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NATIONAL RESEARCH CENTRE FOR BANANA
(Indian Council of Agricultural Research)
Thogamalai Road, Thayanur Post
Tiruchirapalli -620 102, Tamil Nadu, India

राष्ट्-ीय केला अनुसंधान केन्द्र
(भारतीय कृषि अनुसंधान परिषद)
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Front Cover Page : A field view of Grand Naine banana under fertigation

Back Cover Page : Banana squash prepared from Rasthali banana

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1. PREFACE

I am happy and privileged to present the annual report (2005-06) of National Research Centre for Banana. The Centre has taken concerted efforts to fulfill the mandates under four different major activities. It has aimed at developing technologies to minimize the cost of banana production through better input efficiency, canopy management with suitable integrated pest and disease management strategies. This year, the Centre has made tremendous achievements in all the four major thrust areas.

After more than a decade of research efforts by the Centre, a first high yielding selection named UDHAYAM was released for the benefit of the banana growers by Shri Sharad Chandra Pawarji, Hon'ble Union Minister for Agriculture. With the use of molecular markers and morphotaxonamic data, the total collections numbering 946 has been narrowed down to 310 by eliminating the synonyms. Diversity of collected germplasm of AB and AAB accessions were molecularly analyzed for their relatedness with their wild progenitors. Embryogenic Cell Suspensions were developed for Nendran and Ney Poovan.

The production section has come out with paired row planting technology along with fertigation to save 25 per cent recommended fertilizers and also to increase productivity as compared to conventional planting in three important varieties. Six accessions have been found drought tolerant based on Leaf Water Retention Capacity. The Centre has developed three functional foods using banana flour exclusively for diabetic patients. Instead of wasting the peels in chips making industry, it could be utilized as thokku (pickle), a value addition technology developed by the post harvest technology section.

Under IPM for banana, bell injection to control thrips, longitudinal pseudostem trap swabbed with EPN and EPF to effectively manage the weevils and bio-control agents and botanicals were developed to tackle nematodes. Bio-control agents were identified and evaluated for different fungal pathogens of banana. Wilt and viral pathogens of banana are molecularly characterized for effective management through biotechnological tools. Research to find out genes for sigatoka leaf spot and drought resistance traits and transgenic development for BBTV resistance are initiated this year as a part of ICAR Network project.

Four processing technologies developed by the Centre were transferred to private and Government agencies which has also generated good revenue to the Centre. Diagnostic kits developed for viruses are effectively used for testing the mother plants for mass propagation by the industry. The Centre has conducted trainings to self-help groups, officials and farmers of "Mahabanana" association, Maharashtra on value added products. The Centre also disseminated the technologies through mass media, exhibitions and through banana seminars. In order to encourage the young students, the scientists have guided 35 research scholars for their postgraduate degree.

I appreciate and thank Dr.R.Selvarajan, Chairman, Publication committee and the members of editorial committee for their efforts in compiling, editing and bringing out the annual report. I also thank Drs. S.K. Singh and C.K. Narayana for translating executive summary in Hindi.

Tiruchirapalli
November - 2006

(M.M. Mustaffa)
Director

2 कार्यकारी सारांश

राष्ट्रीय केला अनुसंधान केन्द्र (त्रिची) केला उत्पादकों की समस्याओं को सुलझाने के लिए अनेक अनुसंधान गतिविधियां चला रहा है। उत्पादन लागत को कम करना, उत्पादन बढ़ाना, मूल्य संवर्धन एकीकृत कीट एवं रोग प्रबंधन तथा प्रति इकाई क्षेत्रफल से अधिक आमदनी लेना संस्थान की प्रमुख अनुसंधान गतिविधियों में शामिल है। केन्द्र की प्रमुख उपलब्धियों का विवरण निम्नवत है–

जनन द्रव्य संपदा

केन्द्रीय कृषि मंत्री माननीय श्री शरद पवार जी ने सितम्बर, 2005 को पिसांग अवाक नामक कदली चयन को उदयम नामक प्रजाति के रूप विमोचित किया। RAPD एवं SSR नामक चिन्हकों की मदद से *Musa* संकलन को संकुचित करके 310 की संख्या पर ला दिया गया है। NBPGR से 159 तथा अंडमान निकोबार द्वीप समूह से 3 *balbisiana* की नई प्रविष्टियों का समावेश किया गया। 13 नई प्रविष्टियों को अभिलक्षिणित करके उन्हें आंकड़ागत किया गया। 7 एस.एस.आर. चिन्हकों का प्रयोग करके 33 सिल्क एवं 45 ए.बी. जनन द्रव्यों का उनकी आनुवंशिक विविधता तथा जनन संघीय संबंधों के आधार पर अभिलक्षणित किया गया। इनमें से 13 जनन द्रव्यों को पुनः मूल्यांकन के योग्य पाया गया। द्विगुणित नर एवं मादा पौधों का गुणसूत्र दाता के रूप में प्रयोग एवं अजैविक अवसाद के प्रति जांचा परखा गया। नेन्द्रन एवं नेपूवन प्रजातियों के लिए कोशिका भ्रूण निलयन प्रोटोकाल का सफलता पूर्वक विकास किया गया। *मुसा अरनश्याका* की *इन विटरो* गुणन प्रक्रिया का भी विकास किया गया।

उत्पादन प्रौद्योगिकी

संस्थान द्वारा केला उत्पादन की अनेक उन्नत तकनीकों जैसे वानस्पतिक प्रबंधन, सिंचाई एवं एकीकृत पोषण प्रबंधन का विकास किया गया है। रोवस्टा प्रति एकड़ 2,500 पौधे रोपित करने से रोवस्टा एवं ग्रान्डनेने नामक प्रजातियों में प्रति गुच्छा अधिकतम भार पाया गया जबकि 4,500 पौधे प्रति एकड़ रोपित करने से प्रति एकड़ अधिकतम उपज प्राप्त हुई। धान की भूसी की राख एवं फॉस्फोवैक्टीरिया का उर्वरक के रूप में प्रयोग करने से एन.पी.के. की जरूरत में 20 प्रतिशत की कमी पायी गयी, जिससे कि प्रति हैक्टर 50,000 रूपये की अतिरिक्त आमदनी हुई। कुछ प्रजातियों जैसे नेपूवन में पत्ती छंटाई (लीफ क्लिपिंग) तकनीक फायदेमन्द साबित हुई। लीफ क्लिपिंग से नेपूवन में प्रकाश संश्लेष्ण की प्रक्रिया बढ़ गयी लेकिन फलों की गुणवत्ता पर कोई प्रभाव नहीं पड़ा। सूखा अवरोधी परीक्षणों में नाटू पूवन, थेला चक्रकेली, तेरावन मनन्न, लदन, इरोडकई एवं पिसांग बरलिन को पर्णजल धारण क्षमता के आधार पर सहनशील पाया गया।

मूल्य संबर्धन

ग्रांडनेने, रोबस्टा एवं रसथाली प्रजातियों के फलों को गर्म पानी एवं 500 पी.पी.एम. कार्बन्डाजिम नामक फफूंदीनाशक से उपचारित करने तथा 13.5^{0}से. तापक्रम पर भण्डारित करने से फलों की भण्डारण अवधि में 90 से 125 दिन तक की बढ़ोत्तरी देखी गयी। संबर्धित उत्पाद जैसे चपाती, ब्रेड एवं पेय का केले के आटे से उत्पादन निष्पादित किया गया। केले के छिलके का उपयोग अचार बनाने के लिए, तकनीक विकसित की गयी।

एकीकृत कीट एवं रोग प्रबंधन

केले के प्रमुख रोग एवं कीटों को नियंत्रित करने के लिए कई रोग एवं कीट नियामकों का विकास किया गया। 20 ग्राम गेंदे का सत्व तथा 10 ग्राम लिलैसिनम के सत्व का प्रति पौधा उपयोग करने से निमैटोड के नियंत्रण में सफलता पायी गयी। पिसांग अवाक नामक प्रविष्टि में 8 टरपेनोइडस पाये गये, जिनका परमाणुभार 120 से 280 के बीच पाया गया। *बी. बैसियाना* फफूंदी वीविल के नियंत्रण में कारगर साबित हुई। *पी. एरूजिनोसा* तथा *पी. विरडीफ्लेवस* के प्रयोग से क्राउनराट बीमारी पर नियंत्रण पाया गया। बी.बीआर.एम.वी विषाणु के निर्धारण में आर.टी.पी.सी.आर. विधि डी.आई.बी.ए. तथा एलाइजा से अधिक कारगर पायी गयी। *इन विटरो* तकनीक से विकसित 'रोज' नामक प्रजाति के पौधों को सिगाटोंका नामक रोग के प्रति जांचने के लिए खेतों में सफलता पूर्वक रोपित किया गया। केला के पौधों से कुल आर.एन.ए. निष्कासन विधि का विकास किया गया। *फ्यूजेरियम* रोगाणु के 153 पृथकों का डी.एन.ए. निष्कर्षण शोधन एव ंमापन किया गया। विभिन्न *फ्यूजेरियम* रोगाणुओं के आई. टी.एस. आकार में अंतर पाया गया। 65 पृथकों के एम्पलीकोन को विन्यसित किया गया। बी.बी.एम.बी. तथा बी.एस.बी. के लिए रेडियो–अधर्मी जांच विधियां विकसित की गयी तथा पी.सी.आर. द्वारा उनकी जांच क्षमता का आंकलन किया गया। बी.एस.वी. जीनोम के तीन ओ.आर.एफ. की क्लोनिंग एवं विन्यास तैयार किया गया। बी.बीआर.एम.वी को परखने के लिए डाइरेक्ट वाइडिंग पी.सी.आर. विधि का मानकीकरण किया गया। पी–कैम्बिया 2301 के प्रयोग से जी.यू.एस. जीन के दृश्यन तथा उसके प्रभाव से एस्कैल्प तथा शीर्ष परिमार्जन की प्रक्रिया का मानकीकरण किया गया।

प्रद्यौगिकी हस्तान्तरण

केले की **'उदयम'** प्रजाति के पौधे किसानों एवं ऊतक संवर्धन में व्यवसायरत कम्पनियों को दिये गये। आंध्र प्रदेश सरकार के उद्यान विभाग ने राष्ट्रीय केला अनुसंधान केन्द्र, त्रिची की मदद से विषाणु परीक्षण प्रयोगशाला की स्थापना की, जिसका उद्घाटन 13 मार्च, 2006 को समपन्न हुआ। महा बनाना के कर्मचारियों तथा किसानों को केले के मूल्य संबर्धन पर प्रशिक्षण दिया गया। मूल्य संबर्धन पर आधारित तकनीक का स्थानान्तरण जरूरतमन्दों के बीच किया गया।

मानव संसाधन विकास

वैज्ञानिकों, तकनीकी वर्ग तथा प्रशासनिक कर्मचारियों को उनके संबंधित वि ायों में प्रशिक्षण दिलाया गया। जैव रसायन, जैव विज्ञान तथा सूक्ष्मजीव विज्ञान के करीब 31 परास्नातकों ने अपने शोध ग्रन्थ एन.आर.सी.बी त्रिची के सहयोग से पूर्ण किये। केन्द्र ने केले से संबंधित आयोजित होने वाली अनेक गोष्ठियों, सम्मेलनों एवं प्रदर्शनियों में भाग लिया।

मुद्रा अर्जन

केन्द्र ने पौधे एवं उत्पाद विक्रय, कन्सल्टेन्सी तथा प्रसार सेवाओं से 21,28,243 रूपये अर्जित किये।

3 Executive summary

The National Research Centre for Banana, Trichy is carrying out various research activities with multi-disciplinary approach to tackle the problems faced by the banana growers. The main area of research involves : minimizing the cost of production, increasing the productivity, value addition and development of integrated pest and disease management strategies to obtain the maximum profitability from an unit area. The salient achievements of the Centre are briefly summarized below :

Genetic Resources

A high yielding Pisang Awak selection was released as 'Udhayam' from the Centre by the Hon'ble Union Minister of Agriculture Shri Sharad Chandra Pawarji on 15th September 2005. *Musa* accessions available in the Centre has been narrowed down to 310 by eliminating the synonyms using morphotaxonomic and molecular markers viz., RAPD and SSR markers. 3 *balbisiana* accessions from Andaman and Nicobar islands and 159 from NBPGR have been added. 13 newly introduced accessions were characterized and included in the data base. 33 Silk and 45 AB accessions were characterized using SSR markers for their genetic diversity and phylogenetic relationship. 13 accessions have been identified as promising clones for further evaluation.

Male and female diploid parents have been identified as gene donor. 12 hybrid diploids are being evaluated for biotic and abiotic stresses and other horticultural parameters.

Embryogenic cell suspension protocol has been successfully developed for Nendran and Ney Poovan cultivars using immature flower buds. Rasthali, Sannachenkadali, Williams, Sommarani Monthan produced friable callus. *In-vitro* multiplication protocol has been standardized for *Musa aurantiaca*, a member of *Rhodochlamys*.

Production Technology

Several technologies have been developed involving canopy management, fertigation and integrated nutrient management for banana. Maximum bunch weight was recorded in Robusta and Grand Naine under conventional planting with 2500 plants while paired-row planting system with 4500 plants recorded maximum productivity. Quality of the fruit was good in 75% recommended fertilizer through fertigation at weekly intervals in Robusta, Grand Naine and Red banana varieties.

Application of 15 kg rice husk ash + phosphobacteria with 80% recommended NPK reduced the input cost and generated an additional income of Rs.50,000/- per hectare. Ney Poovan variety recorded maximum photosynthesis activity after a month of leaf clipping as compared to Karpuravalli. Leaf clipping has no effect on the carbohydrate, tannin and phenol contents of the banana fruit.

Screening against drought indicated that the accessions viz., Nattu Poovan, Thella Chakkarakeli, Teraban, Mannan, *Musa balbisiana*, Ladan, Erode Kai and Pisang Berlin were tolerant based on leaf water retention capacity (LWRC).

Value Addition

Hot water treatment with 500 ppm Carbendazim with modified storage at 13.5°C extended the green life by 90, 110 and 125 days in Grand Naine, Robusta and Rasthali respectively.

Three functional foods, viz., chappathi, bread and health drink using banana flour have been developed exclusively for diabetic patients. Banana peel-thokku protocol has been standardized which was on par with flower thokku and was acceptable by the consumers.

Integrated Pest Management

Various insect, nematode and disease management strategies have been developed for the control of major pests and diseases in banana. Flower extracts of *Tagetus erecta* was highly effective than the leaf extracts. Application of 20 g *T.viride* or *T.viride* + *Pacelomyces lilacinus* @ 10g each/plant gave good control against *Pratylenchus coffeae* and *M.incognita* infestation.

Eight volatiles collected from Pisang Awak were identified as terpenoids with molecular weight ranging from 120 to 280. Pseudostem traps swabbed with entomopathogenic fungus, *B.bassiana* recorded 90% weevil mortality. Three endophytic bacteria were found effective against Fusarium pathogen under *in-vitro* condtion. *Pseudomonas aeruginosa* and *P.viridiflavus* were effective in controlling Crown rot disease in banana. Bunchy top and Streak virus diseases are wide-spread in North Eastern states also. BBTV cp gene sequence collected from NEH region was 90% similar with the Hill banana isolates of Tamil Nadu. RT-PCR technique was highly sensitive than DIBA and ELISA techniques for dedecting BBrMV.

Primary tetraploid (AAAA) of cultivar Rose (AA) developed through in-vitro polyploidisation has been successfully established in the field for evaluation against Sigatoka leaf spot disease. The total RNA isolation for banana seedlings has been standardized and precipitation of RNA was achieved by lithium chloride.

DNA of Fusarium pathogen was extracted, purified and quantified for 153 isolates. The ITS regions were amplified from different Fusarium isolates using ITS-1 & ITS-4 primers and the amplicons obtained exhibited variation with regard to size. Amplicons for 65 isolates were sequenced.

Non-radioactive probes has been prepared for BBrMV and BSV and tested for their efficiency with PCR. Three ORF's of BSV genome were cloned and sequenced. Direct binding PCR has been standardized to detect BBrMV.

Two complete BBTV components were cloned and sequenced. The cp gene and replicase gene of BBTV Hill banana isolate were analyzed. The intergenic region of BBTV components 1,3 and 5 were cloned and sequenced for assessing the promoter activity. Transformation of scalps and shoot tips with GUS gene and assessment of GUS expression were standardized using p-CAMBIA 2301.

Transfer of Technology

'Udhayam' banana plants were supplied to farmers and tissue culture companies. A virus testing lab was established based on NRCB technology at BTC, Dept. of Horticulture, Govt. of Andhra Pradesh, Hyderabad and was inaugurated on 13th March, 2006. Technologies on value added products were transferred to clients. Value added products training were offered to Mahabanana personnels, Maharashtra, farmers and other beneficiaries.

HRD and Education

Scientists, technicians and administrative staff were trained on different aspects in their respective fields. 35 post graduate students belonging to biotechnology, biochemistry and microbiology have completed their project work in banana. NRCB participated in banana related exhibitions, seminars and field days to impart knowledge on recent developments in banana research and technologies.

Revenue Generation

A revenue of Rs.12,89,919/- was generated from consultancy projects, contract services, technology transfer services, training and also from sale of farm produce. An amount Rs. 9,20,000/- was received from Goverment of AP for establishing a virus testing lab at BTC, Hyderabad on turnkey basis - Consultancy project.

4 Introduction

The National Research Centre for Banana (NRCB) was established at Tiruchirapalli, Tamil Nadu on 21st August, 1993, to strengthen the basic and strategic research and to improve the production and productivity of banana in India. Owing to its richness and diversity of cultivated bananas and plantain, Tiruchirapalli was selected as the location for the Centre. The Centre is having 90 acres land for conducting field research activities. The Centre has good infrastructural facilities like library, ARIS Cell, exhibition hall, green houses, quarantine lab and net houses. The laboratory cum administrative building, staff quarters in the city were built during 10th Five year Plan.

The Centre has four major areas of research viz., Crop Improvement, Crop Production, Crop Protection and Post harvest management. With the funding during 8th, 9th and 10th Five year plan, the Centre has set up well-equipped laboratories for tissue culture, biotechnology, soil science, nutrient management, physiology and biochemistry, entomology, nematology, fungal, bacterial pathology, molecular virology and post harvest technology research.

During the initial years of establishment, the Centre was more focused to collect and conserve the available banana germplasm from primary and secondary sources and has established a field gene bank. Presently, it has the richest banana germplasm collection, which includes accessions from the NEH states, Western Ghats and Andaman and Nicobar Islands. Exotic banana collections were also received from ITC, Belgium through NBPGR, New Delhi. Presently, the Centre has reoriented its research priorities based on the QRT and RAC recommendations. In addition to Centre's in-house projects, 22 external projects funded by AP-Cess fund of ICAR, NATP, DBT, NHB and INIBAP were carried out. The Vision 2020 published in 1998 has been revisited and modified into new perspective plan based on the inputs from QRT and RAC. The Centre conducts Institute Research Council meeting to review and reorient the research priorities frequently based on the RAC and QRT recommendations, urgency and need. The vision of the Centre is to increase the production and productivity of bananas and plantain to meet the growing need in India. The mandate of the Centre are :

- To undertake the basic and strategic research for developing the technology to enhance the productivity and utilization of banana
- To develop improved cultivars through traditional and biotechnological methods and conserve the diversity
- To serve as national repository of germplasm and information related to banana and plantain and also to disseminate the knowledge to improve the production and productivity
- To provide leadership and coordinate the network research for generating location specific variety technology and for solving specific constraints on banana and plantain production
- To collaborate with relevant national and international agencies in achieving the above objectives.

Salient Achievements

Crop Improvement

946 accessions assembled from both indigenous and exotic sources are maintained in the field gene bank. This banana germplasm bank is one of the largest in the world. Collections were made through 8 explorations from all the regions of India. The genomic status of collected accessions has been assigned. Presently 114 AA, 61 AB, 33 BB diploids accessions, 136 AAA, 229 ABB, 224 AAB triploid, 12 each AAAA, AAAB, 5AABB, 9 ABBB, 2 AAAh tetraploid accessions and 8 Fe'i bananas are grouped and maintained. Around 300 accessions could not be assigned their genomic status. Among the accessions available, 92 accessions are highly resistant and 25 resistant to Sigatoka leaf spot disease. The collected germplasm has been narrowed down to 310 by eliminating the synonyms using morphotaxonamic and molecular markers viz., RAPD and SSR. Diversity analysis has been done for AB and AAB(Silk) accessions. Three promising selections have been identified and evaluated for their performance in different locations. NRCB-selection 1 has been released as UDHAYAM for cultivation during this year. This is a high yielding, tolerant to Sigatoka and nematodes and a selection from Pisang Awak clone. Under IMTP trials, wilt, sigatoka and nematode resistant clones were identified. A protocol with modified MS media without growth regulators for embryo culture has been standardized for Pisang Awak (ABB), Bluggoe (ABB), Pome (AAB), Wild *Musa*

balbisiana, *M.nagensium* and *M.ornata*. Standardized the procedure for ex-plant collection in field with initial decontamination with mercuric chloride and culture initiation after 48 hours. 12 hybrids developed are being evaluated under field condition. Embryogenic cell suspensions for Nendran and Ney Poovan have been developed. In addition to NRCB field gene bank, a satellite breeding block has been established at Agali, Kerala.

Crop Production

Application of 25% N as FYM + 50% N as neem cake + 25% N as inorganic fertilizer increased the yield by 20 per cent coupled with least nematode infestation in Rasthali, Poovan, Robusta, Monthan and Karpuravalli cultivars. Application of organic sources, reduced the time taken for flowering, maturity and total crop duration in all cultivars. Weed free conditions in Karpuravalli banana up to 6 months after planting was critical for growth and yield of banana. Weed free condition up to 9 months gave an additional income of Rs.26600/- in Karpuravalli banana. Plants (2250pl/ha) with 20 litre water/day/plant + 75% N (150g N/pl) as fertigation recorded 20% increase in yield with maximum net profit and a benefit cost ratio of 1.96 in Poovan banana.

A combination of distillery sludge 2.5 kg + 1 kg vermicompost + 1 kg neem cake + 2.5 kg poultry manure plant^{-1} recorded the maximum growth parameters in Rasthali and Karpuravalli bananas. It also significantly suppressed the root population of root lesion nematode, root knot nematode and spiral nematodes. The organic manure applied plants had less incidence of Sigatoka leaf spot disease while the inorganic treatment had severe incidence of leaf spot diseases. Application of gypsum @2kg/plant +FYM 15 kg/plant + 120% recommended K produced an increase in yield by 51% over control in saline sodic soil in Nendran and Rasthali banana. Application of 15Kg rice husk ash or 15kg poultry manure per plant resulted in an additional profit of Rs.23, 750/ha and Rs.34, 250/ha respectively in Poovan banana. Paired row planting system with 4500 plants per ha increased the productivity and fruit quality with 75 per cent recommended fertilizers dose as fertigation in Robusta, Grand Naine and Red Banana. 8 drought tolerant accessions were identified based on leaf water retention capacity.

Post harvest Technology

Pre-packaging in 400 gauge LDPE bags, low temperature storage, use of ethylene absorbents and pre-storage treatments resulted in extension of shelf life upto 3 months in Robusta, Grand Naine, Rasthali and Ney Poovan bananas. Several value added products like Flower thokku, peel thokku, fruit pickle, fig, biscuits, jam, ready to serve beaverages and functional fruits like chapaathi, bread and health drink have been developed. Many of these technologies have been commercialized.

Crop Protection

Root-lesion nematode (*Pratylenchus coffeae*) and root-knot nematode (*Meloidogyne incognita*) were present in all banana growing states. The burrowing nematode (*Radopholus similis*) was present in few pockets of Tamil Nadu, Maharashtra,Gujarat, Karnataka and Kerala. Application of 500 g Neem cake per plant reduced the root lesion nematode. *Trichoderma viride* and non-pathogenic *Fusarium* spp. gave effective control of root knot and root-lesion nematodes. Mass production method for *Paecilomyces lilacinus*, which is an egg parasite of root-knot nematode using banana petiole and pseudostem, has been developed. Flower extracts of *Tagetus erecta* was highly effective against nematodes. Bhimkol (BB), Athiakol (BB), Elavazhai (BB) Sapkal(ABB), Dudhsagar (AAA), Pisang Lilin (AA) and Pisang Jari Buaya (AA) were resistant while Nendran was highly susceptible to stem weevil. Use of longitudinal split traps in the field seven months after planting eliminated the weevil population by tenth month. Swabbing 0.06 % Chlorpyrifos 20 EC on the pseudostem to a height of 1.2 m during 5th and 8th months completely controlled BSW. Treating suckers with Monocrotophos 36 EC (14 ml / litre) followed by soil application of Carbofuran 3G, 60 g per plant at 4th and 7th months after planting was found to be effective against corm weevil. Pseudostem traps swabbed with entomopathogenic fungus recorded 90 per cent mortality. Diseases such as Wilt, *Erwinia* rot, Sigatoka leaf spot, peduncle rot (5 to 25 %) were prevalent in all banana growing states. Septoria leaf spot (*Septoria eumusae* = *Mycosphaerella eumusae)*, eye spot (*Drechslera sp*) and pitting disease were recorded for the first time in India. A new wilt disease caused by Triclomataceae fungus of Basidiomycetes has been identified. Five vegetative compatible groups were identified *in Fusarium oxysforum f.spp cubens*. Screening of germplasm and entries from International *Musa* Testing Programme revealed 17 accessions as highly resistant to Sigatoka leaf spot. A fusaric acid detoxifying strain of *Pseudomonas fluorescence* was isolated. Propiconazole (0.1%) or Hexaconazole (0.1%) alternated with Chlorothalonil (0.25%) controlled Sigatoka leaf spot disease and increased the yield by 63 percent. Anthracnose disease of banana was controlled by spraying 25% percent leaf extract of *Solanum tarvum*.

Trichoderma viride (10^9 / ml), *Pseudomonas spp* (10^6 / ml), *Bacillus spp* (10^6 / ml) and Propiconazole (0.1 percent) spray were also effective in controlling the disease. Three applications of *T.harzianum*, *P. fluorescence* and *B.subtilis* at 10 g per plant at the time of planting, 3 and 5 th month after planting reduced the wilt incidence. *P. aerogonosa* and *P.viridiflavus* were effective in controlling crown rot disease.

Viral diseases viz., Banana Bunchy Top (BBTV), Bract Mosaic (BBrMV), Streak (BSV) and Infectious Chlorosis were found present in the entire banana growing areas. The yield loss due to BBrMV in Nendran, Robusta and Ney Poovan were assessed. A yield loss of 49 percent due to BSV was recorded in Poovan. Three aphid vectors including *Pentalonia nigronervosa* transmitted BBrMV and mealy bug vector *Ferrisia virgata* transmits BSV. All the banana viruses could be detected from their vectors by PCR. Polyclonal antiserum to BBTV was produced and ELISA technique has been standardized for detection. NA probe based and PCR based diagnostic techniques have been developed for all the banana viruses and are routinely used for testing the viruses on commercial basis. A multiplex PCR technique has been developed for detecting three banana viruses simultaneously. The viral genomic fragments were cloned and sequenced. Promoter sequences from BBTV were cloned and sequenced. Research to develop transgenic Hill banana plants resistant to BBTV has been initiated.

Transfer of Technology

To popularize the "Udhayam" variety among farmers, suckers and tissue culture plants have been supplied to the interested growers and tissue culture companies. A virus testing lab was developed based on NRCB technology at BTC, Dept of Horticulture, Govt. of AP, Hyderabad which was inaugurated on 13th March 2006 for effective use of virus eradication in AP. Virus testing of mother plants and tissue cultured plants from different tissue culture industries is done on contract service mode. Technologies on value added products were transferred to clients. Virus indexing training was imparted to technical personals of BTC, Hyderabad. Value added products training were offered to Mahabanana personnels, Maharashtra, to farmers and others beneficiaries.

Recognition and Awards

The Centre has been recognized internationally by INIBAP, a programme under IPGRI for conducting 'International Musa Testing Programmes'.

Linkages and Collaboration

The Centre has developed good linkages with international institutes viz., INIBAP, France ; CIRAD, France ; KUL, Belgium ; IAEA, Austria and QDPI, Australia. It collaborates with different national research institutions for different activities viz., NBPGR, New Delhi ; BARC, CIRCOT, Mumbai; IICT, Hyderabad; IIHR, Bangalore; NHB, New Delhi; BTC, Govt. of Andhra Pradesh and all SAUs. Tissue culture industries involved in banana mass propagation, farmers, exporters, banana federations, State Horticulture and Agriculture departments, self-help groups, are linked with the Centre for various research developmental activities.

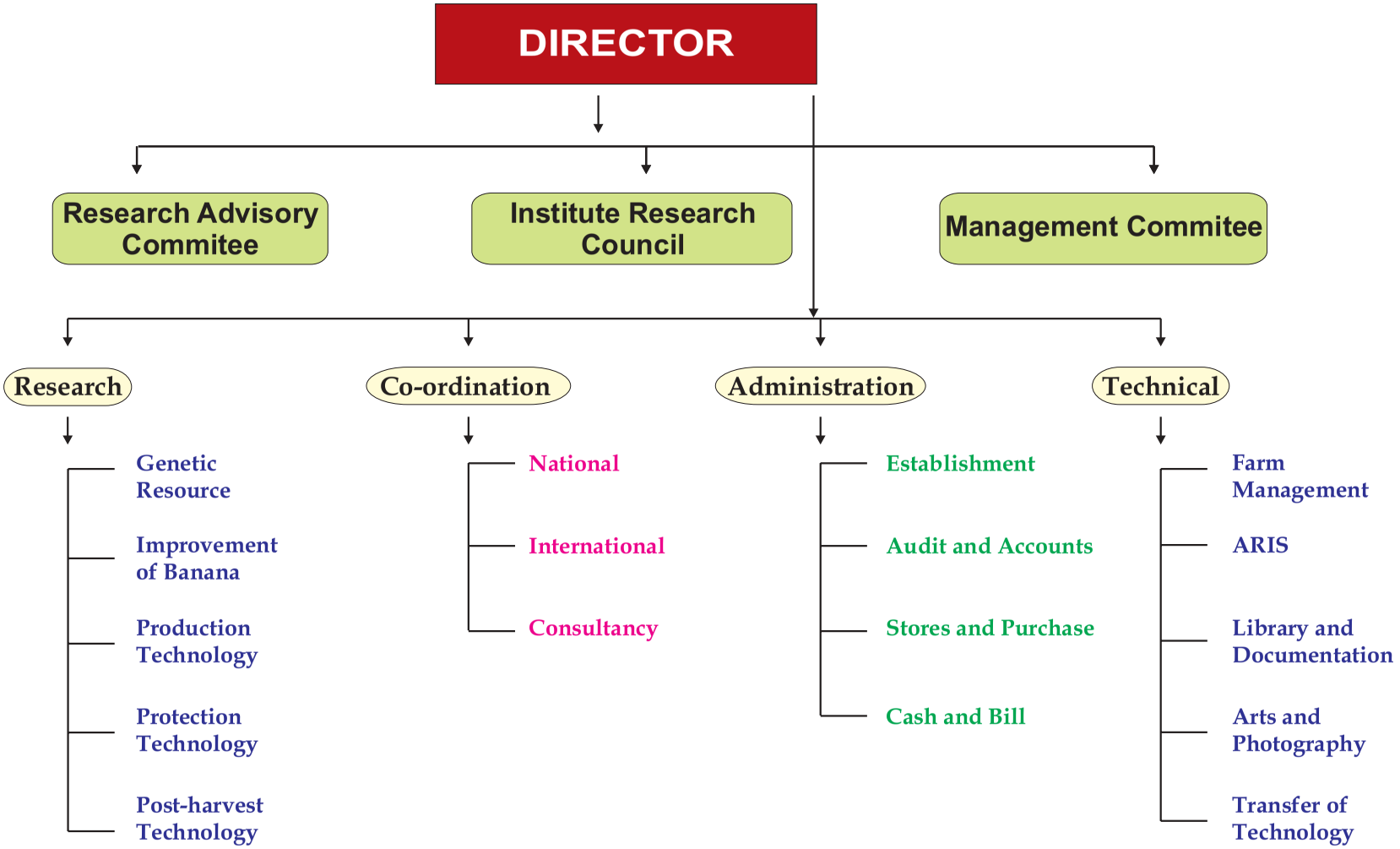
Revenue Generation

A revenue of Rs.12,89,919/- was generated from consultancy projects, contract services, technology transfer services, training and also from sale of farm produce. An amount Rs. 9,20,000/- was received Goverment of AP for establishing a virus testing lab at BTC, Hyderabad on turnkey basis - Consultancy project.

Budget

Budget and Expenditure for 2005-2006 (Rupees in lakhs)

Head of Account	Budget		Expenditure	
	Plan	Non-Plan	Plan	Non-Plan
Estt. Charges	-nil-	113.00	——	102.25
Travelling expense	2.00	1.3	1.74	1.09
HRD	2.00	0.0	1.98	0.00
RC	150.00	50.0	145.88	48.33
IT&Library	6.00	0.0	3.00	0.00
Works	50.00	3.7	50 .00	2.42
Total	210.00	168.00	202.60	154.09



Organisational Flow Chart

5 Research Achievements

CROP IMPROVEMENT

Genetic Resource Management

Collection, characterization, conservation and utilization of *Musa* genetic resources are the major activities of genetic resource management. 946 *Musa* germplasm collected from primary, secondary and other sources since inception of the centre were consolidated into 310, based on morphotaxonomic and molecular markers like isozyme, RAPD and SSR markers. The 310 core accessions represented the diversity in *Musa*. The genomic groups present in core collection are provided in table 1.

Table 1 : Details of core collections maintained in field gene bank

Genome	Core collections
AA	26
AAA	26
AAAA	1
AAB	99
AB	23
ABB	103
ABBB	7
BB	20
Rhodochlamys	5
Total	**310**

Collection

Three wild accessions of *Musa balbisiana* were collected from Andaman and Nicobar Islands in 2005- 06. 107 accessions were received from NBPGR regional station located at Thrissur, Kerala and 52 exotic accessions have been obtained from ITC, Belgium through NBPGR, New Delhi. The details of accessions collected are furnished in table 2.

Conservation

Germplasm collected during exploration and those from secondary sources have been conserved in the field gene bank of the Centre and a duplicate of the rare and unique collections are conserved at a satellite-breeding block at Agali, Kerala. 946 accessions collected since inception of NRCB are being maintained in the field gene banks.

Table 2. Details of accessions collected during 2005-06

Source of collection	Details of accessions collected
Primary source	
Andaman Nicobar Islands	Jungle Kela type I, Jungle Kela type II Beejakela
Kodai hills	*Ensete* sp. type Kodai
Secondary source	
NBPGR, Thrissur	Birbutia, Bluggoe, Bodles Altafort, Boothibale (2), Champa, Chenkalikodan, Chikkebale, Chinali, Chinia, Chirapunji, Elabale, Grand Naine, H-135, Haneji, Hybrid Sawai, Japrikela, Kadali, Kallumonthan, Kalyanbale, Karimpoovan, Karpuravalli (6), Klue Teparod, Kola, Koombillakai, Madhuranga, Malbhog (2), Mas, Matti, Monthan (8), Morris (3), Mottugiri, Mungrekela, *Musa balbisiana(2)*, Myndoli, Nadu(3), Namarai, Ney Poovan, Njali Poovan, Ottunadu, Pacha Bontha Batheesa, Pachanadan, Padathi type, Palayankodan (2), Palur, Pettavazhai, Pisang Awak, Pisang Lilin, Poonkannan, Poovan (8), Rasagalli, Rasthali (7), Robusta, Sakkai (2), Sambrani Poovan, Sannachenkadali, Sikuzani, Tulasimalbhog, Valiyakunnan, Vannan, Vineethmannan, Walha (2), Wather, Zanzibar, Others (5).
Exotic collection	cv. Rose, Amas (South Johnstone), Bata Bata (2), Bega, Cachaco, Cardaba, Cocos, FHIA-23, Fougamou 1, God Mun, Gros Michel (2), Guinen, Kirun, Kluai Lep Mu Nang, Kluai Namwa khom (2), Klue Teparod, Lacatan, Lidi, Long Tavoy, M.ac. ssp. zebrina, *M.ac.*ssp. *malaccensis* type *malaccensis*, *M.ac.*ssp. *microcarpa* type *Borneo*, *Musa balbisiana* chineese (seeds), *Musa maclayi* ssp. *ailuluai*, *Musa maclayi* ssp. *maclayi* var *maclayi*, *Musa peekelii* ssp. *peekelii*, PA 03-22, PC 12-05, Pisang Awak, Pisang Buntal, Pisang Lemak

Characterization

Seven hundred out of 946 surviving accessions were characterized both morphotaxonomically and RAPD and SSR markers.

Morphotaxonomic characterization

13 newly introduced accessions were characterized for 120 morphotaxonomic parameters using *Musa* Descriptor from INIBAP, France / IPGRI, Rome and added to the database.

Molecular characterization using SSR markers

Eleven wild *Musa* spp. accessions collected from North Eastern states, 33 Silk (AAB) group and 45 AB accessions were characterized using SSR markers with standard reference clones to study the genetic diversity and phylogenetic relationship among them.

Diversity among wild and cultivated *Musa* spp. of Arunachal Pradesh

Six SSR primer pairs namely MaSSR 01a, MaSSR 01b; MaSSR 07a, MaSSR 07b; MaSSR 08a, MaSSR 08b; MaSSR 18a, MaSSR 18b; MaSSR 24a, MaSSR 24b; AGMI 133 and AGMI 134 were used to study the diversity and phylogenetic relationship among lesser known 11 wild *Musa* spp. and 8 commercial cultivars of Arunachal Pradesh. The results of the tree matrix clearly indicated clustering of test accessions into 2 major clusters each with 2 minor clusters (table 3).

Table 3. Clustering pattern of lesser-known wild and cultivated bananas from Arunachal Pradesh

Cluster	Minor cluster	Members
I	1	Sessa wild, Adi Kopak, *M. rosacea*
	2	*M. aurantiaca*, Athiakol, Bhimkol, *Ensete*-3, *Ensete*-4, Lairawk, Calcutta-4 Agnimalbhog, Ankur
II	1	*M. itinerans*, *M. velutina*, *M. swarnaphalya*, *M. ornata*, Kuppa, *M. nagensium*
	2	H-5

Minor Cluster 1 exhibited dissimilarity co-efficient of only 10-12 per cent among 3 clones. Adi Kopak, one of the triploid (ABB) commercial banana grouped with Sessa wild, which is a new species identified in Western Arunachal Pradesh. Grouping of these two accessions could be due to the involvement of Sessa wild accession in the development of domesticated variety.

Second major cluster exhibited 2 subgroups with first minor cluster comprising of most of the wild species in sections Eumusa and Rhodochlamys with dissimilarity co-efficient of nearly 15 per cent. H-5, an intersectional hybrid between *Eumusa* and *Rhodochlamys* clustered alone in the minor cluster 2.

Diversity among Silk (AAB) group

Musa specific nine SSR primer pairs viz., MaSSR-07a, MaSSR-07b; MaSSR-08a, MaSSR-08b; MaSSR-18a, MaSSR-18b; MaSSR-24a, MaSSR-24b; AGMI24, AGMI25 ; AGMI161, AGMI162 ; Mb1-12 , Mb1-50 and Mb1-69 were tested for phylogeny and diversity among 33 Silk (AAB) group representatives with 5 wild *acuminata* (AA) and 10 wild *balbisiana* (BB) as controls. The average number of alleles amplified per set of primers was 7, each set of primers amplified 4-10 alleles with a total of 63 identified alleles. The dendrogram for the 48 accessions resulted in the formation of three seperate clusters (table. 4).

Table 4. Clustering pattern in silk group accessions using SSR markers

Groups	Members
Cluster 1	*M. acuminata* ssp. *burmanica* (1118), *M. acuminata* ssp. *burmanicoides* (0642), Lairawk (1019), Chengdawt (1030), Pisang Jajee (0687)
Cluster 2	Bhimkol (0007), Athiakol (0011), *M. balbisiana* (0508), *M.balbisiana* (1353), Sasrabale (0449), Elavazhi (0167), Attikol (0444), Bacharia Malbhog (0446), Phirima wild (1187)
Cluster 3	Malbhog (0560), Thozhuvan (0700), Digjowa (0596), Madhuranga (0491), Nanjangud Rasabale (0728), Dudhsagar (0006), Nanjangud Rasabale (0618), Amrithapani (0546), Sabri (0512), Rasthali (0297), Amruthapani (0212), Mutheli (0264), Digjowa (0014), Therekanchi (0428), Malbhog (0179), Suvandal (0122), Sapkal (0008), Malbhog (0077), Sabri (1005), Khozhi kodu (0712), Sabri (1009), Sakkal Nagpur (0358), Ayirankai Rasthali (0447), Malbhog (0066), Ambeli (0365), Krishnasagar (0798), Baidi Chinia (0445), Pisang Raja Bulu (0462), Sakkarchayna (0355), Amruthapani (0214), Sonial (0367), Digjowa (0030), Malbhog (0001),
	Khungsang wild (1168)

Among cultivated Silk accessions (AAB genome), polymorphism was almost nil (Cluster 3). All 33 Silk accessions exhibited more than 95 per cent similarities, of which 26 accessions were 100 per cent similar and were synonyms. Ayirankai Rasthali (0447), a stable mutant with extended female phase has shown a modest variability from parent Rasthali (0297), while a similar mutant, Mutheli (0264), exhibited 100 per cent similarity.

Pisang Raja Bulu (0462), an exotic introduction is also found to be a synonym with 100 per cent similarity. Similarly, Nanjangud Rasabale (0618), an elite Silk cultivar from Karnataka also confirmed as an ecotype. The present study, revealed a strange lineage of Silk accessions with one of the wild *M. balbisiana* accession Khungsang wild (1168). Although all *M. balbisiana* accessions clustered together, Khungsang wild (1168) exhibited variability of more than 30 per cent and grouped uniquely with Silk accessions. Khungsang wild (1168) may be a putative parent of Silk accessions contributing B genome component of AAB composition of Silk.

The primers used were able to separate cultivars containing the *M. acuminata* (A) genome and *M. balbisiana* (B) genome alone, from interspecific hybrids of *M. acuminata* and *M. balbisiana*. A low degree of polymorphism within the Silk group (AAB) was detected, possibly reflecting a low degree of variability (<5 per cent).

Diversity within AB group

India is the only country, which has the diversity for AB cultivars and grown on commercial scale. Seven SSRs primers (MaSSR-07a, MaSSR-07b; MaSSR-08a, MaSSR-08b; MaSSR-18a, MaSSR-18b; MaSSR-24a, MaSSR-24b; AGMI24, AGMI25; Mb1-50 and Mb1-69) were employed to study the phylogeny and diversity among 45 (AB) accessions in comparison with a wild *acuminata* (AA) and two wild *balbisiana* (BB) as controls. All the seven primers produced well defined discrete banding patterns which revealed 31 alleles at 7 loci. The average number of alleles amplified per primer was 4 and amplified alleles ranged from 3-7 per primer.

All sixteen Ney Poovan ecotypes and synonyms clustered together with more than 95 percent similarities (table 5).

Poomkalli (0196), a Kunnan type based on morphological classification, has clustered with Ney Poovan sub group, which needs to be confirmed with more number of SSR primers. Similarly, Narmine, an ashy mutant of Kunnan has clustered with Ney Poovan, with more than 87 per cent similarity. The seven SSR primers evaluated in the present study were able to discriminate *Musa* genotypes i.e., AA, BB and AB. In some cases, the primers were able to discriminate clones from their respective somatic mutants, to detect erroneously classified cultivars and to identify duplicates (Fig.1).

Table 5. Clustering pattern of AB accessions using SSR markers.

Groups	Members
Cluster 1	Narmine (0369), Nattu Poovan (0186), Poomkalli (0196), Somai (0511), Rasakadali (0486), Elakkibale (0113), Ney poovan (0623), Njali poovan (0188), Putta Bale (0439), Poomkannan Kadali (0382), Rasakelli (0274), Karim Kadali (0313), Vadakkan Kadali (0237), Adukka Kunnan (0147), Nadan (0440), Gragric Sarpara (0361), Rasakeli (0717), Safed Velchi (0458) and Kalyan Bale (0438)
Cluster 2	Adukkan (0114), Kodappanila Kunnan (0558), Kundu (0423), Adukkan (0709), Agniswar (0153), Valia Kunnan (0388), Agniswar (0550), Kunnan (0178), Kijnan (0272), Adukkan (0389), Nendra Kunnan (0107), Nendra Kunnan (0140), Kodappanila Kunnan (0738), Poomkalli (0373), Kunnan (0531), Valia Kunnan (0234), Poomkalli (0539), Kodappanila Kunnan (0174), KNR Mutant (0737), Padali Moongil (0482), Poovilla Chundan (0699) and *M. acuminate* ssp. *burmannica* (1118)
Cluster 3	Bhimkol (0007) and *M. balbisiana* (0508)
Cluster 4	Adukkan (0285), Adukka Kunnan (0392), Nattu Poovan (0232), Aktoman (0053) and Nattu Poovan (0535)

Evaluation

FHIA-23, an introduction from FHIA, Honduras through ITC, Belgium was evaluated in six locations under two different agro-climatic conditions. 3 sites were in Tiruchirapalli district and another three sites viz., Agali, Pattiveeranpatti and Yercaud, are situated at higher altitudes. Performance of FHIA-23 was poor in Tiruchirapalli district while its performance was good at higher altitudes of Pattiveeranpatti with yield ranging from 23-27 kg with good quality fruits. But this hybrid was found highly susceptible to pseudostem weevil at all locations tested.

Utilisation

'Udhayam' (NRCB Selection-1), a single plant selection belongs to Pisang Awak group was released for commercial cultivation.

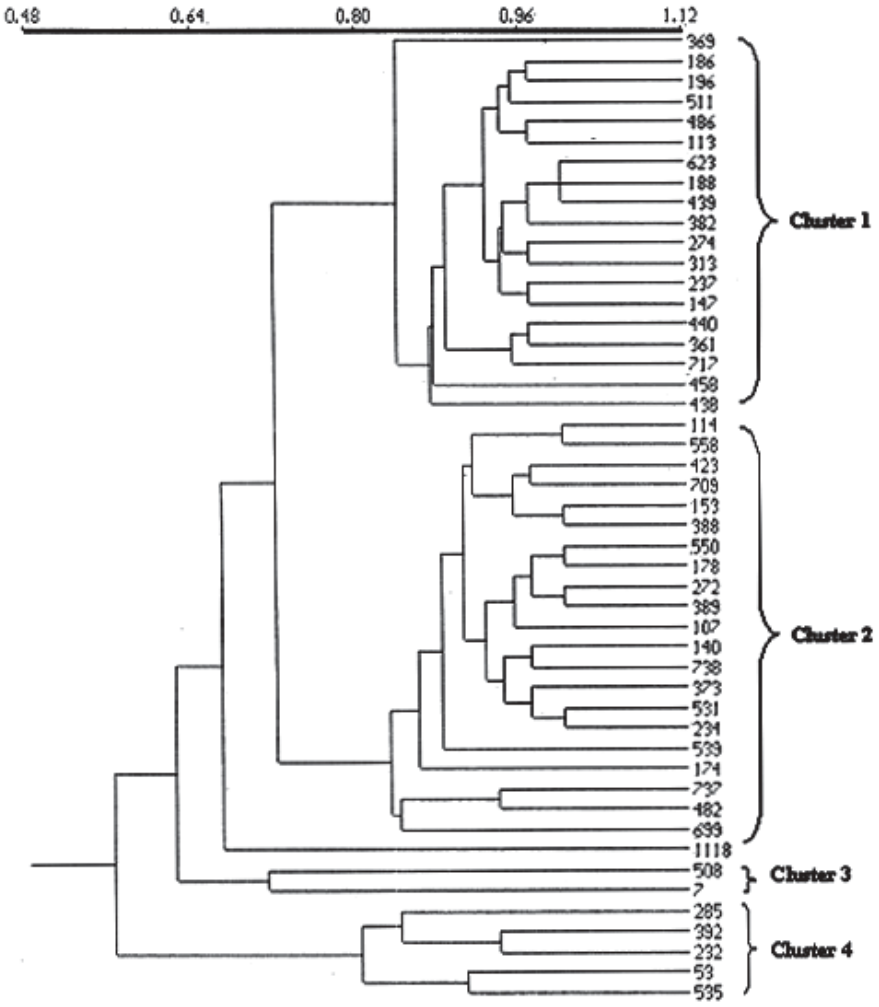


Fig.1. Dendrogram indicating the genetic relationships among 45 test clones (AB) along with a AA and 2 BB as controls based on SSR markers, generated by unweighted pair group method (UPGMA), NTSYS statistical package (Rohlf, 1990)

Documentation and Registration

589 accessions have been documented and published as "Banana- Indian Genetic Resources and Catalogue". 50 unique and elite accessions along with salient features and pictures have been registered at NBPGR, New Delhi to facilitate any IPR issues.

Crop Improvement

Gene pyramiding programme for improvement of male parents

30,044 pollinations were made during this period. Twelve diploids are being evaluated under field condition against biotic and abiotic stresses. Cultivated diploids viz., Anai Komban, Sanna Chenkadali, (Fig. 2) Matti and wild diploids viz., Pisang Jajee and Lairawk as female parents were found compatible with more number of male parents. Anai Komban, Matti, Sanna Chenkadali, Kanai Bansi, and Pisang Mas were used as female parents while Lairawk, Chengdawt, Pisang Jajee, Kanai Bansi, Tongat , Sanna Chenkadali, Pisang Lilin, and *Musa laterita* were used as male parents.

Fig. 2. Seed set in diploid Sanna Chenkadali

Evaluation of diploids for commercial cultivation

Four promising AA diploids viz., Sanna Chenkadali, Matti, Anai Komban and Kanai Bansi, and two AB diploids viz., Poovila Chundan and Ney Poovan were evaluated for commercial cultivation. Kanai Bansi (18.3 kg) and Ney Poovan (21.8 kg) were better in terms of yield in main and ratoon crops. A TSS of 29.5 ^{0}B, 30.1^0 B and 32^0 B were recorded in Matti, Ney Poovan and Poovila Chundan respectively. Anai Komban recorded the shortest duration (12 months).

Evaluation of promising culinary accessions (ABB) for commercial production

13 promising clones viz., Nutepong, Ash Monthan, Kachkel, Monthan, Bluggoe, Bangrier, Saba, Burro Cemsa, Chakkia, Ashy Chakia, Ashy Batheesa, Pacha Bontha Batheesa and Bainsa were evaluated for culinary purpose. Maximum yield (40.8 kg) was recorded with Pacha Bontha Batheesa and Ashy Batheesa (38.9 kg). Most of them recorded an average crop duration of 12 months and Pacha Bontha Batheesa, Chakia, Ash Monthan recorded 13 months period.

Screening of *Musa* germplasms for nematodes

Sixty *Musa* genotypes collected from North Eastern and Western parts of India were screened against root-knot and root-lesion nematodes. Among the accesions screened, Kechulepa, Bhimkol, Athiakol, Kanai Bansi, Ankur-II, *Musa balbisiana* and Karthobiumtham were resistant to *P.coffeae*. None of the accessions were resistant to *M.incognita* whereas, the varieties like Vannan, Venneetu Mannan, Garomoina, Wild Hill, Honda, Bhimkol, Athiakol and Nendrapadathi were moderately resistant to *M.incognita.*

Evaluation of *Musa* germplasm against stem weevil

Imbogo, Pisang balbisiana, FHIA –3, Ankur-2, Dudh Sagar, Thiruvanathapuram, *Musa accuminata*, Pisang Ceylon, Pisang Jahaji, Pisang Raja and Manoranjitham were free from stem weevil infestation and FHIA-23 was highly susceptible. Rasthali and Safed velchi were found free from grub damage.

Development of superior triploids

Under this programme, triploids viz., Karpuravalli, Monthan, Chinia, Chakia, Manoranjitham and Burro Cemsa were used as female parents. Sigatoka and wilt resistance and wild and semi wild as male parents. Three promising progenies which are in vegetative phase are evaluated in the field.

Supply of "Udhayam" Clones

To popularize the "Udhayam" variety among farmers, more than 500 suckers and 100 tissue culture plants have been supplied to the interested growers and tissue culture companies.

Bio-technological approaches

Development of Embryogenic Cell Suspensions (ECS)

Ten commercial cultivars have been tried to develop ECS from immature flower buds and 13 cultivars through scalps (table.6). Youngest 3-15th flower rachis from the male bud were initiated on MS medium with 4mg of 2,4-D, 1mg NAA and IAA each with 30g sucrose. Cultures were kept in total darkness under high humidity condition (>70% RH) at 27°C. The process of embryogenesis induction depended on the cultivar and method used but in general, callogenesis occurred in 3-10 months.

Table 6. Varieties used for development of ECS

Varieties used for Embryogenic Cell Suspension through flower buds	Nendran (AAB), Rasthali (AAB), Ney Poovan (AB), Robusta (AAA), Karpuravalli(ABB), Monthan (ABB), Bluggoe (ABB), Grand Naine (AAA), Chakkia (ABB)
Varieties used for ECS through scalp	Sannachenkadali (AA), Matti (AA), Calcutta- 4 (AA), Rasthali (AAB), Williams (AAA), Robusta (AAA), Pachanadan (AAB), Nendran (AAB), Valiyakunnan (AB), Udhayam (ABB) Manoranjitham (AAA) and Saba (ABB) and *Musa laterita*

Phenolic exudation is a major bottleneck in developing ECS from scalps and flower buds. Initiated floral hands turned black within 1-3 months except for putative embryogenic callus forming floral hands (Fig.3). Similarly browning was also noticed when

Fig. 3. Friable embryogenic callus from floral explant

embryogenic callus was shifted to liquid medium with 2,4-D and sucrose. Ascorbic acid (2mg / l) was effective in controlling phenolic exudation.

ECS has been developed for cultivars Nendran (AAB) (Fig. 4 & 5) and Ney Poovan (AB) using immature flower buds. Embryogenic friable calli was noticed after seven months in Ney Poovan and after five months in Nendran from initiation of flower buds on solid medium. Friable calli of these two cultivars transferred to liquid medium in 25ml Erlenmeyer flask and maintained under continuous darkness at 26°C and 70 rpm in a shaker. Multiplication and proliferation rate was high in Nendran as compared to Ney Poovan.

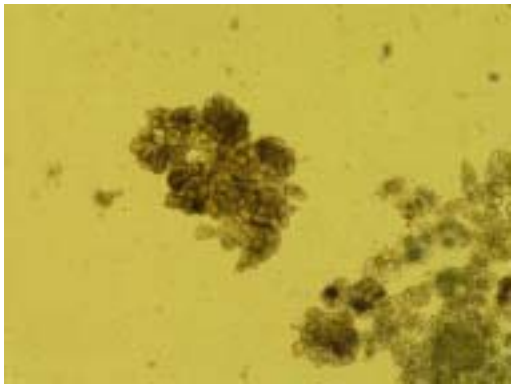


Fig.4. Embryogenic cells of cv. Nendran (AAB)

Fig.5. Embryogenic cell suspension of Nendran

Development of ECS through scalp

Scalp was initiated from the rooted *in-vitro* plants cultured on P4 medium under darkness as per the protocol (KUL, Leuven). Repeated culturing was carried out until the proliferating buds increased in number but reduced size with compact cauliflower like structures (Fig.6). Such scalp was transferred to ZZ medium for the development of friable callus (Fig.7). Compact cauliflower like structures formed in P4 medium were then shifted to ZZ medium (½ MS salts with 1 mg 2,4-D and 0.219 mg / l zeatin). Around 140 cultures of Williams from P4 were transferred to ZZ medium for the production of somatic embryos (Fig.8).

Fig.6. Scalp induction in AAA cultivar

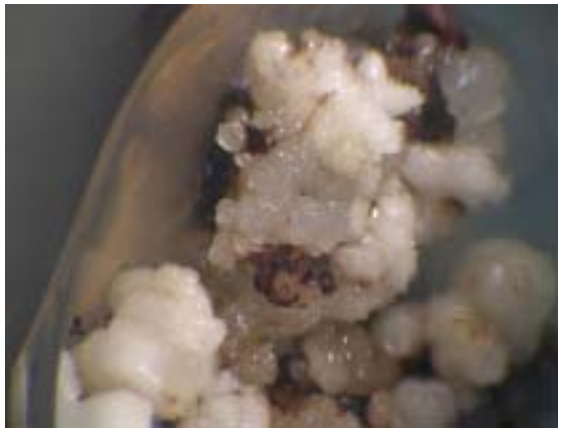


Fig.7. Putative embryogenic calli from scalp explant

Phenolic exudation was also a major problem in culturing of scalps on ZZ medium, which turned brown within 15-30 days. Pre-treatment i.e adding antioxidants in liquid medium overnight were tried on scalps before transferring to ZZ medium. But none of the treatments were 100 per cent effective. Scalps of cultivars Rasthali (AAB), Sannachenkadali (AA), Williams (AAA) and Sommarani Monthan (ABB)

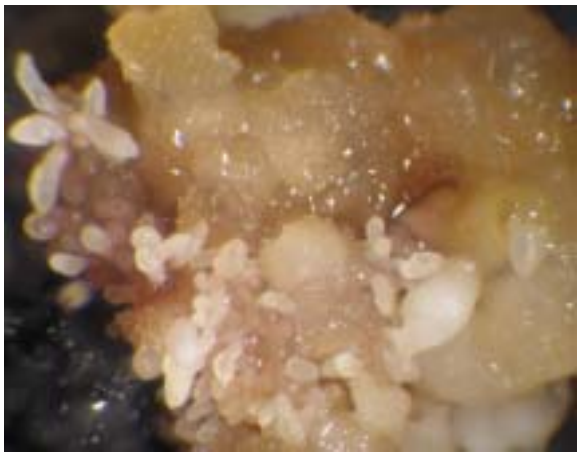


Fig.8. Meristematic globules with distinct embryos and proembryos

responded and developed into friable callus. Out of 140 cultures, 25 developed into cauliflower like structure, an indication of good scalp, with numerous compact flower buds. The responses of varieties for scalp production suggested that it is variety, ploidy and genome dependent (table.7). The time taken for scalp development also varied from 6 months to 14 months.

Embryo rescue / Indirect somatic embryogenesis

Zygotic embryos of the cross *M.laterita* x Pisang Jajee when cultured on MS medium with 4.0 mg/l BAP, a part of the cultures produced plantlets following the direct organogeneitc pathway (Fig.9) while the rest formed embryogenic calli. This calli was sub cultured in the same medium at 4 weeks intervals. To hasten the quality callus formation, it was transferred to two different media with various NAA and IBA concentrations. Good quality callus produced with BAP has been transferred to the liquid medium (MA-2). Attempts were made to regenerate plantlets through indirect embryo genetic pathway using the embryogenic calli as explants and the same calli used for the development of embryogenic cell suspension.

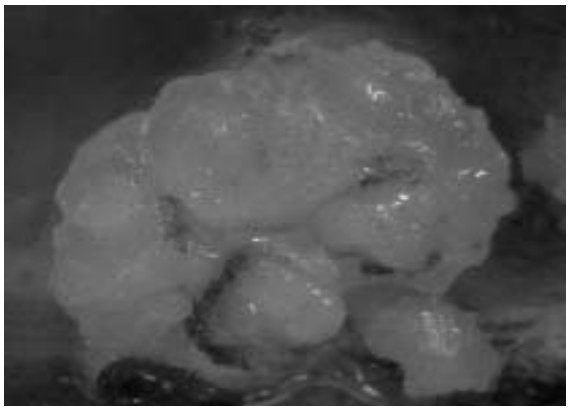


Fig.9. Direct embryogenesis in complex hybrids

Standardization of TC multiplication technique for Rhodochlamys

M. aurantiaca, a member of Rhodochlamys section is difficult to establish away from its natural habitat. *In vitro* multiplication has been standardized with modified BAP and antioxidants. The *in vitro* plants have been successfully established in NRCB field gene bank.

Table 7. List of wild accessions and cultivated varieties and their response for ECS development through scalp

Cultivar	No. of explants initiated	No. of cultures developed till date	Duration for response (in months)
M.ac. ssp. *burmannicoides* (AA wild)	2	*	*
M.ac. ssp. burmannica (AA wild)	616	*	*
Sannachenkadali (AA)	37	100	8
Robusta (AAA)	54	20	*
Williams (AAA)	13	40	10
Manoranjitham (AAA)	20	15	*
Valiya Kunnan (AB)	10		*
Rasthali (AAB)	71	160	6
Pachanadan (AAB)	16	12	*
Udhayam (ABB)	30	49	*
Bangrier (ABB)	10	*	*
Sommarani Monthan (ABB)	12	50	*

* failed to develop

CROP PRODUCTION

High Density Planting and Fertigation

Robusta (AAA)

The plants grown under conventional planting (2.0 x 2.0m) retained more number of healthy leaves at flowering (17.2), lower phyllochran (7.63 days), early bunch emergence (239.5 days) and fruit maturity (99.7 days) as compared to paired row planting. Though the individual bunch weight, number of hands and fingers were more under conventional planting, the estimated total yield was 39.5% more in paired row planting (65.91 tonnes / ha) than the conventional planting (47.24 tonnes / ha) (Table 8). The fruit quality revealed that total sugars (23.29%) and ascorbic acid (10.39%) were significantly different in paired row planting.

Weekly fertigation with 75% of recommended dose of fertilizers recorded the maximum number of hands (8.35), fingers (145.0) per bunch, bunch weight (18.49 kg) and estimated yield (57.68t / ha) indicating 25% economy in fertilizer use. This was on par with 100% recommended dose of 200g N and 300g K_2O / plant.

Grand Naine (AAA)

Under paired row planting, cultivar Grand Naine has recorded the tallest plants (210.0cm) with more number of healthy leaves (16.5), larger mean leaf area (0.93 m^2), total leaf area with more LAI (5.83) than the conventional planting. The plants grown under conventional spacing exhibited early flowering and maturity with maximum bunch weight (14.83 kg) (Table 8), number of hands (8.4) and fingers (134.3) per bunch. The paired row planting recorded an estimated yield of 52.68 t / ha, which was 38.3% higher than conventional planting. Application of 75% of recommended dose of fertilizers was on par with 100% of recommended fertilizers in respect of estimated yield.

Red Banana (AAA)

Conventional planting recorded significantly taller plants (215.9 cm), faster leaf emergence rate (7.63 days), reduced flowering by 15.9 days and the total crop duration by 24.9 days as compared to paired row planting. Conventional planting recorded significantly maximum bunch weight (8.30 kg)(Table 8). Higher total estimated yield (28.45 t / ha) was recorded in paired row planting system as against 20.76 t / ha under conventional planting. The fruits quality revealed that paired row planting recorded more TSS (23.5°Brix), total sugars (20.96%), reducing sugars (3.09%) and ascorbic acid (12.53mg / 100g) but less pulp: peel ratio and acidity as compared to conventional planting.

Application of 100% recommended dose recorded the highest bunch weight (8.25kg) and total estimated yield (25.80t / ha) while the lowest bunch weight (7.45 kg) and yield (23.28t / ha) were recorded in 50% recommended dose of fertilizers. Similarly 100% fertigation also recorded better fruit quality with more TSS (23.0°B), total sugars (20.56%), reducing sugars (3.05%), ascorbic acid (12.01mg / 100g) and low acidity than other fertigation treatments.

Table 8. Effect of high density planting and fertigation on bunch weight (kg) in banana cultivars

	Robusta				Grand Naine				Red Banana			
Treatments	**F1**	**F2**	**F3**	**Mean**	**F1**	**F2**	**F3**	**Mean**	**F1**	**F2**	**F3**	**Mean**
P1 (2500 pl / ha)	18.30	19.77	18.42	18.83	14.82	16.12	13.57	14.83	8.6	8.5	7.8	8.30
P2 (3850 pl / ha)	18.32	17.22	16.50	17.34	14.52	13.40	13.67	13.86	7.4	7.9	7.5	7.60
Mean	18.31	18.49	17.46		14.67	14.76	13.62		8.00	8.21	7.65	
	SEd		CD (p=0.05)		SEd		CD (p=0.05)		SEd		CD (p=0.05)	
Planting(P)	0.278		0.593**		0.271		0.578**		0.170		0.364**	
Fertigation(F)	0.341		0.727**		0.332		0.708**		0.209		NS	
PxF	0.482		1.028**		0.470		1.002**		0.296		NS	

Microbial Activity

In general, the bacterial and actinomycetes population (Fig. 10) and also the peroxidase and polyphenol oxidase (PPO) activity were higher in plants grown under conventional planting system in all the cultivars. Fungi population was the highest under paired row planting in cultivars Robusta and Grand Naine. The highest microbial population were recorded in plants supplied with 50% recommended dose of fertilizers and there was a gradual fall in the

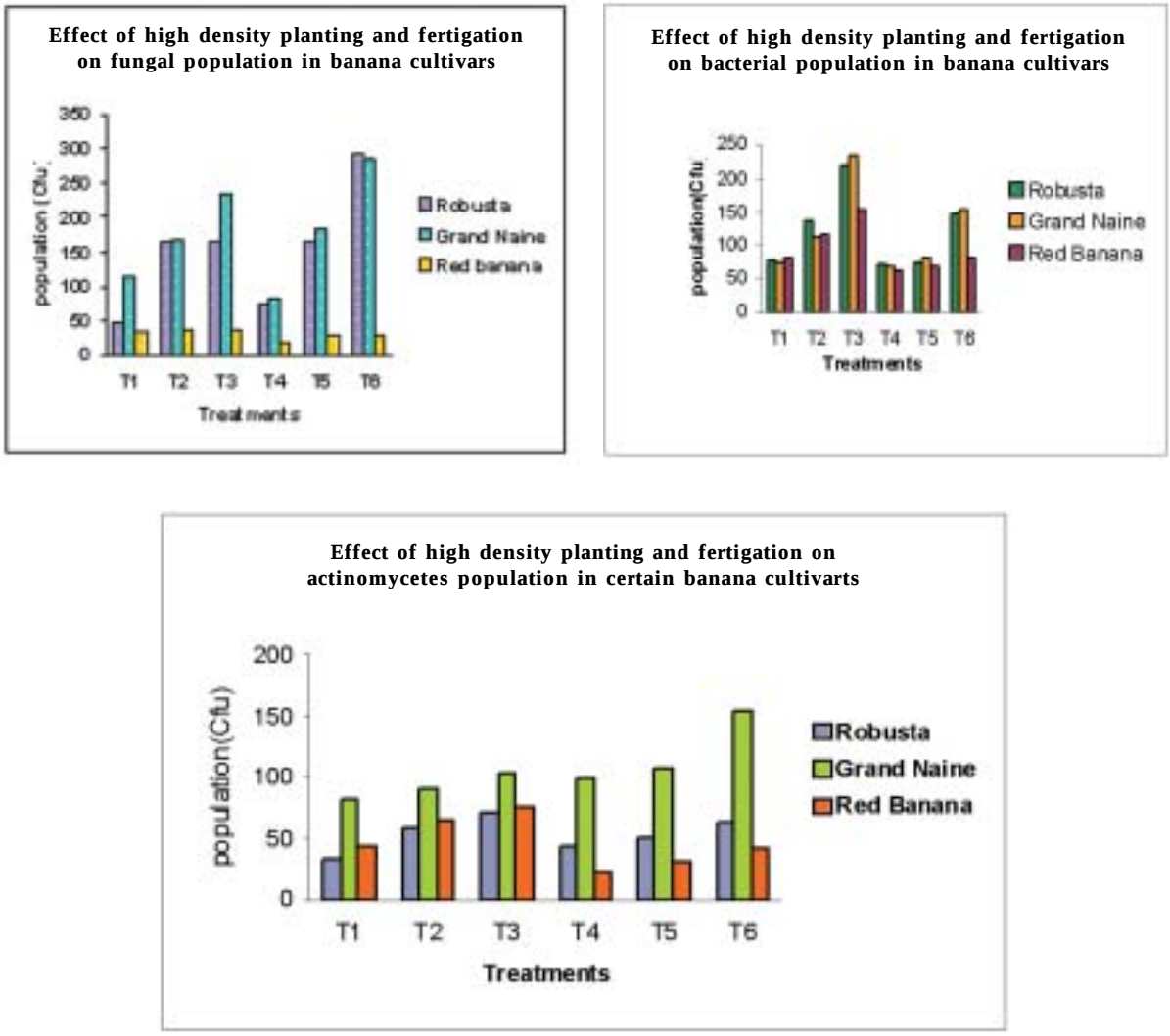


Fig.10. Effect of high density planting and fertigation on Fungal (a), Bacterial (b) and Actinomycetes (c) population in banana cultivars

microbial population with the increased doses of fertigation in all the three varieties studied (Fig. 10).

Studies on Soluble Fertilizers

Ratoon crop

The observations at the flowering stage in the ratoon crop of Robusta and Ney Poovan banana varieties revealed that soil application of 50 % recommended NPK at 3,5 and 7 months after planting (MAP) along with 5 sprays of 3% Polyfeed (19: 19:19) followed by 5 sprays of 3% Multi K (13: 0: 45) at 15 days interval (T3) recorded the maximum plant height (246.9 and 265.4cm), pseudostem girth (63.3 and 62.5cm) and number of healthy leaves (12.7 and 13.08) as well as leaf area (13.97 and 13.49m^2) in Robusta and Ney Poovan respectively . The plants under these treatments also recorded early flowering (204.5 and 221.3 days) and early maturity of bunches (110.3 and 115.8 days) in Robusta and Ney Poovan bananas respectively.

The highest bunch weight (18.10 and 10.52kg), number of hands (8.95 and 9.78), fingers (155.7 and 149.4) per bunch and total dry matter production of 2967 g and 2766 g $plant^{-1}$ in Robusta and Ney Poovan bananas respectively were recorded in T3. The plants treated with 10 sprays of 3% Polyfeed (19: 19:19) at vegetative stage followed by 9 sprays of 3% Multi K (13: 0: 45) at reproductive stage at 15 days interval (T9) produced better fruit quality with the maximum

TSS (25.8 and 32.3°Brix), total sugars (19.92 and 22.30 %) and less acidity (0.54 and 0.51%) in Robusta and Ney Poovan bananas respectively. In Robusta, soil application of recommended inorganic fertilizers at 3,5 and 7 MAP (T1-control) recorded the highest BC ratio of 1.91 followed by T3 (1.80) where as, in Ney Poovan the highest ratio of 1.62 was recorded in T3 closely followed by T1with a BC ratio of 1.61.

The population of nematodes were below the economic threshold level in all the treatments in both the cultivars. The incidence of leaf spot diseases was non significant in both the cultivars.

Integrated Nutrient Management

In the Ist ratoon (Rasthali), the leaf nutrient concentration ranges were : N:2.0-2.9%, P:0.20-0.41%, K:2.7-3.9% (tables 9, 10 and 11) Ca:0.27-0.67%, Mg:0.19-0.38%, Fe:208-312ppm, Cu:2-10ppm, Mn:140-234ppm and Zn:13-29ppm. The post harvest soil nutrient concentration ranges were : N:200-290,

Table 9. Effect of different organic manures and bio-fertilizers with graded levels of NPK on leaf N concentration (%) of Rasthali (Ratoon I)

Treatments	Azospirillum			VAM			Phosphobacteria			Mean
	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	
Control	2.1	2.0	2.1	2.0	2.0	2.1	2.1	2.0	2.1	**2.1^{a}**
Poultry manure	2.3	2.0	2.3	2.3	2.4	2.2	2.0	2.5	2.6	**2.3^{ab}**
Vermicompost	2.4	2.3	2.3	2.4	2.4	2.8	2.1	2.6	2.9	**2.5^{b}**
Rice husk ash	2.0	2.0	2.4	2.1	2.3	2.9	2.4	2.8	2.6	**2.4^{ab}**
Mean	**2.2**	**2.1**	**2.3**	**2.2**	**2.3**	**2.5**	**2.2**	**2.5**	**2.6**	
Mean of BF	**2.2^{a}**			**2.3^{a}**			**2.4^{a}**			

Table 10. Effect of different organic manures and bio-fertilizers with graded levels of NPK on leaf P concentration (%) of Rasthali (Ratoon I)

Treatments	Azospirillum			VAM			Phosphobacteria			Mean
	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	
Control	0.23	0.25	0.31	0.20	0.24	0.28	0.23	0.29	0.39	**0.27^{a}**
Poultry manure	0.26	0.24	0.30	0.28	0.27	0.39	0.27	0.32	0.30	**0.29^{ab}**
Vermicompost	0.32	0.29	0.34	0.22	0.29	0.31	0.23	0.30	0.38	**0.30^{ab}**
Rice husk ash	0.38	0.40	0.40	0.29	0.32	0.40	0.34	0.41	0.40	**0.37^{b}**
Mean	**0.30**	**0.30**	**0.34**	**0.25**	**0.28**	**0.35**	**0.27**	**0.33**	**0.37**	
Mean of BF	**0.31^{ab}**			**0.29^{a}**			**0.32^{b}**			

Table. 11. Effect of different organic manures and bio-fertilisers with graded levels of NPK on leaf K concentration (%) of Rasthali (Ratoon I)

Treatments	Azospirillum			VAM			Phosphobacteria			Mean
	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	
Control	2.7	2.9	3.0	2.7	2.7	2.9	2.7	2.9	2.8	**2.8^{a}**
Poultry manure	2.8	2.7	2.9	2.8	2.8	3.0	2.9	2.8	3.4	**2.9^{ab}**
Vermicompost	2.9	2.8	2.9	3.0	3.8	3.3	2.9	3.2	3.4	**3.1^{bc}**
Rice husk ash	2.8	3.0	3.2	3.0	3.8	3.7	3.1	3.9	3.6	**3.3^{c}**
Mean	**2.8**	**2.9**	**3.0**	**2.9**	**3.3**	**3.2**	**2.9**	**3.2**	**3.3**	
Mean of BF	**2.9^{a}**			**3.1^{a}**			**3.1^{a}**			

Table 12. Effect of different organic manures and bio-fertilizers with graded levels of NPK on bunch weight of Rasthali (Ratoon I)

Treatments	Azospirillum			VAM			Phosphobacteria			Mean
	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	
Control	7.2	7.5	8.3	7.0	7.2	7.6	8.5	11.2	11.0	**8.4** [a]
Poultry manure	8.3	9.5	9.0	6.9	8.2	8.0	10.3	15.4	13.3	**9.9** [ab]
Vermicompost	8.3	8.8	9.0	10.1	9.8	10.5	13.2	15.6	15.8	**11.2** [b]
Rice husk ash	8.3	8.5	9.2	9.6	11.2	10.9	14.0	18.2	16.3	11.8 [b]
Mean	**8.0**	**8.6**	**8.9**	**8.4**	**9.1**	**9.3**	**11.5**	**15.1**	**14.1**	
Mean of BF	**8.5** [a]			**8.9** [ab]			**13.6** [b]			

P:7-10, K:270-320, Ca:1100-2115, Mg:697-952 kg / ha. The highest and optimum leaf nutrient concentrations were observed in 80% rec.NPK + phosphobacteria + rice husk ash which recorded the highest bunch weight, (18.2 kg) (table 12), and was 30 per cent more than 100 % inorganic-NPK fertilizers only.

The performance of phosphobacteria was superior to Azospirillum and VAM, while rice husk ash was superior to vermicompost and poultry manure in increasing the bunch weight. Application of 15 kg rice husk ash + 25 g phosphobacteria + 80% rec. NPK / plant generated an additional profit of Rs. 40,000 / - per hectare and also reduced the input cost of fertilizers by Rs. 10,000 / - per hectare in Rasthali banana. Thus, integration of rice husk ash and phosphobacteria in the NPK fertilization in Rasthali a net additional profit of Rs. 50,000 / - was obtained per hectare.

Micronutrients studies

Uniform Ney Poovan suckers were planted under high soil pH. Foliar application of Fe performed better than soil application and increased the plant growth parameters in cultivar Ney Poovan.

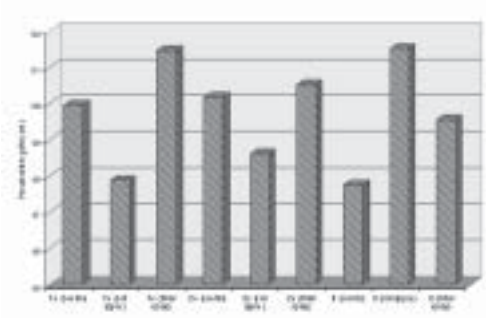


Fig.11. Effect of soil and foliar application of micronutrient on pseudostem girth (cm) in Ney Poovan

The plant height, pseudostem girth, number of leaves, leaf area and phyllochron were recorded. Soil application of boron recorded the highest average girth (51.5cm) (Fig.11) and foliar application of zinc recorded the lowest average phyllochron (6.69 days / leaf) (Fig.12).

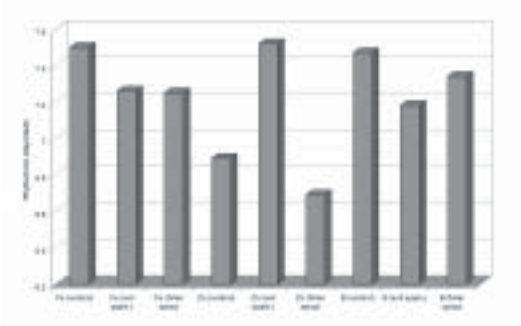


Fig.12. Effect of soil and foliar application of micronutrient on phyllochron (days/leaf) in Ney Poovan

Plant Physiology and Biochemistry

Photosynthesis studies

During flowering of 1st ratoon of Ney Poovan (AB), photosynthesis (Pn) was 23.69 µmol $CO_2 m^{-2} s^{-1}$. One month after leaf clipping, the Pn was significantly higher (11.6µmol $CO_2 m^{-2} s^{-1}$) in T1 (maintained at 6 leaves) than control i.e., no leaf clipping (4.6µmol $CO_2 m^{-2} s^{-1}$). In Karpuravalli (ABB), the Pn was 12.67 µmol $CO_2 m^{-2} s^{-1}$ during flowering and after a month (7.42 µmol $CO_2 m^{-2} s^{-1}$) in control plants, indicating higher Pn in leaf clipped plants. The starch content of harvested fruit ranged from 30-33% and sugars 0.8-0.9% in Ney Poovan and Karpuravalli respectively while leaf clipping has no effect on the carbohydrate content. The tannin and phenol contents of fruits were also not affected by leaf clipping in both the varieties. The post harvest quality characters of Karpuravalli were not affected by leaf clipping treatments. The shelf life of fruits was 120 days in leaf clipped plants as compared to control plants (65 days) under cold storage conditions.

In control plants, during vegetative stage, i.e. after six months of planting, higher photosynthesis (14.62 µmoles $CO_2m^{-2}s^{-1}$) was recorded in Rasthali (AAB), Nendran (5.12 µmoles $CO_2m^{-2}s^{-1}$) and Robusta (5.57µmoles Co_2 m^{-2} s^{-1}). In leaf clipped plants, Pn has increased in Nendran (93%), Robusta (55%), Karpuravalli(15%) and Ney Poovan, (11.02%), but not in Rasthali. Rasthali did not respond to leaf clipping in terms of Pn as compared to other varieties.

Root studies

The number of roots per plant was more in diploid genotype (190.5) than triploid Robusta (165.50) and tetraploid FHIA-23 (104.50) in four months old plants. Similar trend was observed in plant height, where the diploid recorded more height (186.3cm) than triploid (167.75 cm) and tetraploid (178.85 cm). However, the circumference of pseudostem and root thickness were the maximum in tetraploid followed by triploid than diploid varieties. In the three month old plant, highest root number was recorded in Rasthali (120.5) followed by Robusta (106) and Karpuravalli (27.50). The thickness of root was highest in Karpuravalli (7.46) followed by Robusta (5.96) and Rasthali (5.12).

Studies on drought tolerance

The photoysnthesis (Pn) and stomatal conductance (gs) in cultivars Nendran and Robusta under irrigated and water stressed plants were 3.917 & 5.53 µmol $CO_2m^{-2}s^{-1}$ and 0.127 & 0. 09 respectively. In the remaining varieties, no Pn was observed under water stressed condition. The relative water content in Poovan variety was the highest (78.45%) than rest of the varieties and it ranged from 67.13-75.12%. The free amino acids and proline contents increased by 8.12-11.01% and 10.65 -15.13% respectively in water stressed plants as compared to irrigated plants.

After imposing soil moisture stress for three weeks in four month old Robusta plants, the leaf senescence was faster as compared to irrigated plants. The irrigated plant produced 1.5 leaves / plant, while the stressed plants did not produce any new leaf rather three older leaves / plant got senesced within three weeks. The Superoxide Dismutase and Ascorbate Peroxidase activity of water stressed plants have increased threefold and five fold respectively as compared to irrigated plants. The foliar spray of 50mM ABA on water stressed plants increased the antioxidant enzyme activity and reduced the oxidative damage.

One hundred and twelve banana germplasm was screened in field (at four months after planting stage) for drought tolerance based on Leaf Water Retention Capacity of plants. Accessions Nattu Poovan (AB), Thella Chakarakeli (AAA), Teraban (Mysore AAB), Mannan (AAB), *Musa balbisiana* (BB), Ladan (AAB), Erode Kai (ABB) and Pisang Berlin (AA) were tolerant while, Pisang Seribu (AAB), False Horn Plantain (AAB) and Nendran (AAB) were highly susceptible to water stress.

POST HARVEST TECHNOLOGY

Studies on handling, storage and processing

Extension of storage life

Hot water treatment with 500 ppm Carbendazim coupled with modified atmosphere storage at low temperature extended the green life of Grand Naine by 90 days at 13.5°C and 5 days of yellow life at ambient condition. Similar treatment extended the green life up to 110 and 120 days at 13.5°C and yellow life up to 5 and 5 days at ambient condition in Robusta and Rasthali respectively.

Studies on fruit and developmental changes in Grand Naine

Fruit growth parameters were recorded at 15 days interval after completion of fruit set. The results showed that finger length increased from 8.33 cm to 12.67 cm, girth from 5.17 to 11.67 cm, fruit weight from 16.67 to 128.63 and specific gravity from 0.789 to 0.928 during development from fruit set to full maturity.

During 100 days of growth, the moisture decreased from 87.85 to 83.44%, TSS from 5.87° Brix to 4.53°Brix, while the acids increased from 0.131 to 0.279% and total sugars increased from 0.560 to 0.630%. The starch content increased from 4.24 to 20.87% and peel phenols decreased from 0.220 to 0.176%.

Studies on fruit maturity in Grand Naine

The Grand Naine variety took 100 days from shooting to attain harvest maturity. At full maturity, it accumulated 1834 degree days of heat units and had a finger length of 12-13 cm, girth of 11-12 cm, length to girth ratio of 1.09, average fruit weight of 128 g and average volume of 138 cc.

Development of new banana flour based products

Three types of functional diabetic foods viz., chapaties, bread and health drink mix were developed using Robusta banana flour. These products were found to be acceptable when given to diabetic patients. It had an equal effect in controlling the blood sugar levels as compared to other diabetic diets.

Development of new banana peel based products

A study on suitability of peel for producing banana peel thokku was studied using the same recipe of banana flower thokku with slight modification. The product was found acceptable and remained without spoilage or deterioration of edible quality even after 8 months.

CROP PROTECTION

Studies on banana nematodes and their management

Survey

The soil and root samples collected during the survey were analyzed for the nematodes and the results indicated that root lesion (*Pratylenchus coffeae*), root knot (*Meloidogyne incognita*), spiral nematode (*Helicotylenchus multicinctus*) and reniform nematode (*Rotylenchus reniformis*) were the most common nematodes. Among these, root lesion nematode was present in almost all the samples of both root and soil while the burrowing nematode *Radopholus similis* was completely absent in all the samples analyzed.

Evaluation of plant extracts against root knot and root lesions nematodes

Nematode mortality was studied using flower and leaf extracts of *Tagetus erecta* at different concentrations. 100% mortality of root –knot and root-lesion nematodes was observed in flower extract at 72 hours, whereas leaf extract prolonged the mortality period.

Effect of bio-control agents against root lesion and root knot nematodes

Bio-control agents viz ., *T.viride* , *P. lilacinus, P. fluorescens* and *B. subtilis* alone and in different combination along with a nematicide Rugby (Cadusafos) as a check recorded significant increase in plant growth, girth and number of leaves as compared to nematode infested plants. Maximum plant growth and minimum nematode populations of *P.coffeae* and *M.incognita* were recorded in chemical (Rugby) treatment @ 10g / plant followed by *T.viride* alone @ 20g / plant or in combination of *T.viride* + *P. lilacinus* @10g each / plant in all the cultivars tested. Similar results were obtained under field conditions. However in Nendran and Rasthali, *P.coffeae* population was maximum in conventional suckers than TC plants, whereas *M.incognita* population was maximum in TC plants.

Distribution of parasitic nematodes

Vertical and horizontal distribution of plant parasitic nematodes in Nendran was studied in the farmers field. Maximum nematode population was recorded at a distance of 50 cm away from the base of the plant at a depth of 26-50 cm. Negligible or nil population was noticed at a distance 75cm from the base of the plant at a depth of 51-75 cm.

Efficacy of neem based formulations

Sucker dip treatment in Nimbecidine or Juerken @ 15% for 30 minutes or hot water treatment @ 50°C for 20 minutes were most effective treatments resulting in enhanced plant growth with significant reduction in nematode populations or absolute control of nematodes over untreated control.

Application of organic amendments like neem cake @ 200g / plant at the time of planting followed by Rugby 10G (Cadusafos) @ 10g / plant or Carbofuran @ 30g / plant at third and six months after planting recorded the maximum plant growth parameters with significant reduction in nematode populations.

Insect Pest Management

Survey

Survey conducted in different banana growing areas recorded the following new pests in banana and plantains.

Banana fruit fly, *Bactocera* sp (Tephritidae: Diptera) was infested on fruits of cv. Virupakshi at Pantrimalai, the upper Pulney hills. Keeping bait trap containing dry fish and insecticide controlled the fly. Since, the bait also attracted the non-target insects in large quantities, the bait trap should not be used.

Fig 13 Mite infestation on Cultivar Rose

Mite infestation on the fingers of Cultivar Rose was recorded (Fig 13). The infestation reduced the cosmetic value of the fruit. The pest incidences were recorded from Kerala and Tamil Nadu.

Banana fruit scarring moth, *Adoxyphyes privatana* infestation was recorded on the fingers of cv. Matti and cv. Kanai Bansi at Agali Farm, Kerala.

Transparent scale, *Aspidiotus destrctor* (Sign.) (Homoptera: Diaspidae) infestation was noticed on banana bunches of cv. Karpuravalli from Theni district. Due to scale infestation, premature ripening was noticed.

Identification of volatiles

Leaf sheath volatile was collected from 13 cultivars viz., Karpuravalli, Nendran, Red banana, Monthan, Poovan, Ney Poovan, Rasthali, Bhimkol, Athiakol, *Musa accuminata* sub sp. *burmanicoides*, Borkal Baista and Robusta. Corm released volatiles was collected from 3 cultivars viz., Karpuravalli , Robusta and Rasthali. The collected volatile was eluted with organic solvents for polar and non-polar nature for further studies.

GC-MS studies of the leaf sheath volatiles of the cultivar Pisang Awak indicated 8 volatile components. Volatile composition was the same when it was collected either by steam distillation or volatile collection. The collected volatiles were terpenoids and the molecular weight ranged from 120 to 280.

Electroantennogram (EAG) studies

EAG activity of banana stem weevil, *Odoiporus longicollis* indicated variations among the cultivars and between the sexes of weevil. The female weevil response to the ethyl acetate fraction of cv Karpuravalli was higher (0.835 eV) while the male response to ethyl acetate fraction was higher in cv FHIA-23 (0.539 eV).

Mass production of entomopathogenic nematode (EPN) and entomopathogenic fungus (EPF)

Heterorhabditis indica, an EPN was mass produced using Wout's medium and liquid medium. In Wout's medium the nematode production was $1X10^5$ IJ's / flask on 15th day of harvest. EPF (*Beauveria bassiana*) was mass multiplied and the maximum conidial production was recorded in maize flour ($2.5X10^7$ cfu / g). Maximum spore production *B.bassiana* was recorded at 25°C.

Field evaluation of EPN and EPF

White muscardine fungus, *B. bassiana* at $7.5X10^5$, $1.5X10^6$ and 2.2^5X10^6, and an entomopathogenic nematode, *H. indica* at $1X10^5$, $20X10^5$ and $25X10^5$ was evaluated under field conditions. The trapped weevils from treated traps got infection with fungus and nematodes whereas the weevils collected from the

Fig.14. Banana Stem trap as a delivery system for bio control agent (*B.bassiana*) to trap and kill the weevils

control traps did not show mortality. Infected weevils were also collected from the soil and on the bunch-harvested plants as well as inside the infested plants, indicating the spread of weevil infection.

Pseudostem traps swabbed with entomopathogenic fungus, *B.bassiana* indicated 69.4 and 91.23 per cent mortality of the trapped weevils in Red banana and Virupakshi plants respectively (Fig. 14). Hill banana with severe infestation of weevil produced only 3kg bunch while in Red banana, the yield was reduced to 6 kg in severely infested plant.

Management of Rust thrips (*Chaetanophothrips signipennis)*

Bell injection with Imidacloprid 0.01 per cent was effective in controlling rust thrips (Fig.15) followed by bunch sleeves impregnated with 0.1 % Chlorpyrifos + paraffin oil + adjuvant. Blemish free fingers were observed in the treatments viz., bell injected and Chlorpyrifos treated sleeves, where as in the control rust thrips infestation was recorded to the extent of 10 to 30 per cent (Fig. 15).

Fig.15. Bell injection to control banana rust thrips

Extracts from shade dried leaves of *A.paniculata* using hexane, methylene chloride, ethyl acetate and ethanol were studied. 2% ethyl acetate fraction showed anti feedant property to adult weevils.

Search for natural enemies

Banana aphid was mass multiplied in different cultivars under net house. *B. bassiana* and *Verticillum lecanii* were evaluated against banana aphid and mortality was recorded. *B.bassiana* was tested @1.0X10^5 to 5.0X10^5 conidiospores. 100 per cent aphid mortality was recorded on the eighth day of inoculation.

Studies on fungal and bacterial diseases of banana and their management

Screening of endophytic organisms against Fusarium pathogen

40 endophytic bacteria were isolated from the roots and corms of different *Fusarium* resistant as well as susceptible cultivars of banana . Three endophytic bacteria were found effective against Fusarium pathogen under *in vitro* condition.

Bio agents for Cigar end rot disease

A disease score for assessing the cigar end rot damage has been developed. *Trichoderma viride* CT-6 and *Azospirillum* sp and *Pseudomonas* sp were effective for the management of cigar end rot disease which is serious in Nendran, Ney Poovan and Robusta banana varieties.

Management of Crown rot disease of banana

Among the fungal (*Trichoderma viride* RT1, *T.viride* S7 and *T. pseudokoningii*) and bacterial (*Pseudomonas syringae*-2, *P. aeruginosa*, *P. viridiflavus*, *B. cereus*, *Azospirillum* spp) antagonistic isolates, *P. aeruginosa and P. viridiflavus* found effective in controlling the Crown rot disease in Robusta banana.

Carrier material for *P. fluorescens*

Use of rice husk ash as a carrier material for *P. fluorescens* was studied. A population of 10^{15} was maintained even up to six months of storage whereas the talcum powder based formulation could maintain only 10^{10}populations for four months of storage at 25 °C.

Management of Fusarium disease

Trichoderma viride application and injection + drenching of 2% Propiconazole recoreded lowest disease score (1.8) followed by *Solanum torvum* extract +*Bacillus* sp. application (disease score 2. 5) as against 4.8 recorded in *Foc* alone inoculated plants. Besides, these treatments increased the plant growth parameters significantly.

Studies on viral diseases of banana and their management

Survey

A survey was undertaken to NEH states viz., Arunachal Pradesh, Nagaland, Meghalaya and Assam to study the presence of banana viruses in the region. BBTV and BSV are widespread in all the hill states. Wild bananas viz., Ram kola from Meghalaya and *Musa itenerans* from Arunachal Pradesh were found infected with BBTV, which were confirmed after amplification of cp gene of the virus by PCR (Fig.16). BSV infection was noticed in Mysore clones and integrants of its genome was observed in wild *balbisiana* and its inter-specific hybrids.

Comparison of cp gene of BBTV isolates

The BBTV cp gene sequences for four isolates collected from NEH states were compared and have more than 90 percent similarity with Hill banana isolate of TN. The master rep gene of BBTV Hill banana isolate contained 861 nucleotides which had 83 % sequence homology with Cardamum clump virus (Foorkey disease of Large Cardamum) and 98 % & 91 % homology with Coimbatore and Japan isolates of BBTV respectively. Endogenous Para-retro viral sequences of BSV got amplified and cloned in p-GEM-T vector. The sequences had homology with published sequences.

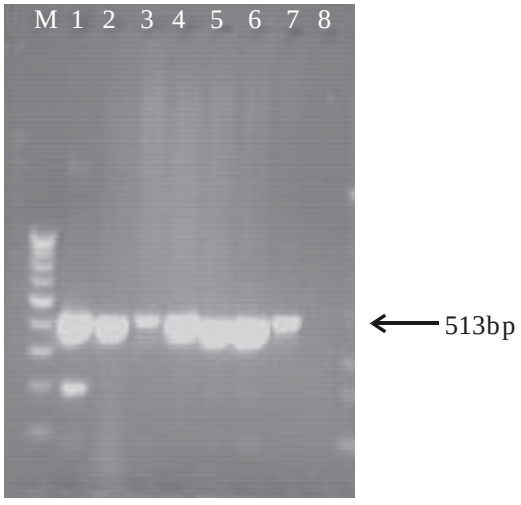


Fig 16. Amplification of cp gene from samples collected from NEH states. Lane 1-6, Survey samples; Lane 7, Positive control; Lane 8, Negative control and M, marker.

Diagnosis

The RT-PCR technique for CMV was standardized for inclusion in Multiplex-PCR along with three viruses detection. DIBA is 10 times more sensitive than DAC-ELISA for detecting the BBrMV from the extracted sap from infected plant. RT-PCR was more sensitive than these two serological

Fig. 17. *Nicotiana glutinosa* plants exhibiting mosaic symptoms after inoculation with CMV-Banana

techniques. RT-PCR could detect the virus preparations diluted up to 500 times. CMV infecting banana has been transferred to *Nicotiana* spp through mechanical sap inoculation (Fig. 17) for virus propagation and purification. Presence of CMV in *Nicotiana glutinosa* plants has been confirmed by RT-PCR technique (Fig. 18).

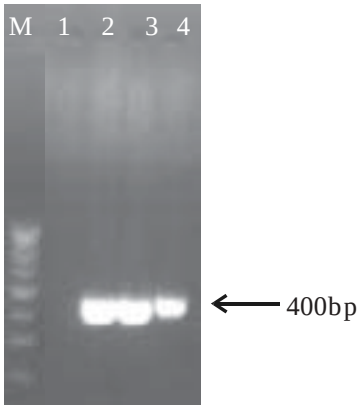


Fig. 18. RT-PCR amplification of CMV specific fragments from mechanically inoculated *Nicotiana glutinosa* leaves.

Characterization of BSV from Poovan and Rasthali

BSV specific fragments got amplified by PCR from BSV infected, symptomatic plants of cultivars Poovan and Rasthali. Technique has been standardized to differentiate episomal virus from the integral endogenous Para-retroviral sequences.

EXTERNALLY FUNDED PROJECTS

Development of Sigatoka Resistant Bananas through polyploidy breeding

Primary tetraploid (AAAA) developed through *in-vitro* polyploidisation of cv. Rose (AA) has been established in the field. The ploidy status was assessed initially using stomatal density studies and it was confirmed using flow cytometry. 6 vegetative progenies have been multiplied and planted in the field. No delay in flowering was observed among the *in-vitro* polyploidised plantlets and have shown a marginal improvement in pollen fertility in terms of pollen output, stainabilility (%) and pollen germinability (%).

Network project on transgenic in Crops
i) Functional Genomics

a) Sigatoka leaf spot

The identification of genes involved in the Sigatoka leaf spot disease and its function in disease resistance are being investigated in ICAR sponsored network project " Functional Genomics". The causative pathogen for yellow Sigatoka leaf spot *Mycosphaerella musicola* has been isolated and confirmed by International Mycological Institute at London. The pathogen for septoria leaf spot *M. eumusae* has been isolated and cultured in PDA slant. The field germplasm was screened against these two leaf spot pathogens adapting International guidelines for Sigatoka screening. The resistant sources viz., Thiruvananthapuram,Manoranjitham,Sannachenkadali, Pisang Seribu, Kalibow, Dudhsagar and Pisang Rajah were identified. The highly susceptible cultivars Rasthali, Robusta, Amirthapani and Malbog were choosen for the study.

The total RNA isolation from banana seedlings was achieved using different commercial RNA isolation kits and also through lithium chloride precipitation method.

b) Drought tolerance

A total of 110 accessions were screened based on their leaf water retention capacity (LWRC) and promising accessions are identified. Pot screening of accessions indicated cv. Poovan as drought tolerant.

ii) Transgenic Development for BBTV and BSV

BBTV characterisation and development of cp gene construct

Six fragments got amplified and cloned in pGEM-T easy vector and transformed in *E. coli*, DH5α cells.

Out of six clones, 2 clones ie. Component 1 and 3 were sequenced. Component 1 contained an ORF encoding replicase gene (861 bp) and another clone containing component 3 had cp gene (513 bp). Primers were further designed to amplify cp gene from component 3 and the amplified cp gene cloned into pGEM-T vector for further cloning into pBINAR. The cp gene excised from pGEM-T using two restriction enzymes for cloning into the binary vector by directional cloning procedure.

Promoters isolation and characterization

Primers were also designed to amplify the intergenic regions from the genomes isolated from partially purified viral preparation. Intergenic regions BBTV components 1, 3 and 5 were amplified (Fig.19) and cloned directly pGEM-T easy vector for further cloning into pBI-121 for assessing promoter activity. These clones are sent for sequencing.

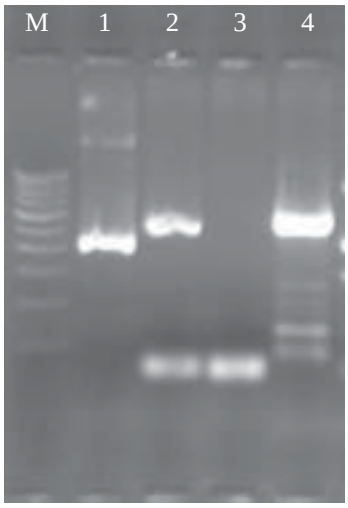


Fig 19. PCR amplification of intergenic regions of BBTV components 1,3 and 5. Component 4 primers did not amplify the intergenic region (Lane 3). Lanes 1,2 and 4 are amplicons of intergenic regions of components 1,3 and 5 respectively.

ECS development in Hill banana

The BBTV free hill banana tissue culture derived shoot tips cultured for obtaining the scalps. The scalps will be used for inducing embryogenesis. Explants (immature flower) from male buds were dissected from indexed hill banana and the culture was initiated in Ma 1 Medium (Fig.20&21).

A survey was conducted in lower Pulany hills of TN, collected male buds from apparently healthy plants. The disease free samples were used for initiating the callus cultures for transformation. Transformation protocol is being standardized with *Agrobacterium* co-cultivation method using *Agrobacterium* (LBA 4404) containing p-CAMBIA vector (2301) for GUS expression. The GUS expression was noticed in co-cultivated explants such as scalps and shoot tips.

Fig 20. Blackening of male floral explants in the Ma I medium due to phenolic exudates.

Fig 21. A close up view of enlarging male floral buds in the callus medium.

ICAR Network Project: a) Wilts of crops with special reference to cultural, morphological, pathogenic and molecular characterization of isolates in India

Roving Survey

Survey was c arried out in different districts of Tamil Nadu, Kerala, Pondichery, Karnataka ,Andra Pradesh, Nagaland, Assam, Arunachal Pradesh and Meghalaya and collected 224 Fusarium samples. Foc was isolated and are being maintained as dried filter paper culture. Besides, 224 soil samples for the isolation of native bio-agents and 224 root samples for the assessment of nematodes (type and population) were collected. During the survey, 95% incidence was observed in Pudukottai and Cuddalore districts of Tamil Nadu.

Isolation of effective microbes against Fusarium pathogen and *in-vitro* screening

75 bacterial antagonists, 16 non - pathogenic Fusarium and 35 *Trichoderma* spp. were isolated from the rhizosphere soil samples. Seven *Trichoderma* spp, three non-pathogenic *Fusarium* spp (NPF) and ten bacterial isolates were found effective in arresting the mycelial growth of Fusarium pathogen under *in vitro* condition. Among the non- pathogenic *Fusarium* spp. an isolate 130A unusually lysed the mycelium of the pathogenic Fusarium.

Molecular characterization

Fusarium DNA was extracted, purified and quantified for 153 isolates. Variation was observed in most of the *Fusarium* isolates with regard to molecular weight of amplified ITS region. The bands of representative isolates of *Fusarium* were gel purified, cloned and sent for DNA sequencing. The sequencing received for 65 isolates are being analyzed for variation.

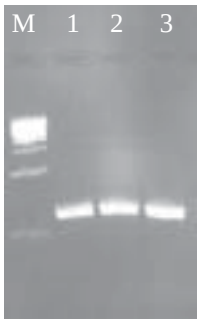
b) Diagnostics of emerging plant viruses (BBrMV and BSV)

Maintenance of Pure culture of the banana bract and streak viruses

The viruses were transferred through vector to healthy plants and maintained in the insect free glass house. For detection of BBrMV, 3 sets of primers were developed using sequence available in public domain. To perform RT-PCR, the total NA isolation protocol was standardized. PCR conditions were optimized for amplifying 600 bp product. Amplification was observed only from infected samples. These same bract mosaic specific primers also amplified a product from sugarcane mosaic and papaya ring spot samples also.

Direct binding - PCR for BBrMV

The partially purified extract with a designed protocol was coated onto PCR tubes and incubated.



600bp

Fig. 22. Direct binding PCR for BBrMV detection.

cDNA was synthesized using oligo dT primers and PCR was performed with specific primers of BBrMV. The viral specific fragment was amplified and cloned for sequencing (Fig. 22).

Cloning and sequencing of banana streak virus partial genome

A 586 bp BSV sequence and three BSV ORF sequences got amplified from cv. Poovan was cloned and transformed into *E.coli* DH5α strain. Recombinant clones were identified based on blue and white colony screening. The cloned fragments have been sequenced.

Development of Non – radioactive probes for BSV

A Dig-oxigenin labeled non-radioactive probe has been made from the 586bp, 1400bp clones for part of the BSV genome. The two probes were compared for detection of BSV in germplasm. PCR probe synthesis kit was used for preparing the probes. Dot blot hybridization test has confirmed the presence of BSV in many of the germplasm accessions having AB, ABB and AAB genomes (Fig. 23).

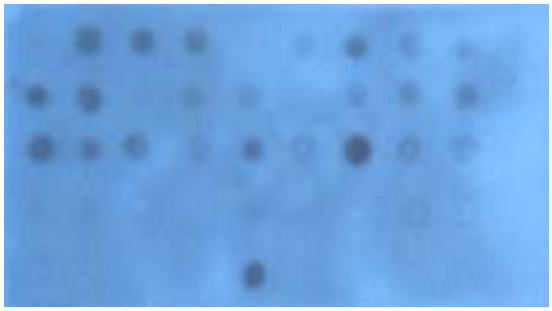


Fig 23. Detection of BSV sequences using viral specific Dig-oxigenin labeled non-radioactive probes. The dark spot indicates positive for BSV.

6 Transfer of Technology

A new high yielding variety 'Udhayam' belonging to Pisang Awak subgroup (ABB) was released for commercial cultivation and the technology has been transferred to Growmore Biotech Ltd., Hosur, private commercial tissue culture laboratory for large scale production.

- Technology of banana flower thokku & fruit pickle preparation was transferred to Mr. Suresh Kumar and Mrs. S.Kumari of Bharathi Society from Salem on 29-30th May 2005.
- Technology of banana RTS (Ready-to-Serve) beverage was transferred to Mr. Rajesh Shah of GSFC during 10th to 12th August 2005.
- Technology of banana chips, fig, pickles, powder and fibre were transferred to two members from Vivekananda Institute of Biotechnology, West Bengal from 31st August to 2nd September 2005.
- Technology of Chips, figs, jam and pickles were transferred to Mr. Sreekumar of M/s.Guideline Innovations, Cochin, Kerala.
- PCR based banana virus-indexing technology was transferred to Biotechnology Centre, Dept of Horticulture, Govt of AP as consultancy project. The laboratory was inaugurated on 13th March 2006.

Transfer of Technologies through mass media : TV Programme

SI. No	Topic	Resource persons	Date of telecast
1.	High density planting on Banana	Dr. M.M. Mustaffa	29.11.05
2.	Drip Irrigation Management on Banana	Dr. M.M.Mustaffa	02.12.05
3.	Insurance on Banana	Dr. M.M. Mustaffa	23.12.05
4.	Value Added Products on banana	Dr.C.K. Narayana	22.12.05
5.	Macronutrient Management on banana	Dr.K.J.Jeyabhaskaran	30.11.05
6.	Micronutrient Management on banana	Dr.K.J.Jeyabhaskaran	01.12.05
7.	Sucker selection and planting of banana	Dr. V. Kumar	28.11.05
8.	Post planting cultivation practices for improving the banana growth and yield	Dr. V. Kumar	19.12.05
9.	National Research centre for Banana – A glimpse	Prof. S. Sathiamoorthy	25.11.05
10.	Tissue Culture Banana and its Cultivation	Prof. S.Sathiamoorthy	05.12.05
11.	Pest and Diseases Handling of Banana & Plantains	Prof. S. Sathiamoorthy	06.12.05
12.	Stem weevil Management on Banana	Dr. B.Padmanaban	07.12.05
13.	Nematodes Management on Banana	Dr.P. Sundararaju	08.12.05
14.	Banana varieties – an overview	Dr. S. Uma	20.12.05
15.	Ornamental Varieties – Panorama	Dr. S. Uma	26.12.05
16.	Management of Leaf Spot Disease on Banana	Dr.R.Thangavelu	09.12.05
17.	Management of Wilt Disease on Banana	Dr.R.Thangavelu	12.12.05
18.	Viral Diseases on Banana	Dr.R. Selvarajan	15.12.05
19.	Interview with a progressive farmer		27.12.05
20.	Scientists- Farmers Interaction on cultivation aspects of banana	All Scientists	29.12.05

Radio Programme

SI. No	Topic	Name of the Scientist	Date of broadcast
1	Banana viruses	Dr.R. Selvarajan	22. 8. 2005
2	High Density Planting Techniques in Banana	Dr.V. Kumar	12. 9. 2005
3	Biofertiliser in banana cultivation	Dr.K. J eyabaskaran	15. 2. 2006
4	Rhizome rot of banana and their management	Dr.R. Thangavelu	31. 3. 2006

Exhibitions

SI. No	Topic	Organisers	Held at	Date
1.	Workshop on Good Agricultural practices, Sanitation and Phytosanitation Standards and Supply Chain Management in Banana	ALO / MSU / TNAU / NRCB	Trichy	7th April 2005
2.	Seminar on "Hill Banana Cultivation"	Department of Horticulture / Tamil Nadu.	Dindugul	9 th July 2005
	Rural Training Centre - farmers meet	IOB	Karaikudi	9 th July 2005
3.	Technical Seminar on Banana Cultivation	SBI	Cuddalore	22 nd July 2005
4.	Seminar on banana cultivation and Exhibition (Thirukatuppalli)	NRCB & Sun Mac Agro	Thanjavur	27 th July 2005
5.	Banana Festival cum Exhibition	Indian Society of Agribusiness and Centre for agriculture and rural development	New Delhi	4 - 6 th Aug. 2005
6.	Agri, INTEX 2005	CODISSIA,	Coimbatore	11- 16 Aug. 2005
7.	Workshop on Commercial Crops	SPIC	Allangudi Pudukottai	27 th Aug. 2005
8.	Vijana mela / Techno Expo	Swadeshi Science Movement	Kochi, Kerala	15 th-20th Sep. 2005
9.	Technical Workshop on Banana Cultivation	SBI - Trichy Branch	Lalkudi	17 th Nov 2005
10.	Value Added banana products "Buyer and Seller meet".	NABARAD / TDC -Co. Bank,	Trichy	30. Dec. 2005
11.	93rd Indian Science Congress-Exhibition	IRD&ANGARU,	Hyderabad	3-7 th Jan. 2006
12.	Tamil Nadu "AGRICON 2006". Industry	Confederation of Indian Industry	Thanjavur	11-12th Feb. 2006
13.	Rashtriya Bagwani Kissan Mela cum Exhibition.	Indian Institute of Horticultural Research /	Bangalore	3 - 4 th Mar. 2006
14.	Banana Festival & Seminar on Production of Value Added banana Products	NRCB, TNAU- KVK and Indian PotashLimited /	Tirupparaithurai (Trichy)	23rd Mar. 2006

Totally 1500 farmers and 950 students have visited to NRCB during the period under report.

Dr. Mangala Rai, DG (ICAR) visiting the NRCB stall in the exhibition held at Hyderabad

Dr.M.S. Swaminathan visiting NRCB stall at Hyderabad

Scientists and banana growers interaction at NRCB experimental plot

Dr. C.K. Narayana explaining about value added products to banana farmers

Farmers from AP visit to NRCB exhibition

Dr. S. Sathiamoorthy, Director addressing in a Banana seminar held at Lalgudi, Trichy

7 Education and Training

35 M. Sc/M. Phil students carried out their project work under the guidence of scientists on different aspects.

Name of the student	Title of the thesis	Name of the guide
D. Chelladurai	Assessment of phylogenetic relationship among wild and cultivated bananas using Microsatellite markers	S.Uma
O. Karthic Kumar	A preliminary study on the detection of dwarf somaclonal variant in micropropagated bananas using Randomly Amplified Polymorphic DNA (RAPD)	S.Uma
L. Karthik	Development of diagnostic marker linked to somaclonal variant with floral deormity in micropropagated bananas using RAPD-A preliminary study	S.Uma
M.S. Dhivya vadhana	Phylogenetic studies and diversity analysis in AAB (Silk) clones of Musa using microsatellite markers	S.Uma
K. Udhayaanjali	SSR assisted diversity analysis in lesser known *Musa* clones of AB genome	S.Uma
R. Hemalatha	Preliminary investigations on Sigatoka resistant gene in banana (*Musa spp.*) through RAPD derived markers	S.Uma
S. Stella Nambikkaimary	Influence of ethylene and storage temperature on the ripening behaviour of Nendran Banana	M.M. Mustaffa
P.Chibichakravarthy	Influence of different organic manures on the soil microflora in the Rhizosphere of Grand Naine banana	M.M. Mustaffa
N. Sathic Basha	Studies on soil microflora and Root enzymatic activities as influenced by population and Fertigation in the Rhizosphere of Banana	M.M. Mustaffa
R. Kanchana	Influence of different organic manures on the soil microflora in Banana Rhizosphere	M.M. Mustaffa
A. Shanmuga	Effect of crop geometry and fertigation techniques on microbial growth and biochemical changes in banana cv.Red Banana (*Musa sp* 'AAA')	V. Kumar
T. Nagaraj	Studies on rhizosphere micro flora and enzymatic activities under high density planting and fertigation in banana cv. Robusta (*Musa sp* 'AAA')	V. Kumar
R. Ambika	Bio - Fortification and Evaluation of Rhizosphere -Soil Microbial Eco system with certain native N- Fixing and P-Mobilizing Bacteria for N and P Fertilization of Banana.	K.J.Jeyabaskaran
Kasthuri	Effect of exogenous ABA application on antioxidative enzymes and osmolyte accumulation in soil moisture stress imposed banana plants.	I.Ravi
P. Umadevi	Studies on Pattern of Phenol, Tannins, Ascorbic Acid and Carbohydrates, accumulation during fruit development in *Musa* spp. Ney Poovan (AB)	I.Ravi
Meenakshi	Effect of soil moisture stress on antioxidative enzyme response in *Musa* spp Robusta (AAA)	I.Ravi
Bhavani	Studies on Soil Moistures stress effect on Growth, Photosynthesis and osmolyte accumulation in banana plants	I.Ravi

Name of the student	Title of the thesis	Name of the guide
P. Nandhini	Effect of chilling injury on carbohydrate metabolism and antioxidative enzymes in banana fruits	I.Ravi
R. Thenmozhi	Efficacy of neem based formulations used as sucker treatment against root-knot nematode, *Meloidogyne incognita* infesting banana in cv. Robusta	P. Sundararaju
R. Sudha	Efficacy of organic amendments on root-lesion nematode, *Pratylenchus coffeae* infecting banana in cv. Nendran	P. Sundararaju
S. Karthik	Biodiversity of plant parasitic nematodes associated with banana in Dindigul district of Tamil Nadu	P. Sundararaju
P. Vausmathi	Evaluation of Halo fungus, *Verticillium lecanii* (Zimm.) Viegas against the banana aphid, *Pentalonia nigronervosa* Coq	B.Padmanaban
R. Suresh	Isolation, mass production and evaluation of Bacillus thuringiensis against banana stem weevil, *Odoiporus longicollis.*	B.Padmanaban
J. Ravi Shankar	Mass production and evaluation of white muscardine fungus, *Beauveria brongniartii* (Sacc.) Petch against banana stem weevil, *Odoiporus longicollis.*	B.Padmanaban
C. Gnana Soundari	Mass production of white muscardine fungus on different substrates molecular characterization and evaluation of *Beauveria bassiana* against banana stem weevil, *Odoiporus longicollis.*	B. Padmanaban
N. Mohan Raj	Bio-control management Fusarium wilt disease of banana caused by *Fusarium oxysporum* f.sp.*cubense* using endophytic bacteria	R.Thangavelu
F. Thissam	Lsolation and evaluation of Non pathogenic of banana isolates againsts fusarium wilt of banana caused by *Fusarium oxysporum* f.sp.*cubense*	R. Thangavelu
A. Mary Louis	Characterization of Fusarium wilt isolates of banana by VCG method	R. Thangavelu
R. Nithya tharani	Molecular characterization of *Colletotruhum musae* isolates	R. Thangavelu
M. Indira	Isolation and purification of lipids from Solanum torvum and *Solanum nigrum* for the management of anthracnose and crownrot diseases of banana	R. Thangavelu
N. Manimala	Movement and distribution of Cucumber Mosaic Virus (Banana isolate) in its propagative host using ELISA and RT-PCR	R. Selvarajan
A. Shanthi	Use of RAPD technique to diagnose and differentiate Banana Streak Virus infection.	R. Selvarajan
S. Arthi	Cloning and sequence analysis of a partial segment of DNA-1 component of banana bunchy top virus	R. Selvarajan
P. Latha	Detection of Cucumber Mosaic Virus (Banana isolate) by Direct Binding - PCR and Immuno-Capture-Reverse Transcription PCR	R. Selvarajan
Linda Suzanne David	Cloning and expression of CP of BBTV in *E.coli*	R. Selvarajan

8 Awards and Recognitions

Awards and Recognition

- Dr. C. K. Narayana received a Certificate of Appreciation jointly from IPGRI, INIBAP (France), Cavite State University, Philippines and PACCARD for being a Resource Person in Global Musa Symposium and Techno-fair held at Cavite State University on 13th October 2005.
- Dr. R. Selvarajan has been nominated as a Member in editorial board in Indian Phytopathological Society for the year 2005 to 2007.
- Dr. I. Ravi, has been nominated as consultant in editor in Indian society of plant physiology for the year 2006-08.

9 Linkages and collaborations in India & Abroad

The Centre has developed good linkages with international institutes viz., INIBAP, France ; CIRAD, France ; KUL, Belgium ; IAEA, Austria and QDPI, Australia. It collaborates with different national research institutions for different activities. NBPGR, New Delhi ; BARC, CIRCOT, Mumbai; IICT, Hyderabad; IIHR, Bangalore; NHB, New Delhi; BTC, Govt. of Andhra Pradesh and all SAUs. Tissue culture industries involved in banana mass propagation, farmers, exporters, banana federations, State Horticulture and Agriculture departments, self-help groups, are linked with the Centre for various research developmental activities.

Dr. C. K. Narayana, Dr. S. Sathiamoorthy and Dr. S.D. Sivakumar undertook an international assignment to conduct a collaborative project sponsored by INIBAP for a National Survey on studying the "Musa Processing Enterprises in India and its Support Environment".

NRCB had linkage with NABARD in development of Banana Products Cluster in Trichy under District Rural Industrialization Project.

10 Publications

BOOKS / BULLETINS

Pandey, S.D., K.J. Jeyabaskaran, C.K. Narayana and S. Sathiamoorthy. 2005. 'Kela Uthpaadan' (Banana Production) Published by the National Research Centre for Banana, Trichy.

Sundararaju,P.,Van den Bergh, I., Sathiamoorthy,S., DeWaele,D., Molina,A.B., and Borromea,K.H (Eds).2005. Banana Nematode Management towards Eco-friendly approach. NRCB ,Tiruchirapalli .

Uma, S., S.Sathiamoorthy and P.Durai, 2005. Banana – Indian Genetic Resources and Catalogue, National Research Centre for Banana, Trichy.

Uma, S., 2006. Farmers' Knowledge of Wild *Musa* in India by Food and Agriculture Organisation (FAO), UN, of the United Nationals, Rome.

RESEARCH ARTICLES

International

Uma,S. S.A.Siva, M.S.Saraswathi, M.Manickavasagam, P.Durai, R.Selvarajan and S.Sathiamoorthy, 2006. Variation and intraspecific relationship Indian wild *Musa balbisiana* (BB) population as evidenced by Randomly Amplified Polymorphic DNA. *Genetic Resources and Crop Evolution*.**53** (2):349-355.

Uma, S., S.A. Siva, M.S.Saraswathi, P.Durai, T.V.R.S.Sharma, D.B.Singh, R.Selvarajan, S.Sathiamoorthy, 2005. Studies on the origin and diversification of Indian wild banana (*Musa balbisiana*) using arbitrarily amplified DNA markers. *The Journal of Horticultural Science and Biotechnology*. **80**(5):575-580.

Uma, S., S. Kalpana, S. Sathiamoorthy and V. Kumar, 2005. Evaluation of commercial cultivars of banana for their suitability to fibre industry. *Plant Genetic Resources Newsletter*, **142**:1-8

National

Uma, S., S.Sathiamoorthy, R.Selvarajan, M.S.Saraswathi and P.Durai, 2005. Genetic Improvement of Musa sp. through clonal selection : NRCB Sel. 001 a better substitute for Indian Pisang Awaks (ABB). *Indian J.Hort*. **62**(4):319-323.

Jeyabaskaran, K.J., S.D. Pandey, M.M. Mustaffa and S. Sathiamoorthy. 2005. Diagnosis and recommendation integrated system for monitoring

status of nitrogen, phosphorus and potassium of 'Nendran' banana (*Musa paradisiaca*). *Indian Journal of Agricultural Sciences*, **75**(7): 432-434.

Narayana, C.K., D.Ramajayam and S.Sathiamoorthy. 2005. Studies on Banana Pickle and its quality changes during storage. *Beverage and Food World.*, May 2005., pp.44-45.

Narayana, C.K., M.M.Mustaffa and S.Sathiamoorthy. 2005. Chilling injury and quality changes in Pachanadan (Pome, AAB group) banana during storage at low temperature. *Indian J.Hort*. **62** (3): 241-243.

Sundararaju, P .,Sasikala,T and Cannayane,I. 2004 ., Biocontrol potential of *Verticillium chlamydosporium* against *Meloidogyne incognita* infesting banana.*Current Nematology* **15(2)**72-75**.**

Sundararaju, P .2005 ., Biodiversity of plant parasitic nematodes associated with banana in northern parts of Tamil Nadu, India .*Current Nematology* **16(1).**

POPULAR ARTICLES

Uma, S., S.Sathiamoorthy, P.Durai and M.S.Saraswathi, 2005. Udhayam – Pudhiya vazhai ragham. SPIC pannai sethimalar October-November, 2005. pp 9.

Jeyabaskaran, K.J. 2005. Soil fertility management in banana orchards. *Kisan World*, **5**: 51-52.

Jeyabaskaran, K.J. 2005. "Chelated Nunnoota Urangal" (in Tamil). *Valarum Velanmai*, 6: 22-23.

Jeyabaskaran, K.J. 2006. "Vellamum, vaazhaiyil baathippum" (in Tamil), Vivasaaya Malar, *Dinamalar*, 8-3-2006.

Padmanaban, B.S.Palanichamy, P.Sundararaju and S.Sathiamoorthy. 2006. Poochiyai Thakkum Noorpuzhukkalai Kondu Vazhai Koon Vandukalai Kattupaduthuvathu Epadi ? Vanoli Uzhavar Sanga Seithikathir pp.23 .

Sundararaju, P. 2005. Biodiversity of plant parasitic nematodes associated with banana in Northern parts of Tamil Nadu, India.Paper presented in Biotechnological Management of Nematode Pests and Scope of Entomopathogenic Nematodes.(Eds) S.Sithanantham, B.Vasantharaj David and P.Selvaraj,2005. Sun Agro Biotech Research Centre Publication.Sun Ray No.1.pp.35-39.

Sundararaju, P.and K. Pandi Suba,.2005. Role of Pathogen related proteins in resistant reaction against banana nematodes. Ibid.pp.15-19.

Sundararaju,P. and S.Sathiamoorthy,. 2005. Present status of banana nematodes and their management. Ibid.pp.43-47.

Sundararaju,P. and V.Saritha,. 2005. Effect of leaf extracts of *Acalypa indica*, *Cassia fistula* and *Solanum torvum* on *Pratylenchus coffeae*.. Ibid.pp.76-77.

Sundararaju,P.2006. Biodiversity of plant parasitic nematodes associated with banana in India.Paper presented in National Seminar on Agro Biodiversity at Chennai during 12-15, February,2006.pp-214.

EXTENSION FOLDERS

Banana Streak Virus –R. Selvarajan, R. Thangavelu, S.Sathiamoorthy

Banana Bract Mosaic Virus - R. Selvarajan, R. Thangavelu, S.Sathiamoorthy

Sigatoka Leaf spot diseases in banana - R. Thangavelu, R. Selvarajan, S.Sathiamoorthy

11 Consultancy services and Commercialization of technologies

The Centre has a consultancy processing cell to effectively transfer technologies on commercial basis as per the Johl's committee recommendations. Five technologies were transferred.

Technologies commercialized

1. A new high yielding variety ' Udhayam' belonging to Pisang Awak subgroup (ABB) has been released for commercial cultivation and the technology has been transferred to Growmore Biotech Ltd., a commercial tissue culture laboratory for large scale production on consultancy norms.
2. Technology of banana flower thokku & fruit pickle preparation was transferred to Mr. Suresh Kumar and Mrs. S.Kumari of Bharathi Society from Salem on 29-30th May 2005.
3. Technology of banana RTS (Ready-to-Serve) beverage was transferred to Mr.Rajesh Shah of GSFC during 10th to12th August 2005.
4. Technology of banana chips, fig, pickles, powder and fibre were transferred to two members from Vivekananda Institute of Biotechnology, West Bengal from 31st August to 2nd September 2005.
5. Technology for production of chips, figs, jam and pickles were transferred to Mr.Sreekumar of M / s. Guideline Innovations, Cochin, Kerala.

Mr. Anil Punetha, Commissioner of Horticulture Govt. of AP Inaugrated the virus testing facility at BTC, Hyderabad

6. PCR based banana virus-indexing technology was transferred to Biotechnology Centre, Dept of Hoticulture, Govt of AP as part of the assignment in the turnkey basis consultancy project. at a cost of 12.89 lakhs. The virus testing lab was formally inaugurated on 13th of March 2006.

Training conducted as per consultancy norms

Paid training on value added products were conducted. The beneficiaries were from Mahabanana Association, Maharastra and self help groups from Tamil Nadu.

Training on value added products for a groups of 20 members each in 2 groups from Banana Cluster villages under NABARD scheme from 14-16th December 2005 and 19th to 21st December 2005.

Contract service

Under contract service, virus testing for mother plants used for tissue culture mass propagation was under taken. Samples were tested against four viruses for tissue culture companies during 2005-06.

Soil and water testing have been done for samples received from farmers and companies.

Contract research

Evaluation of ethylene scrubber impregnated bags for storage of green bananas was done for Reliance Bio Ltd, Mumbai as per contract research basis.

Gross earning under consultancyfor the year 2005-06

Sl.No.	Activity	Amount in (Rs)
1	Transfer of technologies	52,500
2	Contract research	78,496
3	Trainings	65,000
4	Contract services-Virus testing Soil and water testing	6,15,036
5	Farm revenues	3,31,916
6	Consultancy Projects	1,43,971
7	A turnkey basis consultancy Project, from Dept.of Hort., Govt. of AP.	9,20,000
	Total	**22,09,919**

A view of virus testing facility created at BTC

12 RAC,IMC and IRC with significant decisions

7th RAC Meeting

The seventh RAC Meeting was held on 20.04.2005. Dr.H.K.Jain, Chairman-RAC chaired the session and conducted the proceedings. Dr.S.Sathiamoorthy, Director, NRCB welcomed the Chairman and RAC Members. He briefed the research activities and salient achievements of NRCB. Dr.M.M.Mustaffa, Member Secretary, RAC presented the Action Taken Report of last RAC. The Chairman and the Members were satisfied about the action taken on the recommendations of previous RAC Meeting and approved the minutes of the 6th RAC. This was followed by a brainstorming session in which heads of sections and Dr.C.K.Narayana, Sr.Scientist (Post Harvest Technology) presented the various research activities on banana.

After detailed discussions on the research progress of the going projects, the Chairman and RAC members suggested the future programmes to be carried out in various new areas of research in banana. The RAC Chairman in his concluding remarks appreciated the Director and the team of scientists of NRCB for effectively carrying out the research programmes.

Following the brainstorming with the participation of RAC members and Senior Scientists from NRCB, the RAC made the following recommendations. :

1. NRCB should establish a Training Centre at Trichy for close and continuous interaction with banana farmers and with industries. Establishment of a training center will go a long way in disseminating the technologies developed at the Centre to the farmers and industries. Also, NRCB should be more active in using electronic media such as ETV / ANI for sending out messages on as regular basis to the farmers.

2. The RAC noted that, NRCB contrary to the usual practice, has no role in the coordination of research programmes on banana being carried out at different institutions and universities in the country. Currently, the coordination of banana research is being done through the Coordination Unit located at Indian Instt. of Horticultural Research, Bangalore. As banana production constitutes 32% of the total fruit production in the country, the RAC recommends that the existing coordinated project should be revised and as far as research on banana is concerned and the programme for this purpose should be located at NRCB. The RAC recommends that this programme should take the form of a network banana research with its headquarter at NRCB, Trichy. In this context the RAC pointed out that the Johl's committee has also recommended that coordination of research work on different tropical fruits should be the responsibility of the respective NRC's.

3. The RAC noted that a major constraint in increasing the production of banana in the country is non-availability of disease free planting material to the farmers. Present efforts in this regard are very inadequate. The RAC recommends that NRCB should develop exclusively for the production of elite planting material. This material will take the form of nucleus 'Seed', which will be supplied to the companies and institutions, which have programmes of propagation of improved varieties of banana. On the concept, a nucleus "Seed' as in the case of field crops genetic material to be multiplied as the "Seed" From of NRCB will be of high purity and will be totally free from viral and other diseases, which will form the mother material for other multiplication programme. This will become a source of renewal of propagation material.

4. The RAC felt India with millions of small and marginal farming who use little modern farming inputs has a comparative advantages in organic farming of banana. NRCB should have major research thrust on the development of suitable technology for organic farming of banana with emphasis on substituting industrial inputs with those of renewable kind.

5. Planting material produced through tissue culture in the private and public sector must be indexed for virus to minimize the spread of disease and prevent losses on farmers' fields.

RAC Members

Chairman

Dr.H.K.Jain
Ex-Director-IARI,
40, Surya Niketan,
Vikas Marg Estension
New Delhi - 110 092

Member Secretary

Dr.M.M.Mustaffa
Principal Scientist,
NRC for Banana
Tiruchirapalli - 620 102.

Members

Dr.S.J.Singh
Flat No.23, 5th Floor
Prachi Residency
Baner Road
Pune - 411 045

Dr.D.K.Das Gupta
Scientist(F)
Defence Food Research
Laboratory
Sidharthanagar
Mysore - 570 011

Dr.O.P.Srivastava
Director
Instt. Of Agricultural Sciences
Varanasi - 221 005

Shri.V.L.Mahajan
Secretary, Banana Growers Association of India
Jalgaon, Maharastra

Shri. Subash Shamrao Kadam
Nanded, Maharastra

Institute Management Committe Members

Chairman

Dr.S.Sathiamoorthy
Director
NRC for Banana
Tiruchirapalli - 620 102

Members

Dr..K.Bhaskaran, Ph.D., IAS
Director of Horticulture and Plantation
Crops, Govt. of Tamil Nadu, Chennai

Dr.E.Vadivel
Dean (Hort.) TNAU, Coimbatore

Dr.M.M.Mustaffa and Dr.P.Sundararaju
Principal Scienitsts, NRC for Banana
Tiruchirappalli - 620 102

Dr.C.K.Narayana and Dr.S.Uma
Senior Scientists, NRC (Banana), Tiruchirappalli

Non Official Member

Shri.V.L.Mahajan,
Secretary, Banana Growers Association of India
Jalgaon, Maharastra.

Shri. Subash Shamrao Kadam
Nanded, Maharastra.

Members Secretary

Shri B.Vijayakumar,
AAO., NRC for Banana Trichirappalli - 620 102

Staff Research Council Meeting

The Tenth Staff Research Council Meeting (Xth - SRC) was held on 29 march 2006 and important recommendations are follows:

- Susceptibility of Pisang Lilin, to Fusarium wilt needs to be reconfirmed using all the races and different VCG grouping.
- The genetic difference between Red Banana its mutant, Green banana and Sanna Chenkadali has to be identified using SSR markers.
- More emphasis for embryo rescue studies has to be taken up.
- Goal specific crosses should be attempted against major problems like wilt, sigatoka and nematodes.
- The Rhodochlamys hybrids may be tested for its suitability for quality fibre.
- The photosynthetic efficiency under different spacing has to be studied.
- Effect of micronutrients on the fruit size, curvature and its effect on Ney Poovan and Red Banana has be studied.
- Experiment on preservation of banana flower pulp for further use in thokku, besides karpuravalli, Monthan and Poovan, Ney Pooven may also be included.
- The storage life of whole bunch of banana stored at low temperature, its ripening behaviour and quality changes may also be studied.
- A nematode map showing the distribution and occurrence of major nematodes in different districts of Tamil Nadu may be prepared.

List of SRC members

Chairman

Dr. S.Sathiamoorthy
Director,
NRC for banana,
Trichy.

Members

All Scientists of the Centre

Member Secretary

Dr. M.M.Mustaffa
Principal Scientist, NRC for Banana, Trichy.

13 Participation of scientists in conferences, Meetings, Seminars and Symposia

1. All scientist of NRCB participated in a Seminar on "Sanitary and Phyto-sanitary Standards and Good Agricultural Practices" organized at NRCB on 7th April 2005 by ALO – MSU – TNAU under Supply Chain Management programme.

2. Dr. S. Uma attended a meeting on National consultation on certification of tissue culture raised plants organized jointly by DBT and Biotechnology Contortion India Ltd., at New Delhi on 19.04.2005.
3. Dr. K.J.Jeyabaskaran, attended the workshop / seminar on "Capacity Building Programme for Indian Agricultural Research, Extension and Development Organizations in Globalized Economy" held at NAARM, Hyderabad from 29-4-2005 to 30-4-2005.
4. Dr. C.K. Narayana, Dr. R. Selvarajan, Dr. I. Ravi, Dr. S. Sathiamoorthy and Dr. R. Thangavelu attended the Seminar at Hotel Femina on Banana Export and Farmers Meet organized by Tamil Nadu Banana Growers Federation and World Bank team on 14th May 2005.
5. Dr. C.K. Narayana attended a Workshop on Entrepreneurial Development Training programme on 02.06.2005 at J.J.College of Engineering and Technology at Trichy.
6. Dr. R. Selvarajan participated on Brain storming session on "Development of Transgenic plants for virus resistance" held at Department of biotechnology, New Delhi, 6th to 7th June, 2005.
7. Dr. V. Kumar attended a 24th Annual Scientific Advisory Committee Meeting KVK, Sirugamani on June 26, 2005.

8. Dr. M.M. Mustaffa, Dr. P. Sundararaju, Dr. C. K. Narayana and Dr. R. Thangavelu attended Seminar on Banana organized by State Bank of India at Cuddalore on 22.07.2005.

9. Dr. V. Kumar attended 2nd Annual Scientific Advisory Committee Meeting KVK, Oil Seeds Research Station, Tindivanam , July 26,, 2005.

10. Dr. V. Kumar attended 14th Annual Scientific Advisory Committee Meeting KVK, Regional Research Station, Virudhachalam, July 27, 2005.

11. Dr. M. M. Mustaffa, Dr. C.K. Narayana and Dr.R.Selvarajan participated in "Banana festivel and conference" organised by Indian society of agribusiness professionals and centre for agriculture and rural development, ICAR at Pragati Maidan, New Delhi, 4th to 6th August, 2005.

12. Dr. S. Uma and Dr. R. Selvarajan attended meeting on launching programme of ICAR - networking project – Transgenic in Crops - Functional Genomics and Transgenic at National Research Centre on Plant Biotechnology, New Delhi on 22.08.2005.

13. Dr. V. Kumar attended a Workshop on Commercial Crops organized by SPIC-ABC, Alangudi on August 27th 2005.

14. Dr. C.K. Narayana and Dr. M.M. Mustaffa attended a National Conference on "IPR and Research Management" conducted by ICAR at NAAS, New Delhi from 27th to 29th August 2005.

15. Dr. C.K. Narayana attended the Town official Language Implementation committee meeting, at DRM office Trichy on 30.8.05.

16. Dr. K.J. Jeyabaskaran attended a Short Course on "Management of Production Problems in Tropical Fruit Crops" held at Dept.of Fruit Crops, HC& RI, TNAU, Coimbatore, from September 14-23, 2005.

17. Dr. R. Selvarajan attended a training programme on "Bioinformatics training on database and its application in Agriculture" at Centre for Plant Molecular Biology, TNAU, Coimbatore, Tamil Nadu, from 26th to –27th September 2005.

18. Dr. S. Sathiamoorthy and Dr. C.K. Narayana participated in '1st Global Workshop on Banana Uses Enterprise" at Manila, Philippines from 10-12th October 2005, organized by INIBAP, France.

19. Dr. S. Uma attended Seed certification standard meeting at ICAR, New Delhi on 13.10.2005.

20. Dr. C.K. Narayana attended the Global Banana Techno-Fair and Symposium at Cavite State University, Cavite, Philippines on 13th October 2005 organised by INIBAP, France.

21. Dr. M.M. Mustaffa participated in the steering committee meeting of BAPNET at Manila, Phillipines from 14-15 Oct 2005.

22. Dr. C.K. Narayana, Dr. M.M. Mustaffa and Dr. P. Sundararaju attended a Seminar on Banana conducted by District Industries Centre of Tiruvarur on Value added Products of banana on 22nd October 2005.

23. Dr.M.M. Mustaffa, Dr. P. Sundararaju, Dr.V. Kumar, Dr. B. Padmanaban participated in the banana seminar organized by the State Bank of India, Regional Office Madurai at Palani on 22nd October, 2005.

24. Dr. P. Sundararaju and Dr. V. Kumar attended a Technical Workshop on Banana Cultivation at SBI, Batlagundu on October 24th 2005.

25. Dr. P. Sundararaju participated in the XIV Binneial Group Meeting of All India Coordinated Research Project on Plant Parasitic Nematodes with Integrated Approach for their Control at KAU Vellayani ,Thiruvananthapuram,Kerala during 7-8, November 2005.

26. Dr.S.Uma attended the orientation course on Biosafety considerations for evaluation of transgenic crops from 7-14th Nov 2005 at NBPGR, New Delhi.

27. Dr. C.K. Narayana, Dr. R. Thangavelu, Dr. V. Kumar, Dr. K.J. Jeyabaskaran and Dr. S. Sathiamoorthy attended a Seminar on Banana organized by State Bank of India and NRCB jointly at Lalgudi on 17th November 2005.

28. Dr. P. Sundararaju participated in the National Seminar on " Biotechnological Management of Nematode Pests and Scope of Entomopathogenic Nematodes" organised by Sun Agro Biotech Research Centre at Chennai during 21-22, November 2005.

29. Dr. V. Kumar attended the 6th Annual Scientific Advisory Committee Meeting of BMT-KVK, Thanjavur on 22, December 2005.

30. Dr. R. Selvarajan participated International symposium on Management of vector-borne viruses held at ICRISAT, Hyderabad, 7th to 10th February, 2006.

31. Dr. R. Selvarajan participated "Indo-US workshop on plant virology" held at INSA, New Delhi, 11th to 13th February, 2006.

32. Dr. C. K. Narayana attended the Agricon -2006 Conclave at Vallam, Thanjavur on 12th February 2006 organized by Confederation of Indian Industries .

33. Dr. P. Sundararaju participated in the 'National Conference on AgroBiodiversity' organised by National Biodiversity Authority at Chennai during 12-15, February 2006

34. Dr. M.M. Mustaffa and Dr. C.K. Narayana attended a Training –cum- Seminar on 'Banana Production, Protection and Post Harvest Technology' organized by Department of Horticulture, Tamil Nadu under National Horticulture Mission on 5th February 2006.

35. Dr. V. Kumar attended a Rashtriya Bagwani Kissan Mela cum Exhibition IIHR at Bangalore on March 3rd & 4th, 2006.

36. Dr. S.Sathiamoorthy and Dr.R.Selvarajan participated in the inauguration meeting of virus testing lab at BTC, Dept of Horticulture, Govt of AP, on 13th March 2006.

37. Dr. C.K. Narayana attended a National Seminar on Value Added Products from Banana Fibre at College of Home Science, Acharya N.G.Ranga Agricultural University, Hyderabad on 20th March 2006.

38. Dr. C.K. Narayana participated in the National Seed Certification Meeting at Public Gardens, Hyderabad on 21st March 2006.

39. Dr. M.M. Mustaffa, Dr. C.K. Narayana, Dr. B. Padmanaban and Dr. K.J. Jeyabaskaran attended Banana Festival and Seminar on "Value Added Products of Banana" at Thirupparaithurai organized by Indian Potash Limited on 23rd March 2006.

40. Dr. C.K. Narayana attended the District Guidance and Coordination committee meeting of DRIP project of NABARD in office of District Collectorate, at DRDA office Trichy on 7.3.06.

41. Dr. C.K. Narayana and Dr. M.M. Mustaffa attended Banana Product Cluster Development committee meeting, at DRDA office Trichy on 7.3.06.

14 Workshops, Seminars, Summer institutes and farmers days Organized at the Institute

- Dr. C.K. Narayana conducted a training for a group of 20 members from Banana Cluster villages under NABARD scheme from 14-16th December 2005
- Dr. C.K. Narayana conducted a training for a group of 20 members from Banana Cluster villages under NABARD scheme from 19th – 21st December 2005

Inaguration of Cluster Development Programme Buyer & Seller meet - A Part of Entrerprenuership Development held at Ettarai Village, Trichy

15 Distinguished Visitors

Shri Sharad Chandra Pawar,
Hon'ble Union Minister for Agriculture, Food, Consumer Affairs and Public Distribution, Govt. of India, New Delhi.
(15th September 2005)

Dr. Mangal Rai,
Secretary, DARE and Director General, ICAR, Krishi Bhavan, New Delhi.
(15th September 2005)

Dr. Gautam Kalloo,
Dy. Director General (Hort.& CS), ICAR, New Delhi.
(15th September 2005)

Dr. E.Vadivel,
Dean (Hort.),
Tamil Nadu Agriculture University,
Coimbatore, T.N.
(7th April, 2005)

Dr. T.N Balamohan,
Professor and Head,
Dept. Fruit Crops,
Tamil Nadu Agriculture University,
Coimbatore, Tamil Nadu.
(7th April, 2005)

Dr. Jaishankar,
Asst. Professor,
Dept. of Fruits,
University of Guelph,
Canada.
(15th December 2005)

Mr. Srinivas,
Minister for Horticulture,
Government of Karnataka,
Bangalore.
(6th January 2006)

Dr. Rabindra,
Director,
Project Directorate of Biological Control,
Bangalore.
(March 2006)

Dr. S. Sathiamoorthy explaining about NRCB activities to Hon'ble Union Minister for Agriculture

16 Empowerment of Women

Empowerment of Women Through Rural Enterpreneurship

Value added Products of Banana

Two on – campus training programmes of 3 days each were conducted for 40 women of self Help groups in Andhanallur Block of Trichy district under District Industrial Project of NABARD between 14- 21st December 2005.

Inaguration of a Training Programme on Value Addition in Banana for Self Help Group Members

17 Personnel

List of scientific staffs

Name	Designation
Dr.S.Sathiamoorthy	Director
Dr.M.M.Mustaffa	Principal Scientist (Hort.)
Dr.P.Sundararaju	Principal Scientist (Nema.)
Dr.B.Padmanaban	Senior Scientist (Ent.)
Dr.S.D.Pandey	Senior Scientist (Hort.)
Dr.C.K.Narayana	Senior Scientist (Hort.)
Dr.S.Uma	Senior Scientist (Hort.)
Dr.I.Ravi	Senior Scientist (Pl.Phy.)
Dr.R.Thangavelu	Senior Scientist (Pl.Path.)
Dr.R.Selvarajan	Senior Scientist (Pl.Path.)
Dr.V.Kumar	Senior Scientist (Hort.)
Dr.K.J.Jeyabaskaran	Scientist (SS) (Soil Sci.)
Mrs.M.S.Saraswathi	Scientist (Hort.) - Study Leave
Mr.R.Natarajan	Scientist (Eco.Bot.) - Study Leave

List of Technical staffs

Name	Designation
Mr.Raghuraman	T-5 Technical officer
Mr.S.Palanichamy	T-5 Technical officer
Mr.P.Durai	T-4 Lab Technician
Mr.P.Ravichamy	T-4 Technical Asst. (Journalism)
Mrs.T.Anitha Shree	T-4 Lab Technician
Mr.D.Ramachandramoorthy	T-3 Tech. Asst (Civil Overseer)
Mrs.C.S.Jacqueline	T-3 Tech.Asst. (Computer Prog.)
Mr.R.Pitchaimuthu	T-2 Field Technician
Mr.N.Marimuthu	T-2 Field Technician
Mr.V.Selvaraj	T-2 Lab Technician
Mr.T.Sekar	T-2 Lab Technician
Mr.K.Kamaraju	T-2 Lab Technician
Mr.A.Subramanian	T-2 Driver
Mr.P.Mohan	T-2 Tractor Driver
Mr.V.Manoharan	T-2 Driver

List of Administrative, Audits & Accounts and Supporting staffs

Name	Designation
ADMINISTRATION	
Mr.B.Vijayakumar	AAO
Mr.M.Krishnamoorthy	PA to Director
Mr.R.Krishnamurthy	Upper Division Clerk
Mrs.S.Durgavathy	Lower Division Clerk
Mr.R.Sridhar	Stenographer Gr.III
Mr.M.Devarajan	Lower Division Clerk
AUDIT AND ACCOUNTS	
Smt. Gomathi	AFAO
Mr.M.Balu	Assistant
Mr.R.N.M.S. Kannan	Stenographer Gr.III
SUPPORTING	
Mr.R.Mohanraj	Mali SSG-III
Mr.V.Pandiyan	Mali SSG-III
Mr.V.Thangaraju	Messenger SSG-II
Mr.P.Kamaraj	Mali SSG-II
Mr.V.Ganesan	Mali SSG-I
Mr.C.Kumaran	Mazdoor SSG-I
Mrs.K.Mariammal	Safaiwala SSG-I

18 Other informations

Inauguration of Laboratory cum Administrative Building and Laying Foundation store for staff Quarters

The office cum laboratory building of the Centre was inaugurated by **Shri Sharad Chandra Pawarji,** Hon'ble Union Minister for Agriculture, Food, Consumer Affairs and Public Distribution on September 15, 2005. Dr. Mangal Rai, Secretary DARE and Director General, ICAR, New Delhi presided over the function. Dr.Gautam Kalloo, Dy.Director General (Hort.&CS), ICAR,New Delhi addressed the banana growers gathering. Dr.S.Sathiamoorthy, Director,NRCB welcomed the guests and Dr.M.M.Mustaffa, Principal Scientist presented a vote of thanks. While addressing the banana growers, the Hon'ble Minister stressed the need for generation of technologies to reduce cost of cultivation and use of tissue culture plants. He also released many publications of the Centre viz., Banana Indian Genetic Resources and Catalogue, 'Kela Utpaadan' (Banana Production) and Banana Nematode Management towards Eco-friendly approach. On the day of inauguration of the Lab building, a farmers' day / Kissan Mela was organized at the Centre. On this occasion an Exhibition was arranged. Many tissue culture industries, entrepreneurs involved in the production of value added products, many input suppliers participates and research activities of NRCB were displayed in the exhibition. Representatives of banana growers federation of India had a discussion with the Union Minister for increasing productivity and infrastructure for exporting bananas.

Science Day celebration

A 'Science day' was celebrated in the Centre on 28th Feb 2006. Students from different schools visited the Centre. Various research activities were explained to them by the scientists.

Hon'ble Union Minister for Agriculture inaugrating the office cum laboratory building

Hon'ble Union Minister for Agriculture releasing the new banana variety 'Udhayam'

Hon'ble Union Minister for Agriculture releasing the NRCB publication

Students visiting the research labs of NRCB

ANNEXURE - I

List of approved on going projects

I Crop Improvement

1. Management of genetic resources of banana

   Project Leader : **S.Uma**
   Project Associate : S.Sathiamoorthy

2. Crop improvement of banana through conventional breeding

   Project Leader : **S.Sathiamoorthy**
   Project Associate : S.Uma

3. Crop improvement of banana through non-conventional breeding

   Project Leader : **S.Uma**
   Project Associate : S. Sathiamoorthy

II.Crop production and Postharvest technology

4. Standardisation of agrotechniques for banana production and productivity

   Project Leader : **S.D.Pandey**
   Project Associates : M.M.Mustaffa, K.J.Jeyabaskaran

5. Integrated nutrient management in banana

   Project Leader : **K.J.Jeyabaskaran**
   Project Associates : S.D.Pandey, M.M.Mustaffa

6. Studies on micronutrients in banana

   Project Leader : **K.J.Jeyabaskaran**
   Project Associates : S.D.Pandey, V.Kumar

7. Standardization of technology for organic banana production

   Project Leader : **M.M.Mustaffa**
   Project Associates : V.Kumar, K.J.Jeyabaskaran

8. Standardization of nutritional requirements of banana using soluble fertilizers

   Project Leader : **V.Kumar**
   Project Associates : M.M.Mustaffa, K.J.Jeyabaskaran

9. Studies on physiology of flowering and fruit development in banana

   Project Leader : **I.Ravi**
   Project Associates : C.K.Narayana, S.D.Pandey,K.J.Jeyabaskaran

10. Studies on handling, storage and processing of banana

    Project Leader : **C.K.Narayana**
    Project Associate : M.M.Mustaffa

11. Standardization of storage conditions for banana

    Project Leader : **C.K.Narayana**
    Project Associate : I.Ravi

III. Crop Protection

12. Insect pest management in banana

    Project Leader : **B.Padmanaban**
    Project Associates : P.Sundararaju, R.Thangavelu

13. Studies on banana nematodes and their management

    Project Leader : **P.Sundararaju**
    Project Associates : B.Padmanaban, R.Thangavelu

14. Investigation on fungal and bacterial diseases of banana and their management

    Project Leader : **R.Thangavelu**
    Project Associate : R. Selvarajan

15. Studies on viral diseases of banana and their management

    Project Leader : **R.Selvarajan**
    Project Associate : R. Thangavelu

List of on going externally funded projects

1. Development of Sigatoka Resistant Bananas through polyploidy breeding - Funding source DBT

   P.I. : **S. Uma**
   Co. P.I. : S. Sathiamoorthy

2. Field testing of selected IMTP varieties at Farmer's field under EPMG programme - Funding source INIBAP

   P.I. : **S. Uma**
   Co. P.I. : S. Sathiamoorthy

3. Screening of nematode resistance in *Musa* - Funding source VVOB, Belgium

   P.I. : **P. Sundararaju**
   Co. P.I. : S. Sathiamoorthy

4. Transgenic in Crops – Banana Functional Genomics (Sigatoka and Drought)

   P.I. : **S. Uma**
   Co. P.Is : I. Ravi, R. Thangavelu & R. Selvarajan

5. ICAR Network project on Diagnostics of emerging plant viruses - Funding source ICAR AP Cess fund

   P.I.: : **R. Selvarajan**

6. ICAR Network project on Wilts of crops with special reference to cultural pathogenic and molecular characterization of isolates in India - Funding source ICAR AP Cess fund

   P.I. : **R. Thangavelu**

7. Soil test based integrated nutrient tailoring for optimum banana production and sustainable soil health - Funding source ICAR AP Cess fund

   P.I. : **K.J. Jeyabaskaran**

8. Net work Project on Transgenic in Crops - Transgenic Development:
   Development of streak virus and bunchy top virus resistant transgenic banana

   P.I. : **R. Selvarajan**
   Co.P.I : S. Uma

ANNEXURE - II

Meterological Data

Month/Year	Temperature in °C		Total Rainfall
	Min	Max	
April 05	34.6	26.4	28.8
May 05	37.7	27.1	35.7
June 05	36.2	28.5	-
July 05	36.8	27.1	11.4
August 05	36.6	27.7	23.0
September 05	36.9	26.3	94.3
October 05	31.7	24.4	169.0
November 05	29.5	22.5	246.1
December 05	29.0	20.0	103.8
January 06	31.2	21.3	14.6
February 06	32.6	20.1	-
March 06	35.1	23.8	4.0