yield of elephant foot yam compared to POP, farmers practice, NPK+FYM along with liming materials and NPK+FYM along with secondary and micronutrients.

- Evolved three custom mixed fertilizer grades comprising of major, secondary and micronutrients for elephant foot yam intercropped in coconut gardens based on STCR approach (targeted yield of 45 t ha⁻¹) and response curve approach and developed three custom mixed formulations for AEU 3 and AEU 9. Field testing of these three formulations at two rates viz., 500 and 625 kg ha⁻¹ in one location in AEU 3 and three locations in AEU 9 indicated significantly higher yield with 625 kg ha⁻¹, but the tuber yield was on par under the three grades.
- In a study to induce tolerance to high temperature stress through chemical treatments in elephant foot yam, foliar spraying of CaCl₂ (0.2%), Salicylic acid (0.2%) and BA (1000 ppm) during 4th to 8th month increased corm yield by 27.77%, 29.98% and 17.2% respectively as compared to control plants under ~32°C day temperature under field conditions. Under humidified polychamber conditions, foliar spraying of CaCl₂ (0.2%), Salicylic acid (0.2%) and BA (1000 ppm) during 4th to 8th month increased corm yield by 22.70%, 27.12% and 5.04% respectively as compared to control plants under 32-40°C day temperature and >80% RH (10 am – 4 pm). Under polychamber conditions without humidification, foliar spraying of CaCl₂ (0.2%), Salicylic acid (0.2%) and BA (1000 ppm) during 4th to 8th month increased corm yield by 39.73%, 36.43% and 4.26% respectively as compared to control plants under 32-40°C day temperature and ~50% RH (10 am – 4 pm). Compared to field conditions, the corm yield was significantly reduced by 28.78% to 56.68% under polychamber conditions in control as well as under CaCl₂, Salicylic acid and BA treatments.
- Evaluation of organic, inorganic and integrated management practices in cropping



systems involving tuber crops indicated that in taro-green gram and taro-black gram system, the production efficiency was highest for 50% organic + 50% inorganic ($60.56 \text{ kg ha}^{-1} \text{ day}^{-1}$) and 75% organic + 25% inorganic ($68.47 \text{ kg ha}^{-1} \text{ day}^{-1}$) respectively. In cassava-groundnut system, 100% inorganic followed ($141.43 \text{ kg ha}^{-1} \text{ day}^{-1}$) by 100% organic and in cassava-vegetable cowpea system, 100% organic ($112.99 \text{ kg ha}^{-1} \text{ day}^{-1}$) closely followed by 100% inorganic resulted in higher system productivity.



Organic production of taro-blackgram



Organic production of arrowroot

- Based on two years' experimentation at ICAR-CTCRI in arrowroot, organic production technologies involving FYM @ 10 t ha^{-1} , green manure @ $10\text{-}15 \text{ t ha}^{-1}$ and biofertilizers (*Azospirillum*, P solubilizer and K solubilizer @ 3 kg ha^{-1} each) were developed; yield under organic management (12.81 t ha^{-1}) was 2% lower than conventional (13.05 t ha^{-1}) and integrated (12.93 t ha^{-1}) practices.
- Geo-referenced on-farm characterization of organic growers conducted in Thiruvananthapuram district indicated that among the organic farmers surveyed, 94% belonged to small and marginal group with an average land holding size less than 2 ha and the farms were uncertified. Farm animals were an integral part of the organic system. Majority of farmers (79%) practise organic farming mainly for sustenance to provide safe food to their family rather than marketing and making profit. Among the respondents, 42% deployed the on-farm generated organic manures for crop production. Cultural and eco-friendly techniques were mainly adopted for pest management. Among the market centred enterprises, piggery, ornamental fishes and organically produced cut flowers received premium prices with high B:C ratios.
- Mass multiplication of virus free planting materials continued through procedures involving indexing, micro propagation, hardening and miniset multiplication under protected environment. Disease free planting materials were produced and supplied in selected areas of Kerala, Tamil Nadu, Odisha and north-east India in a farmer's participatory mode. Farmers' training programme were also organized



Quality planting material production in cassava (left) and yams (right)

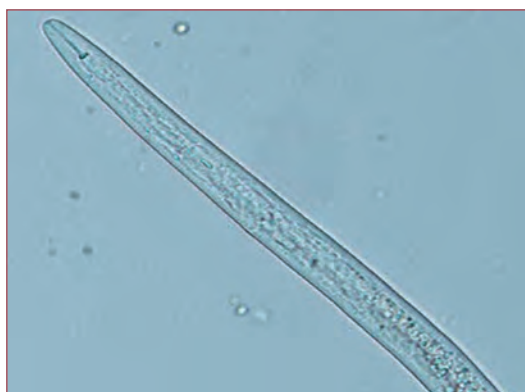
and popularised. A total number of 250 micro plants of different cassava varieties were indexed against cassava mosaic virus through micro propagation technique in the tissue culture laboratory. A total number of 160 micro plants of elephant foot yam, variety Gajendra were indexed.



CROP PROTECTION

- Synthetic pesticides viz., Malathion, Chlorpyrifos, Dimethoate, Fenvalerate, Imidacloprid and Dichlorvos were screened at three concentrations viz., 0.001, 0.01 and 0.05% against sweet potato weevil by feeding the leaves. A positive correlation was noted between mortality of the weevil and concentration of the insecticides used. The toxicity was higher for Imidacloprid followed by Chlorpyrifos, Fenvalerate, Dichlorvos, Dimethoate and Malathion. Systemic action was very high in Imidacloprid. HCN, the active principle in the biopesticide, *Menma*, was estimated in open condition at regular intervals and the residue was negligible at 24 h after exposure.
- Insect pests of sweet potato, taro and yam bean were surveyed in Andhra Pradesh, Kerala and Odisha. Sweet potato weevil, *Cylas formicarius*, was the single and most serious pest causing damage up to 90%, if management practices were not adopted. Koraput, Nabarangpur, Puri, Khurda, Bargarh, districts of Odisha, and the farms of ICAR-CTCRI, Thiruvananthapuram, Kerala, were surveyed.
- Eighteen insecticides including new generation insecticides viz., Imidacloprid @ 30 g ai ha⁻¹, Dimethoate @ 300 g ai ha⁻¹, Acetamiprid @ 15 g ai ha⁻¹, Acephate @ 350 g ai ha⁻¹, Thiomethoxam @ 25 g ai ha⁻¹, Triazophos 35 + Deltamethrin IEC @ 360 g ai ha⁻¹, Chlorpyrifos @ 200 g ai ha⁻¹, Profenophos + Cypermethrin @ 400 g ai ha⁻¹, Profenophos + Cypermethrin @ 400 g ai ha⁻¹, Fipronil @ 40 g ai ha⁻¹, Buprofezin @ 75 g ai ha⁻¹ were evaluated against borer pests of tuber crops during 2016-2017 rabi season at ICAR-CTCRI farm, Bhubaneswar. All the insecticides tested were effective in reducing the weevil incidence and infestation in treated plots (0 to 3.1%), whereas, control plots had 18.20% infestation in tubers. Radish, yam bean, marigold, garlic, *Cleome viscosa* and coriander were used as intercrops (2:2 ratios) in sweet potato for the management of sweet potato weevil. Intercropping with marigold resulted in lowest tuber infestation (13.73%), followed by coriander (17.66%), *Cleome viscosa* (32.33%) and yam bean (30.33%). Sweet potato weevil sex pheromone technology was popularized in different districts of Kerala, Andhra Pradesh and Odisha and pheromone lures were sent to different AICRP Centres in Telangana, Chhattisgarh and Maharashtra.
- Sweet potato weevil samples were collected from different states of India through AICRP centres. The genomic DNA was isolated and the mitochondrial cytochrome oxidase (MtCOX1) gene was amplified by PCR using universal primers LCO 5'GGTCCACCAAT CATAAAGATATTGG3' and HCO 5'TTAACCTCAGGGT GACCAAAAATCA3'. The samples were cloned and the sequences obtained were aligned using BIOEDIT software. All the samples were identified as *Cylas formicarius* with 98-99% similarity. The samples collected from different states showed variation within the sequences.

- A random survey was undertaken in elephant foot yam fields of three southern states of India, Kerala (Manyali, Perinthalmanna and Pulpally), Andhra Pradesh (Kovur) and Tamil Nadu (Apakoodal) between April and December 2016. *Rotylenchulus reniformis* was the most predominant nematode in Perinthalmanna with a prominence value of 75. While, *Pratylenchus* sp. was the most predominant nematode in both Malappuram and Wyanad with prominence values of 60 and 70, respectively.
- In Kovur, *Hoplolaimus indicus* and *Pratylenchus* sp. were observed in maximum frequency and abundance and their prominence values were 33.80 and 10.30, respectively. While, *Meloidogyne incognita* (30.40) and *Pratylenchus* sp. (14.90) were the most predominant nematodes in Apakoodal. In ICAR-CTCRI campus, *Pratylenchus coffeae* and *M. incognita* were the most abundant nematodes with a population density of 1.5 and 1.1 nematodes per gram of soil, respectively. Nematode mapping of Block I of ICAR-CTCRI revealed the presence of nine genera of plant parasitic nematodes.



Meloidogyne incognita

- *In-vitro* efficacy of biopesticide formulation, *Menma*, was tested against second stage juveniles of *Meloidogyne incognita*. There was 100 per cent mortality up to 100 ppm. Two isolates of *Trichoderma asperellum* (CTCRI TR 9 & CTCRI TR 15) showed significant nematicidal activity against second stage juveniles of *Meloidogyne incognita* with CTCRI Tr 9 showing more effect compared to CTCRI Tr 15. Both the isolates of *Bacillus subtilis* (Bs 9 and Bs 19) had significant effect on suppression of infective juveniles of *M. incognita*.
- Association of SLCMV and ICMV was found as mixed infection in all the samples collected from cassava growing areas of Kerala.
- *Bemisia tabaci* specific 10 ISSR primers were identified for studying genetic variations among whitefly populations. Biotypes specific banding patterns were identified using ISSR primers for whitefly biotypes Asia I and Asia II-5.



- Established the role of micronutrients viz., Si>Zn>Ca>P>B in CMD management.
- Protocol for synthetic seed production in cassava has been developed.



Cassava synthetic seed

- ACMV resistant transgenic cassava showed high susceptibility to SLCMV infection through whitefly transmission.
- Out of the six CMD resistant clones viz., 8W5, 9S-127, CR-43-11, 8S-501-2, CR-24-4, CR-43-2 field evaluated in Salem district, the farmers ranked 8S-501-2 as the best variety, followed by CR-24-4 and CR-43-11, owing to its high yield, CMD resistance and close similarity to the locally preferred variety, H-226.
- LAMP based diagnosis of Sri Lankan Cassava mosaic virus (SLCMV) and Dasheen mosaic virus (DsMV) was developed.
- SLCMV coat protein gene was expressed in bacterial system and the protein was purified.
- Sixteen *Trichoderma* isolates, which showed consistent pathogen suppressive potential was identified using TEF and ITS region amplification. The isolates were identified as *Trichoderma asperellum* (11 isolates), *T. harzianum* (3 isolates) and *T. virens* (2 isolates).
- *Piriformospora indica* colonisation in taro plants resulted in growth promotion and less taro leaf blight incidence in Sree Kiran and Muktakeshi. In Sree Kiran, *P.indica* colonized plants showed 57.60%, 50.70% and 84.30% disease reduction and in Muktakeshi, it was 39.90%, 56.20% and 72.50% over control.
- Subtractive suppression hybridization assay was carried out to study the differential expression of genes in *P. indica* colonized taro plants consequent to *Phytophthora colocasiae* infection. Five genes were identified and their functions were determined. Among the identified genes, senescence associated genes, Cytochrome P450, Delta (12) oleic acid desaturase FAD2 and Calcium-dependent protein kinases (CDPKs) fall under different defence related pathways.



Field view of taro showing the TLB suppression by Metalaxyl- M (left) over control (right)



Field view of elephant foot yam with various management strategies against collar rot

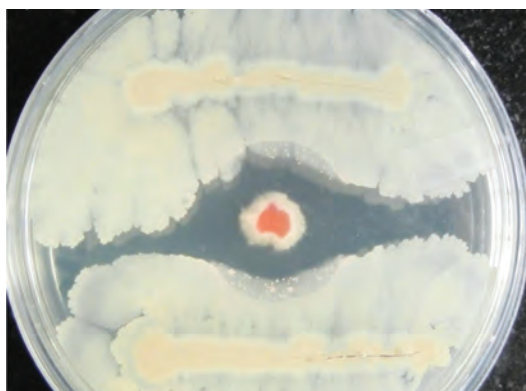
- Among the various strategies to manage taro leaf blight (TLB) incidence, the least percent disease incidence (PDI) at different growth stages was noticed with metalaxyl-M @ 0.05%, with PDIs of 8.13, 15.90, 10.80, 14.80 and 15.90 followed by the treatment, borax + *Bacillus subtilis* + vermicompost with PDIs of 10.70, 27.60, 19.30, 20.20 and 22.30 as against 22.90, 42.10, 32.70, 39.90 and 45.40 in control. The highest yield was obtained in the treatment with metalaxyl-M (15.70 t ha⁻¹).
- Among the various strategies to manage collar rot incidence in elephant foot yam, the least disease incidence was recorded in the treatment, mancozeb + carbendazim @ 0.2% (4%) followed by *T. asperellum* + vermicompost (5.30%) as against 16% in the control.
- The fungicides, carbendazim (bavistin), mancozeb + carbendazim (sprint and saaf), copper hydroxide (kocide), bio-pesticide (Nanma) and neem oil were tested against the mycelial growth of the pathogens associated with post-harvest diseases in elephant foot yam under *in vitro* condition. The fungicide, mancozeb + carbendazim (sprint) could completely arrest the growth of all the pathogens at 100 ppm.



Post-harvest infection in elephant foot yam



- Suitable SSR markers were identified for characterizing *P. colocasiae* from reported SSR markers for *Phytophthora* spp.
- Resistant Gene Analogues (RGAs) were amplified, sequenced and characterized from resistant (Muktakeshi) and susceptible (Sree Kiran) taro cultivars.
- In the second year of field trial on refinement of the management of anthracnose in greater yam, soil application @ 50 g of 10^7 cfu g^{-1} and tuber treatment with 5 g of *Trichoderma* in fresh cowdung slurry per kg of tubers along with foliar spraying of carbendazim @ 0.05% seven times, first three at fortnight intervals and further at monthly intervals after symptom initiation significantly reduced the disease intensity (63%) and increased yield by 32% compared to absolute control.
- A pot trial on the effect of cassava based biopesticides on greater yam anthracnose indicated that soil and tuber treatment with *Menma* @ 1% and spraying *Nanma* @ 0.7% at weekly intervals showed maximum reduction in PDI (71%) compared to control. This was followed by soil and tuber treatment with *Nanma* @ 0.7 % (43%) and also soil and tuber treatment with *Menma* @ 1% and spraying neem oil @ 0.2% weekly (37%).
- Fungal and bacterial endophytes were isolated from the leaves and roots of arrowroot, Chinese potato, taro and yam. One fungal and three bacterial isolates showed inhibition of the growth of *Colletotrichum gloeosporioides*. They were identified as *Trichoderma* sp, *Bacillus subtilis*, *B. amyloliquefaciens* and *B. pumilus*.



Bacillus amyloliquefaciens inhibiting *Colletotrichum gloeosporioides*

- The intensity of anthracnose in greater yam was generally less in highly tolerant varieties, Sree Karthika, Sree Keerthi and susceptible variety Orissa Elite because of low rainfall during 2016-2017. However, the disease advanced in August after rainfall at the end of July and it was almost static till September in all the varieties. After rainfall in October, the intensity increased. Orissa Elite attained the maximum intensity (100%) during November after 7 months of planting.



- The Resistant gene analogue (RGA) has been amplified from greater yam using published and newly designed primers. Their expression was increased following *Colletotrichum gloeosporioides* infection. They behaved differently in response to time in the tolerant and the susceptible varieties. Expression studies on tissue culture plants showed increased expression earlier in tolerant variety, Sree Keerthi (3rd day) than susceptible, Orissa Elite (5th day).
- The presence of *Badna virus* was detected in taro leaves using genus and virus specific primers.
- Detection of *Yam mild mosaic virus* (YMMV) from lesser yam tubers was standardized. Among the different parts of the tuber, the tuber flesh was good for sampling.
- Ninety kg of virus free tissue cultured elephant foot yam tubers were planted in farmers' field, which yielded 13 fold (~1196 kg). Tuber samples collected from the farmer's field were indexed for DsMV and were free from infection. Indexing of field grown elephant foot yam tubers has also been done for DsMV infection using DAS-ELISA. Among 37 samples tested only 3 (8%) showed positive. The healthy tubers are being multiplied at ICAR-CTCRI and also in farmer's field.



CROP UTILIZATION

- A cassava harvester was evaluated and the capacity was between 1800-2580 cassava plants per hour, whereas only 840 plants could be harvested manually in an hour. The percentage of damage was 8.40%.

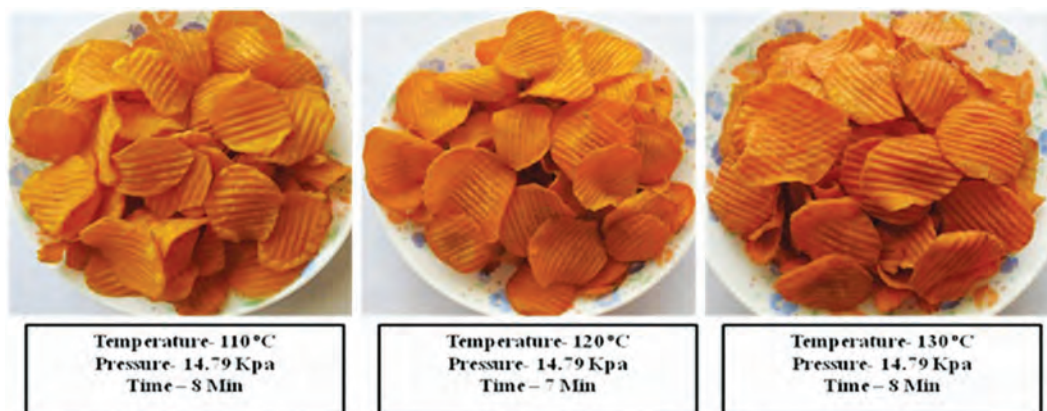


Cassava harvester

- Protein-energy rich functional cookies has been developed using curcuma starch (25%), pearl millet flour (20%), soy flour (5-15%), Bengal gram flour (5-15%) and whey protein concentrate. It provides protein 8.24%, fibre 3.33%, carbohydrate 57.3% and energy 481.37 kcal.
- Calcium rich functional cookies were developed using curcuma starch (25%), pearl millet flour (20%) and finger millet flour (10-20%). It provides calcium 42.64 mg 100g⁻¹, protein 3.45%, fibre 2.40%, carbohydrate 62.08% and energy 466.04 kcal.
- Fibre rich functional cookies has been developed using curcuma starch (25%), pearl millet flour (20%), wheat bran flour (10-20%) and oat bran flour. It provides fibre 6.79%, protein 3.79%, carbohydrate 62.27% and 446.02 kcal energy.
- Particle boards developed from dried cassava stems using urea formaldehyde as binding agent with 300 g feed weight, 120°C press temperature and 10 min press time had a density of 978 kg m⁻³, moisture content 11.40%, modulus of rupture 11.14 N mm⁻², water absorption 6.75% after 2 h soaking and 12.55% after 24 h soaking.
- Particle boards developed from dried cassava stems using melamine urea formaldehyde as binding agent with 225 g feed weight, 120°C press temperature and 5 min press time had density 953 kg m⁻³, moisture content 14.50%, modulus of rupture 13.42 N mm⁻² and water absorption 10.23% after 2 h soaking and 21.35% after 24 h soaking.
- Green particle boards developed from dried cassava stems using cassava starch (15%) as bio-adhesive with glycerol (10%), pressure (60 bar) and press time (15

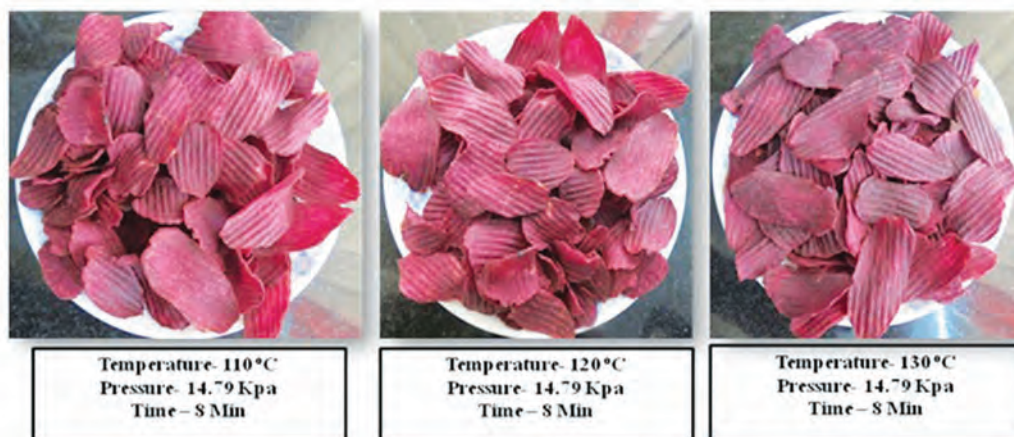
min) had density 988 kg m⁻³, moisture content 17.21%, modulus of rupture 4.55 N mm⁻² and water absorption 24% after 2h soaking.

- Particle boards were developed from dried cassava stems without using binders and using generally available plasticizers viz., water and glycerol (2 to 10%). The resulting boards had density in the range 815-957 kg m⁻³, moisture content 7.67-8.72%, water absorption 95-188% after 2 h and 148-236% after 24 h soaking and modulus of rupture 1.46-4.14 N mm⁻². The process needs further modifications to reduce the water absorption.
- Single phase corrugating adhesive formulations were developed from the acid thinned starch.
- Modified atmospheric storage of cassava roots was carried out with high CO₂ in storage container with five varieties of cassava (Sree Jaya, Sree Vijaya, Vellayani Hraswa, Kalpaka and Sree Swarna) to delay PPD. Shelf-life was extended up to one week for the fresh tubers, however, high transpiration of tubers increased the relative humidity, which resulted in fungal growth. Desiccant such as CaCl₂ helped to reduce the relative humidity (RH) and the condensation of water inside the container thus preventing microbial and fungal growth. The results were encouraging as there was a reduction in RH and fungal growth in stored tubers.
- Wax coating of cassava after selected pre-treatment techniques was developed for increasing shelf-life for one month or more periods for retail sale or export of cassava roots. The tubers were successfully stored for a month without any loss in quality. The method is being standardized for commercialization.
- Screening tool for PPD using Near Infrared Spectroscopy (NIRS) was developed to analyse root samples for PPD and the spectral data were analyzed through principal component analysis (PCA) and chemometric tools to group the different PPD category in root tissues of cassava.
- FT-NIR technique was developed for analysing the quality changes in tubers under storage. NIRS was applied to characterize the cassava roots with varying PPD symptom levels. The NIR spectral features were analysed using PCA and chemometric tools to differentiate PPD category in root tissue. The results showed that spectral features of fresh and deteriorated root tissue differed in the NIR regions of wave numbers from 5300, 5200-5100, 4600-4400, 4240-4150 cm⁻¹ in the first principal component, wave such as 5450, 5250, 4700 and 4400 cm⁻¹ for the second principal component. The third component belonged to 4800 cm⁻¹.
- Orange-fleshed sweet potato vacuum fried chips were developed by considering frying temperature, vacuum pressure and frying time as critical factors by using three-level Box–Behnken design. The optimized conditions were frying temperature, 110°C; vacuum pressure, 16.12 Kpa and frying time, 7 min. The vacuum fried samples showed lower oil retention (about 54.65% less) and higher carotenoid retention (6.81 mg 100g⁻¹) when compared to atmospheric fried chips.



Vacuum fried chips of orange-fleshed sweet potato

- Purple-fleshed sweet potato vacuum fried chips were developed by considering frying temperature, vacuum pressure and frying time as critical factors. The optimized conditions are frying temperature 115°C, vacuum pressure 16.15 Kpa, frying time 7 min. When optimized, vacuum fried samples were compared with atmospheric fried samples; the former absorbed about 60% less oil and retained higher anthocyanin (58.42 mg 100g⁻¹).

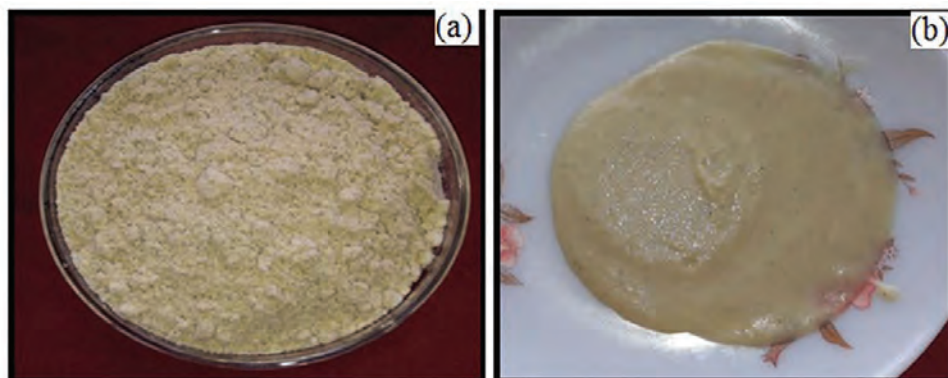


Vacuum fried chips of purple-fleshed sweet potato

- Flour and ready to fry/roast papad were developed from elephant foot yam. The flour for papad making was standardized as 30% elephant foot yam flour + 40% black gram flour + 20% green gram flour. Other ingredients were water, salt, papad masala and oil. Ready to fry *Jimikand* shorts were developed from elephant foot yam after shredding the tuber and pre-treatment.
- Thermoplastic sheets from cassava starch with glycerol as plasticizing agent were

produced by thermo pressing method. Thermoplastic sheets with cassava starch-cassava stem powder-glycerol blends and cassava starch-coconut pith-glycerol blends were also developed.

- Cassava and sweet potato starches were subjected to dual modification viz., esterification followed by retrogradation to synthesize resistant starch, which resulted in significant increase in resistant starch and slowly digestible starch with lowering of glyceamic index.
- Treatment of starch with long chain fatty acid resulted in the formation of RS5 type resistant starch. The resistant starch (RS) content increased from $1.5 \pm 0.39\%$ to $33.6 \pm 0.32\%$ for cassava starch and the estimated glyceamic index (EGI) reduced from 91.2 ± 1.34 to 61.2 ± 0.76 . For sweet potato starch, the RS content increased from $3.4 \pm 0.50\%$ to $33.2 \pm 1.29\%$ and the EGI decreased from 86.3 ± 3.12 to 59.9 ± 1.83 .
- Hydrogels prepared from native and modified starches of cassava and its composites have been evaluated *in vitro* as matrices for incorporating the antibiotic drug, ampicillin for obtaining sustained release property. Starch-konjac glucomannan gel showed more sustained release of ampicillin from it (77% and 59% respectively, at pH 2.1 and 7.4 after 6 h of incubation) compared to other hydrogels.
- Lacto pickle was developed from yam tubers (var. Orissa Elite) by inoculation with mixed starter cultures of *Lactobacillus plantarum* and *L. acidophilus* and incubation for 21 days. The lacto-pickle with 8-10% brine had a pH of 3.04-3.30 and the titratable acidity of 2.8-3.0 g kg⁻¹. The composition of the pickle was as follows: starch 38-54 g kg⁻¹, total sugar 13-18 g kg⁻¹, lactic acid 2.8-3.2 g kg⁻¹ and ascorbic acid 31-46 mg kg⁻¹ on fresh weight basis. Lactobacilli counts varied from 2.2×10^6 to 4.7×10^5 during a period of about 30 days.
- The procedure for the development of taro flour based functional pasta using pulses and millets were standardized. It contained 70% taro flour along with whole wheat flour, Bengal gram flour and cassava gelatinized starch. It provides 62.7% starch, 12.1% sugar, 11.0% protein, 2.6% crude fibre and negligible amounts of fat.
- A ready-to-eat nutri bar was developed using sweet potato flour (20-30%), Bengal gram (10-15%) and green gram (10-15%) with oats, nuts etc. It contained 6.4% protein, 51.8% carbohydrates, 494.78 kcal, 4.52 mg 100g⁻¹ iron, 30 mg 100g⁻¹ calcium and 6.06 mg 100g⁻¹ magnesium.
- The formulation for the development of sweet potato based weaning food mix powder was standardized. The sweet potato flour was used in the range of 40-70% with cow pea flour (5-10%), soybean flour (5-15%), peanut flour and milk powder. It provided starch 29.79-37.41%, sugar 26.07-32.01%, fat 10.72-15.41%, protein 8.63-18.46% and fibre 1.66-1.78%.
- A cassava slicer for the preparation of sample was developed. The slicer comprised of two components viz., a fixed platform and a movable plate. By keeping the cassava tuber on the fixed platform and moving the movable plate downwards the slices of desired thickness can be obtained.



Sweet potato based weaning food mix powder (a) and paste (b)

- A cassava starch meter was developed, which consists of 3 units - sensor unit, microcontroller unit and a display unit. PIC16F877A microcontroller and LM016L LCD are used in the equipment. The gadget was evaluated at SAGOSERVE, Salem and a high level of correlation was established between the gadget and chemical readings of starch content. During the demonstration it was found that the gadget received good acceptability among the cassava farmers, traders as well as starch and sago manufacturers. A MoU has been signed with the industrial partner M/s Environmental Measurements and Controls (EMCON), Cochin for commercialising the gadget.



Cassava starch meter

- The process for the production of high quality cassava flour was optimised. The size of the polycarbonated roofed yard was 18 m × 12 m. An automatic weather station had been fixed in the solar yard to note the process weather parameters. The best sample was obtained from crushed and pressed gratings dried in the polycarbonated roofed yard with a loading density of 3 kg m⁻².



Poly carbonated roofed yard for cassava flour production

- Five varieties of sweet potato, local, Sree Kanaka, Sree Arun, ST-13 and ST-14 were planted in 15 acres in the mining areas of Belgaum. The average yield of tubers/plant was 250 g and the highest yield was obtained for Sree Arun followed by ST-14 (150-200 g per plant). Sree Kanaka produced 100-150 g per plant tuber yield.
- A high power tractor (75 hp) was purchased.
- A total of nine anthocyanins were identified in the tubers of sweet potato (var. ST-13) as well as in the leaves of Acc. S-1467, all of them were acylated and six were in diacylated form. The major anthocyanin was Peo-3-O-(6''-caffeoyl-6''-p-hydroxybenzoyl soph)-5-O-glc.
- Four new anthocyanins along with the other two earlier reported anthocyanins (total of six anthocyanins) were identified in the tubers of purple-fleshed greater yam (Acc. Da-340). The major anthocyanin was in diacylated form and it contributed up to 70.5% of total anthocyanins.
- Cell line studies have shown that the tuber anthocyanins were non-toxic to normal cells even at concentration as high as 400 $\mu\text{g ml}^{-1}$. These anthocyanins inhibited cell cycle and induced apoptosis in human cervical cancer, breast cancer and colon cancer cell lines at a dose of 200 $\mu\text{g ml}^{-1}$ or below, proving their potential anticancer properties.
- Purified anthocyanins were encapsulated by spray drying technique and the encapsulated products showed a significant reduction in pigment degradation compared to pure anthocyanins.
- The nutrient release behaviour of urea coated with grafted cassava starch was studied. The coated urea samples showed significant water retention capacities in the range of 74.20 to 405.60%. In laterite and black soils, the release of N from the grafted starch coated urea was more sustained than that from uncoated urea. However, in the red soil and kari soil, the available N content was slightly higher during the initial 15-30 days in coated urea treated soils.



EXTENSION AND SOCIAL SCIENCES

- Front Line Demonstration (FLD) was conducted at Belagavi, Karnataka under commercial sweet potato systems. Sree Arun produced the highest yield (36 t ha^{-1}), followed by ST -14 (20.15 t ha^{-1}) and Sree Kanaka (16.12 t ha^{-1}).



Co-operating farmer with ST-14 tuber harvested from his field

- The *Kunbi* indigenous people of Joida, Karnataka were efficient conservators of varieties of taro and yams. Indigenous knowledge like seed storage, ethnic foods and removing anti-nutritional factors through river streams were documented.



Indigenous seed storage mechanism followed by *Kunbi*

- In a consumer acceptability study, the urban pasta consumers preferred cassava pasta because of its aroma (mean = 6.06) and taste (mean = 6.10) and suggested improvements in appearance, colour and texture of pasta. The willingness-to-pay estimates derived from Vickers second price auction, respondent's average willingness to pay was Rs 146.50, which increased to Rs 188.00 (increase by

28%) when crop information was supplied. When the health benefits of cassava pasta were explained, the willingness-to-pay increased to Rs. 191.00, indicating a significant rise over the commercial pasta.

- Livelihood analysis study conducted in Kanya Kumari and Tirunelveli districts of Tamil Nadu indicated that the indices for human capital, physical capital, natural capital and financial capital was more for rice farmers (0.61, 0.71, 0.70, 0.56), when compared to tuber crops farmers (0.49, 0.68, 0.66, 0.45 respectively). Social capital was the same for both the farmers (0.57). The rural sustainable livelihood index for rice farmers was more (0.63) than that for tuber crops farmers (0.52). The *t* test revealed that there exists significant differences between the rice and tuber crop farmers in the variables, namely experience in farming ($t=3.87$), farm size (2.26), annual income (2.57) and access to agricultural institutions (3.57).
- Electronic Crop (E-Crop) was installed in sweet potato field for validation. Weather data and soil moisture content was collected by the device with the help of the sensors connected to it. The weather data was collected at 15 minutes interval and uploaded to the website of the institute. At 7:30 pm all these data get downloaded to the local machine automatically. Once the data is downloaded, the sweet potato model SPOTCOMS runs using the data files downloaded and computes the dry matter produced by the crop till date and calculates the potential yield the crop can achieve as per the growth the crop has already attained. All these information will be sent to the mobile of the farmer in the form of advisory.
- Quantitative structure activity relationship of anthocyanins of greater yam and sweet potato were studied. The TEAC (Tolox Equivalent Antioxidant Capacity) in radish and egg plant was used as training set to predict the antioxidant activity of anthocyanin isolated from yams and sweet potato.
- Anthocyanins from both greater yam and sweet potato showed high antioxidant activity. The polyphenolic compounds of yams and Chinese potato were docked against enzyme molecules, Acetylcholin esterase and Angiotensin converting enzyme and the overall drug likeness were tested in silico.
- Kaemferol and rosmarini acid act as a promising drug, which can inhibit activity of Angiotensin Converting Enzyme (ACE), thereby reducing cardiovascular and neurological disorders. Interactive visualization tools for high dimensional data were developed in R using the package Plotly.
- During 2016-2017, six agricultural start-ups were surveyed to document the product pricing strategies followed. Majority of the start-ups (57%) were using competitive pricing strategies based on the competitor price. No pricing algorithm or software was used. The pricing algorithms were developed based on cost incurred in developing technologies, revenue based pricing and market demand based pricing.



Greater yam + maize intercropping
in Nuaguda village, Koraput



Tuber crops cultivation at Kenjaguda village,
Kandhamal



Tuber crops cultivation at Burahkocha village, Ranchi

- During the reporting period, Nuaguda village (39 household), Potangi block, Koraput district; Kenjaguda village (49 household), Chakapada block, Kandhamal district and Burahkocha village (57 household), Angara block, Ranchi district were adopted for demonstration of farming systems involving tuber crops under Tribal Sub Plan Programme on livelihood improvement of tribal farmers through tuber crop technologies. Planting material of tuber crops were provided to the farmers along with the improved varieties of the major crops grown by them. Two trainings were organized before and after the interventions to up-grade the skill of tribal farmers in these villages. The socio-economic conditions of the farmers improved after the interventions. Farming system involving tuber crops (0.4 ha model) generated B:C ratio of 2.75 (which was 1.5-1.9 prior to the interventions) and additional employment generation of 89-112 man days ha⁻¹ over the existing system.



ALL INDIA CO-ORDINATED RESEARCH PROJECT ON TUBER CROPS

- A total of 132 new collections were made by different centres during 2016-2017. Altogether 4156 different accessions of root and tuber crops were maintained as gene bank for improvement of major crops including cassava, sweet potato, aroids, yams and minor tuber crops at 22 centres. Among the centres, maximum accessions of twelve tuber crops (1329) were maintained at RAU, Dholi. IC numbers were obtained for a total of 1977 germplasm collections at different centres.
- Under MLT on greater yam, maximum yield was obtained in IGDA-2 both at Jagdalpur (31.22 t ha⁻¹) and Navsari (18.8 t ha⁻¹) and can be recommended for release.
- Five new varieties, three in cassava (TCMS-2, TCMS-7 for central release and TCMS-5 for Andhra Pradesh and adjoining areas) and two in Bunda (Bidhan Ghat Kachu (BCB-2) for West Bengal and Chhattisgarh Shaken Bunda-1 (IGB-5)) were recommended for release during the 16th Annual Group Meeting held at BCKV, Kalyani, West Bengal during 24 - 26 May 2016.
- The farming systems involving tuber crops introduced in Hadibadi (village), Chakapada (Block), Kandhamal (District), Odisha state generated a gross income of Rs 1, 88,682 ha⁻¹, B: C ratio of 2.73 and employment generation of 304 man days ha⁻¹ in the place of gross income of Rs 90,125 ha⁻¹, B:C ratio of 1.91 and employment generation of 225 man days ha⁻¹.
- The gross income and net income increased at four locations of Jharkhand after interventions of different components under tuber crops based farming system from the year 2012-2013 to 2016-2017. Average B:C ratio of income of the famers increased from 1.28 to 2.24. The model created an additional employment of 70 man days. Tuber crops based farming system introduced at four locations of Manipur state generated a net income of Rs. 81675 ha⁻¹ and 186 days of employment generation compared to Rs. 41,500 and 105 days prior to intervention.
- Under micro nutrient studies in cassava, positive response in terms of tuber yield was obtained with the application of micro nutrients. Tuber yield as well as B:C ratio was maximum with POP + MgSO₄ + ZnSO₄ + Borax + FeSO₄ at Yethapur, Kalyani, Dapoli and VR Gudem. In sweet potato, application of micro nutrients (Mg, B, Zn) resulted in more tuber yield at Rajendranagar, Kalyani, Ranchi and Dholi. At Dharwaad, the response to B and at Udaipur, response to Zn was more pronounced.
- Greater yam + maize (1:3 additive) intercropping was beneficial with more yam equivalent yield and benefit:cost ratio, hence growing of maize as intercrop in greater yam for staking purpose will be profitable than growing of yams by staking with bamboo poles.
- Validation of organic farming technologies in greater yam, elephant foot yam and taro indicated positive response to organic farming over conventional methods.



- Under integrated management of sweet potato weevil, the lowest vine infestation at collar region with minimum tuber infestation and maximum marketable tuber yield was noticed with dipping the planting material in 0.02% chlorpyrifos (20 EC) for 10 min, incorporation of cassava leaves and spraying biopesticide, *Nanma*.



IGB -5 recommended for release in the state of Chhattisgarh



Glimpses of tuber crop based farming system at Harminder Bay, Port Blair

General

TRAINING AND OTHER PROGRAMMES

- During this period, 282 farmers, 1446 students and 161 department officials from different parts of the country were imparted training on various aspects of production and processing of tuber crops.
- One day National Workshop on “Horticulture for East Coast” was organized at the Regional Centre, ICAR-CTCRI, Bhubaneswar on 1 July 2016. Fifty delegates from different institutes participated in this workshop.
- Seventy five trainees belonging to officers and technical staff category from Department of Agriculture, Govt. of Kerala, representing nine districts were trained in five batches of “Orientation Training Program on Soil Analysis” during July-November 2016. The program was funded by Department of Agriculture, Govt. of Kerala under National Mission for Sustainable Agriculture scheme of Govt. of India.
- Training on “Production and Processing of Tuber Crops” was imparted to 10 farmers and two officials from Salem at ICAR-CTCRI, Thiruvananthapuram on 11 August 2016.
- Training on “Production and Value Addition in Tuber Crops” was organized for 20 farmers from Ariyalur at ICAR-CTCRI, Thiruvananthapuram during 29-31 August 2016.



Participants of the Short Course on Root and Tuber Crops based Integrated Farming System



Horticulture for East Coast

- ICAR sponsored Short Course on “Processing Machineries, Value Addition and Entrepreneurship Development in Tuber Crops”, was organized during 31 August-9 September 2016 at ICAR-CTCRI and 18 participants attended the same.
- A Model Training Course entitled “Root and Tuber Crops based Integrated Farming System: A Way Forward to Address Climate Change and Livelihood Improvement”



was organized at ICAR-CTCRI, Regional Centre, Bhubaneswar during 19-26 September 2016.



Participants of the Training Programme on Bankable projects

NAARM-MANAGE-CTCRI-CRISP workshop

- CTCRI-SAMETI capacity building programme on “Preparation of Bankable Project Profiles for Agri-business” at SAMETI, Thiruvananthapuram during 3-5 November 2016.
- Training was conducted on “Production and Processing of Tuber Crops Technology” for 20 farmers and three officials from Namakkal under ATMA at ICAR-CTCRI, Thiruvananthapuram on 11 November 2016.
- NAARM-MANAGE-CTCRI-CRISP collaborative workshop on “Good Practices in Extension Research and Evaluation” at ICAR-NAARM, Hyderabad during 29 November 2016 to 2 December 2016.
- Training was conducted on “Tuber Crops Production and Processing” to 60 farmers under the PMKY scheme of ATMA at ICAR-CTCRI, Thiruvananthapuram on 20 January 2017.
- One day brainstorming session on “Management of Sweet potato Weevil: Present Status and Future Directions” was held at the Regional Centre, ICAR-CTCRI, Bhubaneswar on 4 February 2017. About 25 delegates from OUAT, AICRP centers and ICAR sister institutes participated in this.
- Training programme on “Entrepreneurship Development Programme for Agriculture Students” was jointly organized by ICAR-CTCRI and KAU at Vellayani, Thiruvananthapuram on 16-18 February 2017.
- Training on “Preparation of Bankable Projects (AC & ABC scheme)” was jointly organized by ICAR-CTCRI and KAU at ICAR-CTCRI, Thiruvananthapuram during 15-17 March 2017.

- Six training programmes were organized on farming systems involving tuber crops at Hatibadi (village), Kandhamal (dist.), Odisha; Burhakocha (village), Ranchi (dist.), Jharkhand; Kenjaguda (village), Kandhamal (dist.), Odisha; Nuaguda (village), Koraput (dist), Odisha, under AICRPTC-TSP.
- Seven scientists (On Probation) who had joined ICAR-CTCRI were given one month orientation training (10 April-10 May 2016) in the institute.
- A two days training for knowledge and skill enhancement was conducted for 22 Skilled Support Staff (SSS) at ICAR-CTCRI during 28 February 2017 to 1 March 2017.
- Techno-Incubation Centre, ICAR-CTCRI organized 22 training programmes in the campus and 11 trainings off campus on practical demonstration, value addition and entrepreneurship development in tuber crops.
- More than 142 classes on production, protection, processing and value addition aspects were handled by scientists of various divisions under different programmes 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.
- Twenty one scientists attended 18 training programmes, 10 technical staff attended eight training programmes and six administrative staff attended four training programmes organized at National level from ICAR-CTCRI.

TOP EVENTS



Shri. K. Jayakumar, IAS, Vice Chancellor, Thunchathuzhuthachan Malayalam University, inaugurating the H.H. Sree Visakhram Thirunal Endowment lecture - 2016



Dr. Shashi Tharoor, Hon'ble MP inaugurating NCTTC-2016 by lighting the ceremonial lamp in the presence of Dr. T. Mohapatra, Hon'ble DG, ICAR



Programme	Date
National Technology Day	11 May 2016
H.H. Sree Visakhram Thirunal Endowment Lecture-2016	17 June 2016
53 rd Foundation Day Celebration of ICAR-CTCRI	28 July 2016
Foundation stone laying of Farmers Facilitation Centre by Shri. Radha Mohan Singh, Hon'ble Union Minister of Agriculture & Farmers Welfare	29 September 2016
NCTTC-2016	20-22 October 2016
14 th Institute Management Committee Meeting	29 November 2016
Agriculture Education Day	3 December 2016
World Soil Day	5 December 2016
Tuber Crops Day	9 December 2016
Technology Week Celebrations	19-21 December 2016
Visit of Shri. Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture and Farmers Welfare	28 January 2017
National Productivity Week Celebrations	12-18 February 2017
National Science Day Celebrations-2017	16-17 February 2017
Third Meeting of Research Advisory Committee VII	22-23 February 2017
43 rd Annual Institute Research Council	23-25 March 2017



Release of ICAR-CTCRI publications by Shri. Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare. Dr. James George, Director (Acting) and Sri. P.R. Muraleedharan, Member, Coconut Development Board are also seen



Shri. Sudarshan Bhagat, Hon'ble Union Minister of State for Agriculture and Farmers Welfare inaugurating the drip fertigation facility established at the institute as a part of 'More crop per drop' programme



PARTICIPATION IN EXHIBITIONS

- ICAR-CTCRI participated in 13 exhibitions and bagged three prizes. The Institute bagged first prize in the Krishi Mela Centenary Expo 2016, organised by ICAR-CPCRI, Kasargod and won second prizes in the Vaiga 2016 organised by Government of Kerala and Regional Horticultural Fair 2017 conducted by ICAR-IIHR, Bengaluru.

VISITS ABROAD

- Two scientists, Dr. C A. Jayaprakas and Mr. P. Prakash visited Bosnia and Herzegovina and Bangkok, Thailand respectively to participate and present research papers in international conferences.

PUBLICATIONS

- Research papers in journals: 70
- Book chapters: 14
- Course/training manuals: 3
- Popular articles: 9
- Folders/leaflets/pamphlets: 5
- Papers in conferences/proceedings/seminars: 132
- Conference document: 1
- Lecture notes in short courses: 20
- Other institute publications: 8
- Radio talks: 7

ONGOING PROJECTS

- Institute projects: 10
- Externally aided projects: 27



AWARDS

- Dr. C. Visalakshi Chandra was awarded the Young Scientist Award for the Best Oral Presentation titled “Characterization and identification of genotypes for tolerance to post-harvest physiological deterioration in cassava” (authored by C. Visalakshi Chandra, M.N. Sheela, Saravanan Raju, C. Mohan, Vivek Hegde, S. Darshan and A. Vijayan) in the National Conference on Tropical Tuber Crops for the Sustenance and Welfare of Tribal Communities (NCTTC-2016) held at ICAR-CTCRI during 20 - 22 October 2016.



Dr. C. Visalakshi Chandra receiving the Young Scientist Award of NCTTC-2016 from Director, ICAR-CTCRI



Mr. Prakash receiving the best oral presentation award in NCTTC-2016 from Director, ICAR-CTCRI

- Ms. P. Lakshmipriya bagged the Young Scientist Award (Runner up-I) for the oral research paper titled “*Piriformospora indica*, a cultivable endophyte for growth promotion and disease management in taro” (authored by P. Lakshmipriya, Vishnu S. Nath, S.S. Veena, K.N. Anith, J. Sreekumar and M. L. Jeeva) in the National Conference on Tropical Tuber Crops for the Sustenance and Welfare of Tribal Communities (NCTTC-2016) held at ICAR-CTCRI during 20 - 22 October 2016.
- Ms. G. Saranya, received the Young Scientist Award (Runner up-II) for the oral research paper titled “Mining of resistance genes associated with anthracnose infection in greater yam (*Dioscorea alata* L.)” (authored by G. Saranya, Vishnu, S. Nath, M.L. Jeeva and T. Makesh Kumar) in the National Conference on Tropical Tuber Crops for the Sustenance and Welfare of Tribal Communities (NCTTC-2016) held at ICAR-CTCRI during 20 - 22 October 2016.
- Drs. M.N. Sheela, G. Suja and S.S. Veena, Ms. R. Remya and Mr. P. Prakash received Best Oral Paper Awards and Drs. V. Ramesh and R. Muthuraj and Mr. E.R. Harish received Best Poster Paper Awards in NCTTC-2016 held at ICAR-CTCRI during 20 - 22 October 2016.
- Dr. K. Susan John won the second place in the International Plant Nutrition Institute (IPNI) photo contest 2016 in the other category for B deficiency in cassava. The award carried US Dollars 100, a certificate and a USB with nutrient disorder archives.



- Ms. Irfa Anwar, Dr. M.N. Sheela, Dr. K.I. Asha, Ms. Athira Jyothi, Mr. B.S. Prakash Krishnan and Mr. P.V. Abhilash bagged the Best Poster Presentation award for the research paper on “Genetic diversity analysis of wild yams in India”, in Session IV on Crop Wild Relatives at the 1st International Agrobiodiversity Congress at New Delhi held during 6 - 9 November 2016.
- Dr. Kalidas Pati, Scientist was selected for the prestigious Endeavour Research Fellowship 2017 for post-doctoral research at The University of Western Australia, Perth, Australia under ‘Australia Awards’ of Australian Government Department of Education and Training.
- Ms. Pradeepika Chintha has been awarded the Netaji Subhas-ICAR International Fellowship for the year 2016 for pursuing higher education in university abroad.
- Drs. Archana Mukherjee, Vivek Hegde and P. Sethuraman Sivakumar visited Joida to get GI registration of taro and the Joida dasheen taro. Received GI registration and the community got “Plant Genome Saviour Award”.
- Dr. Sanket J. More bagged the ASPEE Foundation Gold Plated Silver Medal in Ph.D. for securing highest overall C.G.P.A. and conducting quality research.

Award of Ph. D.

- Shri. A.V.V. Koundinyya, Scientist, Crop Improvement was awarded Ph. D. in Vegetable Science on 26 October 2016 from Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal under the guide ship of Dr. (Prof.) Manas Kumar Pandit on the topic, “Profiling of quality parameters as a function of cropping season, character association, stability analysis and screening against fruit and shoot borer infestation in brinjal”.
- Ms. C.S. Suchithra was awarded Ph. D. in Environmental Science from the University of Kerala for the thesis titled “Soil phosphorus management for sustainable cassava production and environmental health in Ultisols” done under the guidance of Dr. G. Byju.
- Ms. A.C. Hridya was awarded Ph. D. in Environmental Science from the University of Kerala for the thesis titled “Soil related constraints and site specific nutrient management in cassava (*Manihot esculenta* Crantz)” done under the guidance of Dr. G. Byju.
- Ms. Sabitha Soman was awarded Ph. D. in Environmental Science from the University of Kerala for the thesis titled “GIS based nutrient decision support system for sustainable cassava production in Thiruvananthapuram district, Kerala” done under the guidance of Dr. G. Byju.

M. Sc. Biotechnology/B.Sc.-M.Sc. Integrated Biotechnology

- Eight students were awarded M.Sc. Biotechnology and B.Sc.-M.Sc. (Integrated) Biotechnology from Cochin University of Science and Technology and Kerala Agricultural University respectively under the guidance of Scientists of ICAR-CTCRI.



DISTINGUISHED VISITORS

The following distinguished persons visited ICAR-CTCRI at the headquarters and regional centre during the year

- Shri. Radha Mohan Singh, Union Minister of Agriculture and Farmers Welfare, Government of India, New Delhi.
- Shri. Sudarshan Bhagat, Minister of State for Agriculture & Farmers Welfare, Government of India, New Delhi.
- Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), New Delhi.
- Dr. Shashi Tharoor, Member of Parliament (Lok Sabha), Thiruvananthapuram, Kerala.
- Shri. V.S. Sunilkumar, Minister for Agriculture, Thiruvananthapuram, Kerala.
- Shri. Kadakampally Surendran, Minister for Electricity & Devaswom, Kerala.
- Shri. K. Jayakumar, Vice-chancellor, Thunchathuzhachan Malayalam University, Tirur, Malappuram, Kerala.
- Dr. G. Gopakumar, Vice Chancellor, Central University of Kerala.
- Dr. M. Premjit Singh, Vice Chancellor, Central Agricultural University.
- Prof. D.P. Ray, Former Vice Chancellor, Orissa University of Agricultural & Technology and Advisor, SOA University, Bhubaneswar, Odisha.
- Dr. N.K. Krishna Kumar, Former Deputy Director General (Horticulture Science), ICAR, New Delhi.
- Dr. A.K. Singh, Deputy Director General (Extension & Horticulture Science), ICAR, New Delhi.
- Dr. T. Janakiram, Assistant Director General (Horticulture Science), ICAR, New Delhi.
- Padmashree Dr. A.K. Parida, Director, Institute of Life Sciences, Bhubaneswar
- Dr. S. Dam Roy, Director, ICAR-Central Island Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands.
- Dr. M.R. Dinesh, Director, ICAR-Indian Institute of Horticultural Research, Bengaluru.
- Shri. Biju Prabhakar, IAS, Directorate of Agriculture, Vikas Bhavan, Thiruvananthapuram, Kerala.
- Shri. Manoj Ahuja, Principal Secretary, DAFE, Govt. of Odisha.
- Shri. S. Prusty, Director, Directorate of Horticulture, Govt of Odisha.
- Smt. D. Sreedevi, Chairperson of Kerala Women's Commission, Pattom, Thiruvananthapuram, Kerala.
- Dr. Samuel N. Mathew, Executive Director, National Institute for Speech and Hearing, Thiruvananthapuram, Kerala.
- Shri. Muraleedharan Thazhakar, Programme Executive, All India Radio, Thiruvananthapuram, Kerala.
- Shri. L.P. Chithir, Director, Suchitwa Mission, Government of Kerala
- Dr. R.P. Raja, Member of Travancore of the Royal Families, Thiruvananthapuram, Kerala.

- Shri. Samraj, Assistant Director (OL) (Retd.), Indian Railway & Official Language Consultant, C-DAC, Thiruvananthapuram.
- Dr. P. Rethinam, Former Assistant Director General, ICAR & Chairman, RAC, VII.
- Dr. Umesh Srivastava, Former Assistant Director General (Horticulture Science), ICAR & Member, RAC VII.
- Dr. P.S. Naik, Former Director, ICAR-Indian Institute of Vegetable Research & Member, RAC VII.
- Dr. V.G. Malathi, Adjunct Faculty & Emeritus Scientist, Tamil Nadu Agricultural University & Member, RAC VII.
- Ms. Tiffany Brar, Founder, “Jyothirgamaya”, A Mobile Blind School, Ambala mukku, Thiruvananthapuram.
- Shri. Alathara Anilkumar, Councillor, Cheruvaikal, Thiruvananthapuram, Kerala.



Shri. Radha Mohan Singh, Union Minister of Agriculture and Farmers Welfare, Government of India, New Delhi unveiling the plaque after laying foundation stone of the Farmers Facilitation Centre at ICAR-CTCRI, Thiruvananthapuram

Shri. Sudarshan Bhagat, Minister of State for Agriculture & Farmers Welfare, Government of India, New Delhi, releasing the publications at ICAR-CTCRI, Thiruvananthapuram



Dr. Trilochan Mohapatra, Secretary (DARE) & Director General (ICAR), visiting the experimental fields at ICAR-CTCRI, Thiruvananthapuram, on the occasion of NCTTC-2016



INSTITUTE TECHNOLOGY MANAGEMENT UNIT (ITMU)

The Institute Technology Management Unit (ITMU) of the Institute has been active in carrying out the following IP activities during the period 2016-2017. The unit had engaged with public/private parties for the commercialization of the following technologies:

Technologies commercialized

Name of the technology/innovation/material	Contracting party	Mode of technology transfer	Year	Revenue earned (₹)
Technology for fried snack foods and fried chips from cassava	Shri. N. P. Suneer, M/s KV Food Products Ltd., Kannur 670 613	Consultancy	September 2016	25,000
Technology for value addition of cassava products	Kudumbashree-State Eradication Mission under the Department of Local Self Government, Govt. of Kerala, Thiruvananthapuram	Consultancy	November 2016	As per the prevailing rate of Techno-Incubation Centre
Electronic Gadget for measuring starch content of cassava tubers	Shri. Sreejith M/s Environmental Measurements & Control, Kochi	Licensing	January 2017	10,000
Technology for fried snack foods and fried chips from cassava	Shri. C. Manoj, Thottumkal House, Thengali, Thiruvalla	Consultancy	January 2017	25,000
Production of high quality cassava flour from cassava	M/s VERDS FAB PRODUCTS, No. 535 Ponnammallee High Road, Arumbakkam, Chennai 600 106	Contract research	March 2017	3,00,000
Developing jackfruit –cassava gluten free pasta	M/s Artocarpus Foods Pvt. Ltd, Plot No. F, Kinfra Park, Nadukani, Kannur	Contract research	March 2017	48,000
Technology for fried snack foods and fried chips from cassava	Shri. Santosh Kumar, Kerala	Consultancy	March 2017	25,000

LIBRARY SERVICES

Library continued the information support services to the research activities of the institute. During the period, 7 books, 6 Indian journals, 41 E-journal collections on Agriculture and Horticulture, 295 numbers of E-books and online database (indiastat.com) were included in the library collection. E-books, e-journals and Online database facility was provided to Regional centre also through IP address by <http://www.sciencedirect.com/science/bookbshsrw>, j-Gateplus.com (CeRA resource sharing platform) and indiastat.com respectively. Library continued to provide services like ready reference, reading and



reference facilities to the institute staff, research students, B.Sc. and M.Sc. project students and outside users with the permission of the competent authority, library membership facility, circulation of library documents, document delivery services through CeRA and photocopying services to the users. During this period, library provided user orientation training to the new library users about the library collection and other services rendered by library. Training-cum-awareness programme on j-Gate @ CeRA was also provided to various categories of library users.

Consultancy and patents

- Saravanan, R., Gajbhiye, N. A. and Maiti, S. 2016. Method of Preparing Aloin. Indian Patent. No. 277501. Application Number 1261/MUM/2008, Publication Number 52/2009.

Technologies transferred

The following technologies were included in Package of Practices Recommendations, Crops (2016), Kerala Agricultural University

- INM for tannia.
- Technology for organic production of yams.
- Technology for organic production of taro.

AGRICULTURE KNOWLEDGE MANAGEMENT UNIT (AKMU)

Our Institute has established a full fledged Local Area Network connecting various Divisions, Administration, Accounts and farm sections of ICAR-CTCRI through a strong fiber optic backbone. The entire network is supported by state of the art equipments such as fiber optic core switches, routers and firewalls. The entire campus is now wi-fi enabled through access controlled wi-fi devices and controllers. The servers are powered with Microsoft Windows 2012 operating system. The network consists of Windows 2012 staff server, Windows 2012 student server, storage Server, internet proxy server, 204 computers, laser printers, inkjet printers, scanners, DTP and multimedia workstations. AVPN connectivity is established for global access to the servers. Legal Licensed versions of popular software packages are installed for various types of application. Our AKMU became one of the nodal point of National Knowledge Network of India (NKN) for effective sharing of scientific resources. CTCRI has set up a home page on the Internet. This can be accessed at <http://www.ctcri.org>, which provides a comprehensive picture about the various activities of the Institute.



Planting material production

Sl. No.	Crop	Variety	Quantity of planting material produced	
			Number of stems/vine cuttings	Tonnes
1.	Cassava	Sree Vijaya	24000	-
		Sree Jaya	26000	-
		Sree Pavithra	6000	-
		Sree Swarna	5000	-
		Vellayani Hraswa	4000	-
		Total	65000	-
2.	Elephant foot yam	Gajendra		30.0
3.	Greater yam	Sree Keerthi	-	3.5
		Sree Shilpa	-	1.0
		Sree Roopa	-	3.5
		Da-293	-	8.0
		Orissa Elite	-	2.0
		Total	-	18.0
4.	Taro	Telia	-	1.5
		Muktakeshi	-	0.8
		Total	-	2.3
5.	Sweet potato	ST- 14	100000	-
		Kishan	120000	-
		Total	220000	-
6.	Yam bean	RM-1		0.3

Scientific Staff Strength
53 including Director



हर कदम, हर लम्हर
किसानों का हमसफर
कर्मों की अग्रिम रीति

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