NRCB

वार्षिक प्रतिवेदन
Annual Report
2003 - 2004

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

PMEC
16/3/05

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ANNUAL REPORT
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With Best Compliments

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Correct Citation : Annual Report 2003 - 2004
National Research Centre for Banana
Thogamalai Road, Thayanur Post
Tiruchirapalli -620 102
Tamil Nadu, India

Published by : **Dr. S. SATHIAMOORTHY**
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Cover photographs & design by : Dr. R. Selvarajan

Hindi Translation : Dr. S. D.Pandey and Dr. C. K. Narayana

Front Cover Page :

Inflorescence of *Ensete* sp.

Back Cover Page :

Front view of the NRCB Research Farm

Printed at : Sri Sakthi Promotional Litho Process
54, Robertson Road, R.S. Puram
Coimbatore - 641 002
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PREFACE

It is my proud pleasure to present the Annual Report 2003-04 of the National Research Centre for Banana, Trichy (TN). Though the Centre is in its early phases of development, it has a creditable record of fruitful research findings, praise worthy developmental activities, popular out-reach programmes and a strong binding with the farmers and entrepreneurs.

Banana is an important food-fruit and India is the largest producer with an uniqueness of the entire production base being polyclonal and peasantry in nature. Production systems are wider ranging from coastal belt, deep interior region to high altitude hills of upto 1500m MSL. NRC Banana considers all such polyclonal production systems while addressing biotic and abiotic constraints.

India being one of the centers of origin and diversity of *Musa,* NRCB has taken a strenuous job exploring inhospitable regions of Western and Eastern Ghats and North-Eastern hilly areas. A new wild sub species of *Musa acuminata* collected in Anamalai Hills of Tamil Nadu, appears to be a new source of resistance to Black Sigatoka leaf spot disease, opening a new avenue in the breeding for leaf spot resistance. The *Musa* gene bank consists of about 1100 accessions comprising wild and cultivars in many genomic combinations. They are being systematically characterized and conserved. To strengthen the breeding programme, a new Satellite Breeding Block has been established at 'Agali' (Kerala) at an altitude of 1000 m from MSL.

To combat drought, the Centre has successfully developed several technologies among which the standardization of a novel high density planting system coupled with micro-irrigation and fertigation deserves special mention. Development of bio-control technologies including pheromones / kairomones for stem weevil and diagnostic kit for major viruses are some of the important achievements. Value-added products from banana developed by the NRCB had fetched laurels from farmers and entrepreneurs.

In the sphere of HRD, the Centre has organized training on virus indexing to technicians of the Tissue Culture industries sponsored by FAO, GOI & NATP. In collaboration with INIBAP and VVOB, an International Training cum Workshop on "Recent advances for Eco-friendly Management of Nematodes in Banana" was organized. Paid trainings were offered to motivate entrepreneurs on production of value-added products. The Centre has been actively engaged in several out-reach programmes to transfer the technologies now and then. The Centre has organized an International Banana Breeders' Meet during June, 2003 sponsored by INIBAP. Breeders from 10 countries were participated.

I appreciate the efforts made by the Editorial and Publication Committee and all the staff members for their cooperation.

Tiruchirapalli (TN)
March, 2005

S. SATHIAMOORTHY

1 कार्यकारी सारांश

जनन द्रव्य प्रबंधः

कर्नाटक के पश्चिमीघाट, तमिलनाडु की पलनी एवं अन्नामलाई पहाडी एवं केरला का जनन द्रव्यों के लिए सर्वेक्षण किया गया। एनसिटे की एक नई प्रजाति तमिलनाडु के कोडई पहाड़ी क्षेत्र में पायी गई। पश्चिमी घाट की अन्नामलाई पहाड़ी क्षेत्र से मूसा एकूमिनाटा की एक नई उप प्रजाति एकत्रित की गयी। 6 नये जननद्रव्य आर्डटीसी से एन.बी.पी.जी.आर – नई दिल्ली के माध्यम से एकत्रित किये गये । रा.के.अनु. के. त्रिची के तीन श्रेष्ठ सेलेक्शन को 8 विभिन्न स्थानों पर मूल्यांकन किया गया। इनमें एन आर सी बी सेलेक्शन 1 को मूल्यांकन में अच्छा पाया गया। कोयम्बटूर से 35 कि.मी दूर गन्ना प्रजनन संस्थान के क्षेत्रीय अनुसंधान केन्द्र, अगली में एक सेटेलाइट प्रजनन ब्लाक की स्थापना केले में अच्छे बीज बनने के लिए की गयी, प्रथम चरण में 32 चयनित जनन द्रव्यों को लगाया गया है।

फसल उत्पादनः

विभिन्न कार्वनिक खादों का केले की करपूरावल्ली एवं रस्थाली जातियों की पेड़ी फसल पर अध्ययन किया गया। अध्ययन के परिणामों में 2.5 किलो कम्पोस्ट खाद +1 किलो वर्मी कम्पोस्ट +1 किलो नीम की खली +2.5 किलो मुर्गी की खाद प्रति पौधा तीसरे, पांचवे एवं सातवें महीनें में देने पर अच्छा उत्पादन प्राप्त हुआ। मिट्टी में वैक्टीरिया एवं फंफूद की संख्या भी इसमें ज्यादा पायी गयी, सघन केला उत्पादन एवं फर्टीगेशन के अध्ययन में 75% नत्रजन एवं पोटेशियम की मात्रा पौधों की वृद्धि के लिए अच्छी पायी गयी। लवणीय मृदाओं में करपूरावल्ली जाति पर सूक्ष्म तत्वों के प्रभाव का अध्ययन किया गया एवं पाया गया कि लोहे की 5 ग्राम प्रति पौधा मात्रा भूमि में देने से एवं जस्ते की 0.9% एवं बोरान का 4 पी पी एम (बोरिक एसिड) पर्णीम छिड़काव करने से सामान्य से 43.2 प्रतिशत ज्यादा उत्पादन प्राप्त हुआ। डिस्टिलरी इफ्लूएन्ट 30,000 लीटर / एकड़ एवं 240 ग्राम पोटेशियम प्रति पौधा देने से नेपूवन जाति में ३२ प्रतिशत उत्पादन सामान्य से ज्यादा प्राप्त हुआ।

तुड़ाई–उपरांत संभलावः

रस्थाली केले की भण्डारण एवं गुणवत्ता का अध्ययन 400 गेज पालीथीन थैलियों में वाकूम पैकिंग करके 13.5° से. तापमान पर रखकर किया गया। अध्ययन में फल 40 दिन तक हरे रहे, परंतु भण्डारण से 20 दिन बाद निकालकर सामान्य तापमान पर रखने पर केले पके नहीं। जिन केलों को सामान्य रुप से पालीथीन थैलियों में बंद करके रखा गया, बिना वाकूम उनकी भंडारण क्षमता 8 दिन रही, जब कि सामान्य केले 10 दिन तक हरे रहे। सीमेंट क्लिनफ्लू डस्ट या डिस्टिलरी इफ्लूएन्ट का अकेले या पोटेशियम के साथ प्रक्षेत्र में पौधों में डालने पर फलों की भंडारण क्षमता पर कोई प्रभाव नहीं देखा गया, परंतु फलों की गुणवता अच्छी पायी गयी। रस्थाली केले को माडिफाइड एटमासफियरिक पैकेजिंग मे 10° से. तापमान पर बिना किसी नुकसान के रखा जा सकता है। जब कि सामान्य रुप से भंण्डारित केलों में 13.5° से. तापमान पर शीत क्षति के घाव पाये गये। मोन्दन केले से किण्वित अचार तैयार किया गया, जिसमें 25% नमी, 0.7% अम्लता, 3.19% क्लोराइड, 38% तेल की मात्रा पायी गयी। अचार की गुणवता अध्ययन के आधार पर अच्छी पायी गयी।

फसल सुरक्षाः

तना बेधक कीट के नियंत्रण के लिए तना जाल (स्टेम ट्रैप) का किसान के प्रेक्षेत्र पर सफल प्रदर्शन किया गया। चकिया जाति में 5 महीने में प्रेक्षेत्र पूर्ण रुप से कीट मुक्त पाया गया। रस्ट थ्रिप्स के लिए बंच कबर (पालीथीन 100 गेज) को क्लोरोपाइरीफास एवं पैराफीन वैक्स से उपचारित करके प्रयोग करने से थ्रिप्स का प्रभाव नहीं देखा गया। तना बेधक कीट के लिए 17 जनन द्रव्यों का प्रयोगशाला में प्रतिरोधी क्षमता के लिए मूल्यांकन किया गया एवं 0265 और 0409 को कुछ प्रतिरोधी पाया गया।

केले की पांच जातियों में जैवरसायनों की मात्रा एवं उसका सूत्रकृमि से संबंधों का अध्ययन किया गया। अध्ययन में प्रोटीन की मात्रा नेन्द्रन जाति में सबसे ज्यादा पायी गयी जब कि मूसा बलबिसियाना में सबसे कम पायी गयी।

सूत्रकृमि के नियंत्रण के लिए जैव नियंत्रको के अध्ययन में वैसिलस सबटिलिस को प्रभावी पाया गया। केले के 85 जनन द्रव्यों की छटनी रुट लेजन, पी. काफी एवं रुट नाट सूत्रकृमि के लिए की गयी। जिनमें 5 जनन द्रव्यों को रुट लेजन सूत्रकृमि के लिए प्रतिरोधी पाया गया। रुट नाट सूत्रकृमि के लिए कोई भी जनन द्रव्य प्रतिरोधी नहीं पाया गया।

सिगाटोका पत्ती धब्बा रोग के लिए 700 जनन द्रव्यों की छटनी की गयी जिनमें 9 जनन द्रव्य पूर्णरुप से प्रतिरोधी पाये गये।

फ्यूजेरियम आक्सिसपोरम-1 एवं 2 (नान पैथोजनिक आइसोलेट) को ऊकठा रोग (विल्ट) के नियंत्रण के लिए अच्छा पाया गया। प्रयोगशाला अध्ययन में सोलेनम प्रजाति से प्राप्त इथाईल एसीटेट, कोलेटो ट्राईकम मूसे एवं बोट्रियोडिप्लोडिया, थिमोब्रोमी की वृद्धि को नियंत्रित करने में काफी प्रभावी देखा गया। शीर्ष विगलन रोग (क्राऊनराट) के नियंत्रण के लिए ट्राइकोडरमा विरडी का प्रभाव अच्छा देखा गया। ट्राइकोडरमा विरडी के ज्यादा उत्पादन के लिए सस्ती तकनीकि का विकास किया गया है, जिसमें किसान इसका प्रक्षेत्र पर खुद उत्पादन कर सकते हैं।

केले के शीर्ष गुच्छा रोग (बंचीटाप) से नुकसान पलनी के पहाड़ी एवं मैदानी क्षेत्रों में काफी देखा गया है। केले के बंची टाप बिषाणु (शीर्ष गु विषाणु) एवं बी.एस.वी (केले का पत्ती रोग) की पहचान (साथ-साथ) के ड्यूफ्लेक्स पीसीआर तकनीकि का वि किया गया है। मट्टी, चेनकदली, सनाचेन्क एवं कुन्नन जातियों को बी एस वी (केले पत्ती धारी रोग) से मुक्त पाया गया। केले विषाणु रोग का प्रसारण (फैलाव) मिली (फेरिसिमा विरगाटा) के द्वारा पाया गया। मि बग में विषाणु पी सी आार तकनीकि से गया। 18 जनन द्रव्यों (बी.बी.समूह) में 8 ज द्रव्य बी.एस.वी के लिए धनात्मक (पाजि पाये गये।

तकनीकि स्थानान्तरणः

रा.के.अनु. केन्द्र तिरुच्ची द्वारा विकसित अन्य उपयोगी तकनीकि के स्थनान्तरण लिए, किसान गोष्ठी, प्रक्षेत्र सलाह, आकाशव एवं दूरदर्शन द्वारा प्रसारण, प्रशिक्षण एवं प्रचार माध्यमों द्वारा सलाह दी जाती है। इ अलावा अनुसंधान केन्द्र पर प्रक्षेत्र प्रदर्शन प्रशिक्षण के द्वारा केले की उत्पादन तकनी बीमारियों एवं कीडों की पहचान, एवं केले संभलाव, भंडारण, प्रसंस्करण एवं उद्योग पर तकनीकि का प्रशिक्षण भी समय-समय आयोजित किया जाता है।

2 EXECUTIVE SUMMARY

Germplasm Management

A total of three explorations in Western Ghats of Karnataka, Lower Palani Hills of Tamil Nadu and Anamalai hills of Tamil Nadu and Kerala were undertaken. A new species of *Ensete* was recorded from Kodai Hill of Tamil Nadu. A new sub sp. of diploid *Musa acuminata* from Anaimalai Hill range of the Western Ghats was collected. It seems to be free from leaf spot diseases. Sixtyone exotic collections have been added from ITC through NBPGR, New Delhi. Twenty accessions were characterized for 120 morphotaxonomic parameters using, '*Musa descriptor*' of INIBAP/IPGRI, Rome and added to the NRCB database. Accessions numbering 138 comprising wild *Musa balbisiana* were collected from Andaman and Nicobar Islands and North Eastern States. Mysore Group (AAB) and Pisang Awak Group (ABB) accessions were subjected for RAPD marker analysis to study the genetic diversity and phylogenetic relationship. Three promising selections of NRCB have been evaluated at 8 different locations including Tripura State. The performance of NRCB Sel.01 has been very promising. To improve the seed setting in banana and plantains, a Satellite Breeding Block was established at the Sugarcane Breeding Institute, Regional Station, Agali, Kerala, 35 km from Coimbatore. In the 1st phase planting of 32 unique accessions belonging to the sub groups AA (14), AAA (2), ABB (6), AAAA (1), AAAB (1), ABBB (1), Rhodochlamys (2) and others (5) have been planted.

Production

Studies carried out on the effect of different organic manures on growth and yield of first ratoon crop of Karpuravalli and Rasthali bananas revealed that application of compost 2.5kg + 1kg vermicompost + 1kg neem cake + 2.5kg poultry manure plant^{-1} at 3rd, 5th and 7th month after planting recorded the maximum plant growth parameters, bunch weight, number of hands and number of fingers in both Karpuravalli and Rasthali bananas. Maximum bacterial population (56.33 X 10^3 CFU) and fungi (14.33X 10^5 CFU) were also recorded in the same treatment. The effect of different densities and fertigation on growth, yield and quality parameters studied in Robusta (AAA), Rasthali (AAB) and Saba (ABB) showed that maximum plant height and average leaf area were recorded in conventional planting (1.8 x 1.8 m) with 75 % N & K fertigation. A field experiment initiated to compare the foliar application of micronutrients with soil application in banana cv. Karpuravalli, under high pH soil (> 8.5) revealed that foliar application of Zn and B was found to be better than soil application, in high pH soil, based on the growth parameters. Soil application of Zn reduced P concentration of leaves of ratoon crop of Karpuravalli. Soil application of Fe (as 5 g Ferrous Sulphate/ plant) with foliar application of Zn (as 0.5 % Zinc Sulphate) and B (as 4 ppm Boric acid) recorded highest bunch weight of 12.6 kg, which is 43.2 per cent more than that of control in high pH soils. Application of distillery effluent @ 30,000 l/ac along with 240g of K/plant as KCL recorded 32% more bunch weight over control. Integration of cement kiln flue dust @ 0.5 kg/plant and distillery effluent @ 30,000 l/ac with 180g of K/plant as KCL gave additonal profit ranging from Rs.27,500 to 31,750 per hectare in Karpuravalli banana and Ney Poovan banana respectively.

Postharvest

The storage life and quality changes studied on mature Rasthali banana by using vacuum sealed 400 guage polybags and stored at 13.5°C showed that the vacuum sealed fruits though had 40 days of green life at 13.5°C; but failed to ripen when shifted to ambient condition after 20 days of storage at 13.5°C. Those sealed in polybags without vacuum had a green life of 8 days and control had 10 days green life. Cement Kiln Flue Dust or Distillery effluent alone or in combination with potassium when applied at preharvest stage did not affect the green life or yellow life significantly as compared to control. The taste of fruits was found to be relatively better in Cement Kiln Flue Dust treatment followed by Distillery effluent treatment. Modified atmosphere packaging of Rasthali banana could control the chilling injury in Rasthali banana even at 10°C. The control exhibited chilling injury even at 13.5°C after 2 weeks of storage. The fermented banana pickle was developed using Monthan banana. The fermented pickle showed 25% moisture, 0.7% acidity, 3.19% total chlorides, 38% oil content and 1.54 mgKOH/g acid values. The microbiological examination did not reveal any harmful microbes. The organoleptic score

showed that all the treatments of pickle were acceptable.

Protection

Two new minor pests were reported in banana. The banana pseudostem trap developed at the centre was successfully tested in a farmer's field at Maharajapuram in cultivar Sakkia. The stem weevil population was completely eliminated from the garden within 5 months. Bunch cover impregnated with Chloropyrifos + liquid paraffin + adjuvant has eliminated rust thrips infestation. Bunch covering also reduced the harvest time and improved the finger colour. Out of seventeen triploid accessions evaluated against stem weevil under laboratory conditions, two accessions viz., 0265 and 0409 were found moderately resistant to stem weevil and the rest were susceptible.

Among the five varieties tested for the biochemical and molecular modification between nematodes and different cultivars of banana, the cultivar Nendran (AAB) showed highest total protein content whereas minimum was noticed in *Musa balbisiana.* Increased protein content was reported in nematode infected Nendran and Robusta cultivars, but it was the reverse in cv. Pisang Jary Buaya and *Musa balbisiana.* Four biocontrol agents viz., *Pseudomonos fluorescens, Bacillus subtilis, Paecilomyces lilacinus* and *Trichoderma viride* were effective in inhibiting the hatching of root-knot nematodes. Among the four organisms tested *B. subtilis* showed better colonization than others. Out of 85 banana varieties screened for their reaction to root-lesion nematode, *Pratylenchus coffeae* and root-knot nematode, *Meloidogyne incognita,* five cultivars namely Singhlal (ABB), Sakkarachayan (AAB), Malai Kali (AAB), Manik Chempa (AAB) and Kartobiumtham (ABB) were found resistant to root-lesion nematode followed by eight varieties showing moderate resistance to *P. coffeae.* None of the varieties were found resistant to root-knot nematode, *M. incognita.*

Out of 700 *Musa* germplasm screened against Sigatoka leaf spot diseases, nine accessions were found immune to Sigatoka pathogen. Among 20 IMTP accessions screened for wilt pathogen, 11 accessions were resistant to Fusarium Wilt diseases. Pisang lilin, hitherto resistant, has become susceptible to wilt disease. Nineteen NRCB germplasm accessions mostly belonging to ABB Monthan group were susceptible to wilt. Non-pathogenic isola viz., *F.oxysporum* -1 and *F.oxysporum* -2 pro to control the wilt disease. Ethyl acet fractions from *Solanum* spp. record maximum inhibition against bo *Colletotrichum musae* and *Botryodiplo theobromae* under *in vitro* condition. Amo many *Trichoderma* spp. evaluated *in vi* against crown rot pathogen, *B.theobrom T.pseudokoningii* and *T.viride*- RT were found be effective in inhibiting the mycelial growth the pathogen. Among 60 bacterial isolat screened against crown rot pathogen, t bacterial isolates such as *Pseudomonas syring 1, P. syringae 2, P. caryophili, P. aeruginos P. syringae* 3, *P. viridiflav* and *Bacillus cereus* we found inhibiting the pathogen. Out of 1 botanicals screened against *B. theobromae, vitro,* only one ie. *Solanum nigrum* show inhibition of mycelial growth. A method mass production of *Trichoderma viride* using ri chaffy grains has been developed at the cent and the same technique could be used farmers themselves in their farm itself.

High incidence of BBTV has been record both in plains and hills of Lower Palani. As hi as 15 % BBTV has been recorded in Nadukave village of Tanjore district. A duplex PCR h been developed for detecting BSV and BB simultaneously. RT- PCR technique has be developed for detecting Banana Bract Mos Virus. Nucleic acid spot hybridizati technique has been standardized for detecti the Bunchy top virus. The diploids viz., Ma Venkadali, Sanna Chenkadali and Kunn used for polyploidization under DBT proj were found free of both episomal and integra form of BSV viral genome. The mealy b *Ferrisia virgata* found to transfer the vi among bananas. The virus was detected mealy bug *(Ferrisia virgata)* by PCR techniq Eight of the 18 BB accessions were positive BSV integrants. A non-radioactive probe h been made for part of the BSV genome. O RAPD marker has been identified differentiating the BSV infection / integration in Poovan. Meristems with size 0.5 to 0.7 mm found to be devoid of virus h culturing such small meristems in tiss culture ended in failure. BBMV has be partially purified and part of the cp gene h been amplified from it were cloned a sequenced. Similarly the BSV was partia purified from Poovan plants. The DNA isol

was used for amplification of six partial segments. The six PCR products were cloned in p-GEM -T vector and the clones have been sequenced. BBTV cp gene also cloned and sequenced for the Indian isolate.

Transfer of Technology

In order to disseminate the technology developed at the centre to the farming community various activities like on-farm advise, farmer's meeting, giving training on the identification of the diseases / nematode infested suckers were undertaken. In addition, training was also given to the small farmers and women entrepreneurs in processing and value added products including fibres.

Human Resource Development

Scientists and technical personnel were deputed for short and medium term training to upgrade their knowledge in different areas of specialisation. Consultancy projects were also carried out to test various commercial formulations.

3 INTRODUCTION

The National Research Centre for Banana (NRCB) was established on the recommendation of the Task Force Committee appointed by the Indian Council of Agricultural Research w.e.f. 21st August, 1993 and started functioning effectively from 1st April, 1994. It is located about 14 km west of Trichy (11.50 N latitude; 74.50 E longitude and 90 m above mean sea level). The centre receives a precipitation of 800-900 mm annually both from North-East and South-West monsoons. Climate is tropical with highest mean maximum temperature in April-May. The farm has a total area of 38 ha. In the last one decade, the centre has made appreciable progress with respect to infrastructural development as well as in the research.

Salient Research Achievements Since Inception

I. Genetic Management and Improvement

The research centre has the mandate to collect the available indigenous and exotic germplasm in *Musa* genome for genetic enhancement, utilization and conservation. In this connection, a total of three explorations in Western Ghats of Karnataka, Kodai Hills of Tamil Nadu and Anamalai hills of Kerala were undertaken. A new species of *Ensete* was recorded from Kodai Hills of Tamil Nadu. Identified a new diploid *Musa acuminata* from Anaimalai Hill range of the Western Ghats, which is found to be free from leaf spot diseases. Sixtyone exotic collections have been added from ITC through NBPGR, New Delhi. Twenty accessions were characterized for 120 morphotaxonomic parameters using, "*Musa* descriptor' from INIBAP/IPGRI, Rome and added to the NRCB database and 138 accessions from wild *Musa balbisiana* collected from Andaman and Nicobar Islands, North Eastern States, Mysore Group (AAB) and Pisang Awak Group (ABB) accessions were subjected for RAPD marker analysis to study the genetic diversity and phylogenetic relationship. Three promising selections of NRCB have evaluated at 8 different locations including Tripura State. The performance of NRCB Sel.01 has been very promising. To improve the seed setting in banana and plantains, a Satellite Breeding Block was established at Sugarcane Breeding Research Station, Agali, Kerala, 35 km from Coimbatore. In the 1st phase planting of 32 unique accessions belonging to the sub groups AA (14), AAA (2), ABB (6), AAAA (1), AAA (1), ABBB (1), Rhodochlamys (2) and others have been planted.

II. Production

Studied the effect of different organic manur on growth and yield of first ratoon crop Karpuravalli and Rasthali bananas. Amo organics, application of compost 2.5kg + 1 vermicompost + 1kg neem cake + 2.5kg poult manure plant^{-1} at 3rd, 5th and 7th month af planting (T8) recorded the maximum pla growth parameters, bunch weight (15.52 k number of hands (6.80) and number of fing (59.85) in both Karpuravalli and Rasth bananas. Maximum bacterial population (56 X 10^3 CFU) and fungi (14.33X 10^6 CFU) w also recorded from the same treatment. T effect of different densities and fertigation growth, yield and quality parameters studi in Robusta (AAA), Rasthali (AAB) and Sa (ABB) resulted that maximum plant height a average leaf area was recorded in conventio planting (1.8 x 1.8 m) with 75 % N & fertigation. Other growth parameters show non - significant response to the differ combination of densities and fertigation lev A field experiment was initiated to compare foliar application of micronutrients with application in banana cv. Karpuravalli, un high pH soil (> 8.5). The results revealed foliar application of Zn and B was found t better than soil application, in high pH s based on the growth parameters. It interesting to note that soil application of reduced the P concentration of leaves of rat crop of Karpuravalli. Under high pH soil, application of Fe (as 5 g Ferrous Sulpha plant) with foliar application of Zn (as 0.5 Zinc Sulphate) and B (as 4 ppm Boric a recorded highest bunch weight of 12.6 which is 43.2 per cent more than that of con The fruit quality parameters like total soli solids (TSS), acidity and TSS/acidity ratio significantly influenced by the applicatio soil or foliar application of micronutrie Application of distillery effluent (DE) @ 3 1/ac along with 80% of recommen potassium (K) as KCL recorded (32%) i bunch weight over control. Integratio CKFD @ 0.5kg/plant and DE @ 30,0001/ac 60% recommended K as KCL gave additional profit of Rs.27,500 to 31,750 hectare in Karpuravalli banana and Poovan banana respectively.

III. Protection

Two new minor pests were reported in banana. The banana pseudostem trap developed at the centre was tested in a farmer's field at Maharajapuram where in cultivar Sakkia was heavily infested with banana stem weevil. 144 longitudinal stem traps were kept in and around the garden and collected the weevil population within one month after initiation of trapping. The trap catch was gradually reduced at 5th month. Weevil population is completely eliminated from the garden. Bunch cover impregnated with Chloropyrifos + liquid paraffin + adjuvant resulted in bunches free from rust thrips infestation. Bunch covering also reduced the harvest time and improved the finger colour. Seventeen germplasm accessions belonging to triploid category evaluated against stem weevil under laboratory conditions resulted two accessions viz., 0265 and 0409 were shown moderately resistant reaction to stem weevil and the rest were found susceptible. In order to test the banana pseudostem stem trap as a delivery system for entomopathogenic nematode, *H. indica* was mass multiplied in galleria larva. The nematode suspension having infective juveniles was swabbed on the pseudostem and poured on the soil. The released weevils were checked for mortality. Observations indicated weevil mortality and emergence of entomopathogenic nematodes from the cadavers. Mutualistic bacteria from the soil inhabiting nematodes were isolated by hanging blood drop method in galleria larval haemolymph. Seven bacteria were isolated and identified.

(The biochemical and molecular modification between nematodes and different cultivars of banana were studied. Among the five varieties tested, the cultivar Nendran (AAB) showed highest total protein content whereas minimum was noticed in *Musa balbisiana*. Increased protein content was reported in nematode infected Nendran and Robusta cultivars, but the case was reverse in Pisang Jary Buaya and *Musa balbisana*. Four biocontrol agents viz., *Pseudomonos fluorescens, Bacillus subtilis, Paecilomyces lilacinus* and *Trichoderma viride* were used for controlling the root-knot nematode infesting banana. The results revealed that all the four organisms were found effective in inhibiting the hatching of root-knot nematodes. Among the four organisms tested *B. subtilis* showed better colonization compared to other organizations. Eighty - five banana varieties were screened for their reaction to root-lesion nematode, *Pratylenchus coffeae* and root-knot nematode, *Meloidogyne incognita* resulted five cultivars namely Singhlal (ABB), Sakkarachayan (AAB), Malai Kala (AAB), Manik Cempa (AAB) and Kartobiumtham (ABB) were found resistant to root-lesion nematode. The eight varieties were shown moderately resistant to *P. coffeae*. In the case of root-knot nematode, *M. incognita*, none of the varieties were found resistant.)

Screened 700 *Musa* germplasm in the filed gene bank, against Sigatoka leaf spot diseases. The results indicated that nine out of 700 accessions were found immune to Sigatoka pathogen. Among 20 IMTP accessions screened for wilt pathogen, 11 were found resistant. Interestingly Pisang lilin hitherto resistant has become susceptible to wilt disease. Nineteen NRCB germplasm accessions mostly belong to ABB Monthan group were susceptible wilt disease. Non-pathogenic isolates isolated from banana viz., *F.oxysporum* 1 and *F.oxysporum* 2 proved to control the wilt disease. Ethyl acetate fractions from *Solanum* spp. recorded maximum inhibition against both *Colletotrichum musae* and *Botryodiplodia theobromae* under *in vitro* condition. Among many *Trichoderma* spp. evaluated against crown rot pathogen, *B.theobromae* under *in vitro* condition. *T.pseudokoningii* and *T.viride*- RT were found effective in inhibiting the mycelial growth. Among 60 bacterial isolates screened against crown rot pathogen, the bacterial isolates such as *Pseudomonas syringae 1, P.syringae 2, P.caryophili, P.aeruginosa, P.syringae 3, P.viridiflav* and *Bacillus cereus* were found inhibitory to the pathogen. Out of 115 botanicals screened against *B. theobromae in vitro*, only one botanical *Solanum nigrum* showed inhibition of mycelial growth. A method of mass production of *Trichoderma viride* using rice chaffy grains has been developed and the technique has been standardized for mass production of *Trichoderma* by farmer themselves in their farm holdings itself.

High incidence of BBTV has been recorded both in plains (Karur and Tanjore) and hills of Lower Palani in Dindugal district. As high as 15 % BBTV has been recorded in Nadukaveri, Tanjore. A duplex PCR has been developed for detecting BSV and BBTV was simultaneously detected in PCR. RT- PCR technique has been developed for detecting Banana Bract Mosaic Virus. Nucleic acid spot hybridization technique has been standardized for detecting the bunchy top virus. The diploids viz., Matti, Venkadali, Sanna Chenkadali and Kunnan used for polyploidization under DBT project were found free of both episomal and integrant form of BSV viral genome. *Ferrisia virgata* found to transfer the virus from banana to banana. The virus was detected in mealy bugs *(Ferrisia virgata)* by PCR technique. Eight of the 18 BB accessions were positive for BSV integrants. A non-radioactive probe has been made for part of the BSV genome. One RAPD marker has been identified for differentiating the BSV infection / or integration in Poovan. Meristems with size of 0.5 to 0.7 mm found to be devoid of virus but culturing such small meristems in tissue culture ended in failure. Banana bract mosaic virus has been partially purified and part of the cp gene has been amplified from it were cloned and sequenced. Similarly the BSV was partially purified from Poovan plants. The DNA isolated was used for amplification of six partial segments. The six PCR products were cloned in p-GEM-T vector and the clones have been sequenced. BBTV cp gene also cloned and sequenced for the Indian isolate.

IV. Physiology and Biochemistry

The senescence studies carried out on five-month-old tissue culture Robusta (AAA) plants planted at different densities revealed that the density influenced the hastening the senescence. The Ascorbate Oxidase activity was higher in 3 plants/pit than 2plants/ pit and single plant/pit.

V. Postharvest Technology

The storage life and quality changes studied on mature Rasthali banana by using vacuum sealed in 400 guage polybags and stored
13.5°C showed that the vacuum sealed fru
though had a 40 days green life at 13.5°C; b
failed to ripen when shifted to ambie
condition after 20 days of storage at 13.5
Those sealed normally in polybags had a gre
life of 8 days and control had 10 days green li
Cement Kiln Flue Dust or Distillery efflue
alone or in combination with potassium wh
applied at preharvest stage did not affect t
green life or yellow life significantly
compared to control. The taste of fruits w
found to be relatively better in Cement Ki
Flue Dust treatment followed by Distille
effluent treatment. Modified atmosphe
packaging of Rasthali banana could control t
chilling injury in Rasthali banana even at 10
The control exhibited chilling injury even
13.5°C after 2 weeks of storage. The ferment
banana pickle was developed using Month
banana. The fermented pickle showed 2
moisture, 0.7% acidity, 3.19% total chlorid
38% oil content and 1.54 mgKOH/g a
values. The microbiological examinati
showed no presence of any spoilage microb
The organoleptic score showed that all t
treatments of pickle were acceptable.

VI. Transfer of Technology

In order to disseminate the technolo
developed at the centre to the farm
community, various activites like on-fa
advise, farmer's meeting, giving training on
identification of the diseased suckers w
undertaken. In addition, training was a
given to the small farmers and wom
entrepreneurs in processing and value add
products including fibres.

VII. Human Resource Development

Scientists and technical personnel w
deputed for short and medium term training
upgrade their knowledge in different areas
specialisation. Consultancy projects were a
carried out to test various commerc
formulations.

Budget

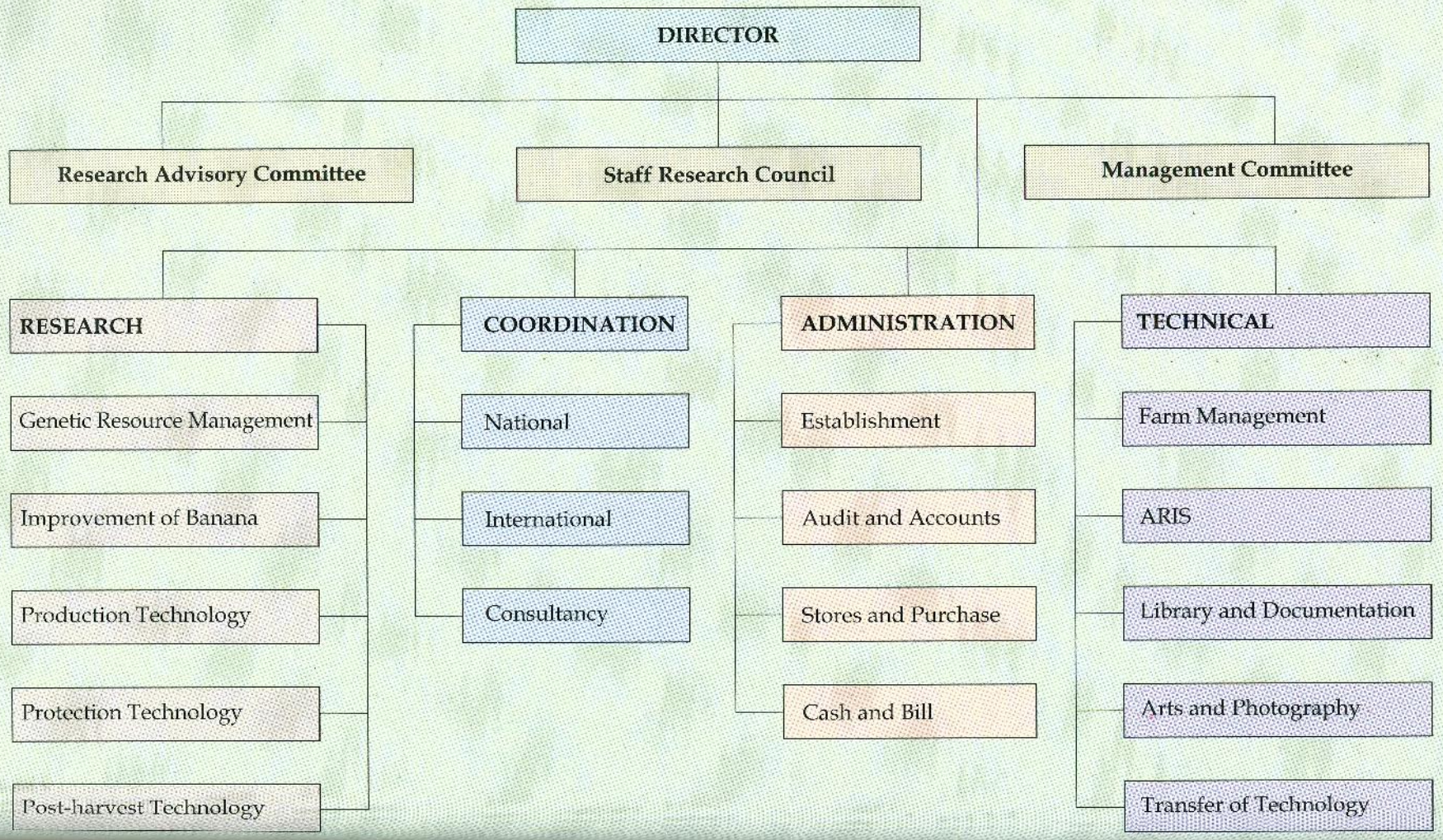
Budget and Expenditure for 2003-2004 (Rupees in lakhs)

Head of Account	Budget for 2003-2004		Expenditure 2003-2004	
	Plan	Non-Plan	Plan	Non-Plan
Esst. Charges	5.00	-	72.50	71.84
Travelling expense	3.00	3.20	0.90	1.00
Other charges	115.00	150.39	20.50	29.89
Works	15.00	5.41	-	1.00
Total	**138.00**	**159.00**	**95.00**	**103.73**

Manpower

Grade	Sanctioned	In position	Vacant
Scientific	16	14	2
Technical	15	15	-
Administration	9	8	1
Supporting	7	7	-
Total	**47**	**44**	**3**

ORGANISATION CHART



I. CROP IMPROVEMENT

1 Genetic Resource Management

(S.Uma, S.Sathiamoorthy and M.S.Saraswathi)

1.1 Germplasm collection

1.1.1 Collection through exploration

A total of three explorations in Western Ghats of Karnataka, Kodai Hills of Tamil Nadu and Anamalai hills of Kerala were undertaken during the period. During this explorations a new species of *Ensete* from Kodai Hills of Tamil Nadu was collected whose species status is yet to be ascertained. Explorations of Anaimalai Hill range of the Western Ghats, led to the identification of a new diploid *Musa acuminata* which is found to be free of leaf spot diseases but affected by stem weevil.

In Western Ghats of Karnataka exploration was conducted from Kudremukh, Kalasa, Mudigere, Ujireh and Kottigere. Wild species of banana were not found in these regions. Only seven local cultivars (AAA-1, AB-2, AAB-1 and ABB-3) of the area were collected (Table 1).

1.2 Collection through secondary sources and exotic introductions:

NBPGR regional station in Thrissur supplied 208 accessions to NRCB which are maintained in field genebank. Sixtyone exotic accessions have been obtained from International Transit Centre (ITC), Belgium through NBPGR, New Delhi.

Table 1. Details of accessions collected during 2003-2004

Source of collection	Details of accessions collected
Through explorations	
Kodaikanal hills, Tamil Nadu	*Ensete spp(?)*
Anaimalai Hills, Kerala	*Musa acuminata*
Western Ghats, Karnataka	Boothi Bale, Kalyan Bale, Kari Bale, Mysore Puttabale, Pacha Bale, Putta Bale, Salem Puttabale
Through Secondary sources	
NBPGR, Thrissur	Ashybatheesa, Bainsa, Bargi Bale, Beula, Bodles Altofort, Chakkarakeli, Champa, Chandra Bale, Charakkali, Chikke Bale, China Bale, Desi Malbhog, Dudhsagar, Elavazhai(2), Ennabenian, Gauria, Govakkai, Haneji, Kachkola, Kali(2), Kali Bale, Kalibow, Kanchi Kela, Kappavazhai, Kari Bale, Karimpoovan, Karimkadali, Karpuravalli(12), Kattu Bale, Klue Teparot, Kola, Koombillakkai, Krishnavazhai, Kunnan(3), Lalkela, Madavazhai, Madhubhas, Malaikali, Malai Monthan, Malavazhai, Malbhog, Mannan, Manoranjitham, Manua, Marthman, Mas, Mathuraannan, Matti, Monthan (13), Morris, Mungrekela, *Musa balbisiana*, Nadu (3), Nattuvazhai(2), Nendra Padathi, Nendran, Njalipoovan(14), Octoman, Ottunadu(3), Pachakappa(2), Pachanadan(12), Padalimoongil, Padathi, Palayankodan(3), Palur, Perumpadali, Pettavazhai, Peyan, Pidi Monthan, Pisang Awak, Pisang Seribu, Podhamanua, Poonkali, Poonkannan Kadali, Poovan(21), Rajavazhai, Rasthali(15), Red banana(2), Redjasiree, Saguakol, Sakkai(9), Sampranipoovan, Sawakol, Senna Chenkadali, Sirumalai, Sivakasiottu, Thekkantaleda, Thenvazhai, Tongat, Tulasimalbhog, Valiyakunnan, Vannan, Vannan-NL, Velipadathi, Vineethmannan, Wather.

Source of collection	Details of accessions collected
NBPGR, New Delhi	2390-2, Amas (South Jahnstone), Bata Bata, Cachaco(2), CRPB 3 FHIA - 21 (# 68), FHIA 01(2), FHIA-02, FHIA 03, FHIA-18(3), FHI 25(2), GCTCV-119, Green Red, *M.ac.ssp.banksii* x *M.*, Gros Michel(Guyod, Lep Chang Kut, *M.ac.ssp.burmaniccoides* (Calcutta-4)(2) *M.ac.ssp.microcarpa* type Borneo, *M.acuminata ssp.zebrina, Musa ssp. truncata, Musa ac. ssp. zebrina, Musa maclayi ssp.ailuluai, Mu peekelii ssp.peekili,* Njombe(2), Pa (Mysore) no. 3 x, PA 03-22, PC 12-0 Pisang Berangan, Pisang Ceylan, Pisang Cici Alas, *M.ac.ssp.banksi* M., Pisang Lilin(2)

(Figures in the paranthesis are number of accessions in the same name)

1.2. Conservation

Germplasm collected during the exploration are conserved at NRCB field genebank and are also maintained at Gudalur, Tamil Nadu.

1.3. Characterisation

1.3.1. Morphotaxonomic characterisation

Twenty accessions were characterized for 120 morphotaxonomic parameters using, "*Musa* descriptor' from INIBAP/IPGRI, Rome and added to the NRCB database

1.3.2 Molecular characterization

One hundred and eight samples consisting of 13 pure wild *Musa balbisiana* collected from Andaman and Nicobar Islands, 16 wild types from North Eastern States, 36 Mysore (AAB) and 43 Pisang Awak (ABB) group accessions were subjected for RAPD marker analysis to study the genetic diversity and phylogenetic relationship.

Fresh leaf samples (cigar leaf) were used for the isolation of DNA. Isolated DNA was treated with RNAase. It was further purified and the resultant DNA was dissolved in nuclease free water and stored at 20°C. DNA samples were diluted in the ratio of 1:250 and quantification was done using spectrophotometer. Based on the quantification data, appropriate quantity of template DNA was used for PCR amplification. The amplified samples were run in agarose gels and the banding patterns were documented using Alpha Image Analyser.

PCR bands from individual plants were scored as either present (1) or absent (0). Analysis of similarity matrix within the NTSYS program, using the unweighted pair-group method with arithmetic averages (UPGMA), to determine values of genetic distance.

Cluster analysis with RAPD markers

Musa balbisiana (BB) accessions

The genetic diversity, phylogene relationship in relation to their place of ori and geographical distribution were analys Further, the selected diploid cultivars w tested with 4 selected random primers (O 11, OPB-04, OPC-04 & OPD-03).

A total of 48 amplified fragments w detected with an average of 20 per cent source of collection. The result from electrophoresis is shown in Fig. 1. Among amplified fragments, 39 (82%) w polymorphic of the size ranging between bp to 2.4 Kb with an average of 19.5 perc per source of collection. The avera polymorphism among the amplified mark exhibited 81.65 percent showing the existe of considerable variation not only at genome level but also with the geographi distributions. The results of the tree mat clearly indicated the clustering of test clo into two major clusters. The two major clust were recognized as (1). 16 types of wild *M balbisiana* subspecies from Indian mainland; 13 wild types from Andaman & Nicol Islands.

The overall diversity of *Musa balbis* clearly indicates the regional distinctn between the accessions from both Ind mainland and Andaman and Nicobar Islan But within the Indian mainland the collecti from Western Ghats and North Eastern Sta exhibited genetic relatedness suggesting t the place of origin for *Musa balbisiana* could one common place but diversified in th different regions like Western Ghats of Ke and Karnataka, Eastern Ghats in And

Pradesh and Orissa and North Eastern States. Andaman and Nicobar could be another centre where origin and diversifications occurred parallel with Indian mainland.

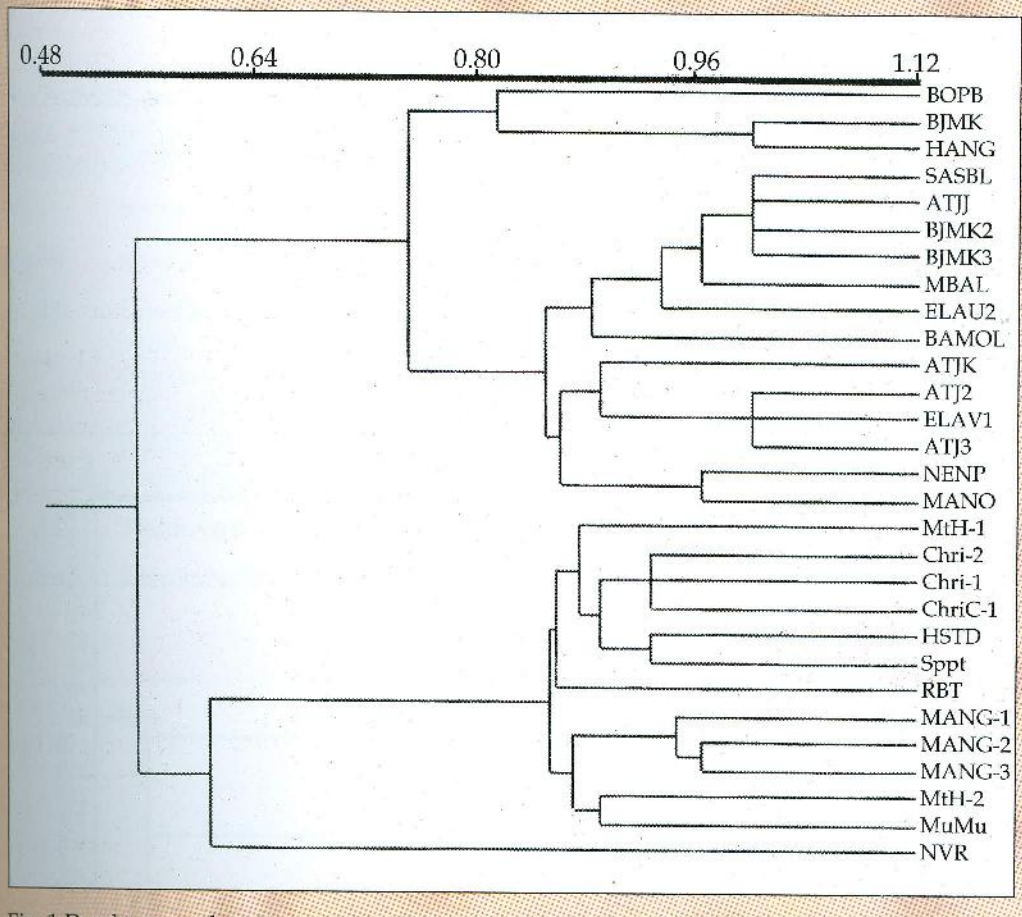


Fig. 1 Dendrogram showing genetic relationships among 29 wild *Musa balbisiana* diploids using UPGMA cluster analysis.

Mysore group (AAB)

The genetic diversity and phylogenetic relationship was analysed for 36 accessions. Among the six selected random primers (OPA-11, OPD-06, OPD-18, OPK-04, OPK-19, OPK-07), five primers produced concurrent results except OPK-07.

The results of the tree matrix clearly indicated the clustering of test clones into five major clusters (Table 2). The phylogenetic tree constructed by the UPGMA method is shown in figure 2.

Table 2. Clustering pattern of Mysore sub group accessions

Cluster	Members
Cluster 1	Chandan, Poovan (0197), Jatikal, Chenichampa (0015), Chenichampa (0041), Gar Moina, Dasaman, Alpon, Mysore Kadali, Champa (0143), H-2 (0230), H-2 (0210), Chakkara Kunnan, Karpura Chakkarakeli, Lalvelchi, Poovan (0294), Kottavazhai, Palayankodan.
Cluster 2	Borchampa.
Cluster 3	Soneri, Champa (0330), Chandra Bale (0422), Mysore Bale, Poovan (0595), Poovan (0568), Motta Poovan, H-2 (0477), Terabun, Chenichampa (0601), Mysore Chandra Bale (0485), Ladiya Champa, Poovan (0613), Pisang Ceylan (0653).
Cluster 4	Pisang Ceylan (0646).
Cluster 5	H-2 (0545).

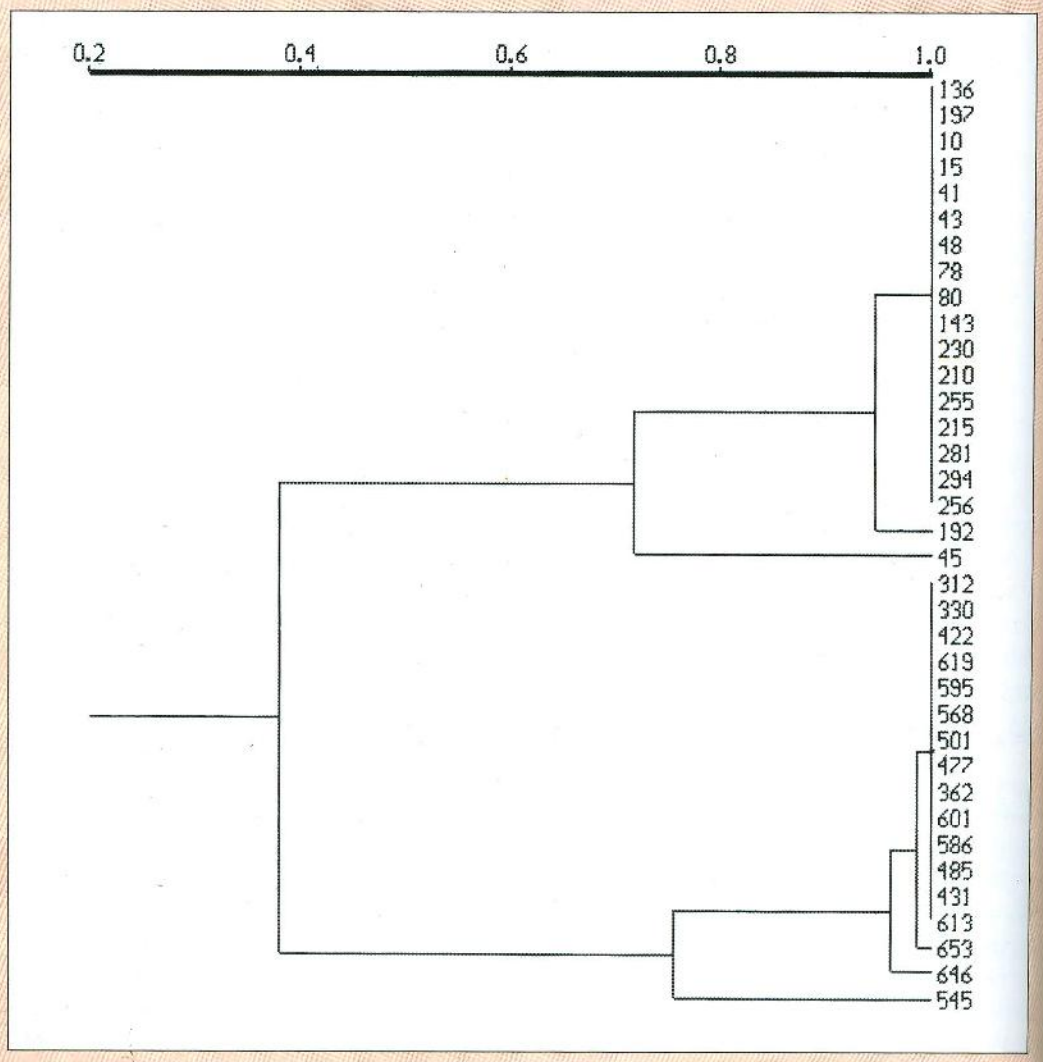


Fig. 2 Dendrogram showing genetic relationships among 36 Mysore (AAB) group accessions using UPGMA cluster analysis.

Pisang Awak (ABB)

The genetic diversity and phylogenetic relationship were analysed for 43 accessions. Among seven selected random primers (OPA-11, OPA-13, OPC-16, OPC-17, OPD-03, OPD-06 and OPD-18), only four primers produced concurrent results except OPD-03, OPA-13, OPC-16.

The results of the tree matrix clearly indicated the clustering of test clones into two major clusters (Table 3) and cluster 2 with four minor clusters. The phylogenetic tree constructed by the UPGMA method is shown in figure 3.

Table 3. Clustering pattern of Pisang Awak sub group accessions

Cluster	Members
Cluster 1	Boothi Bale (0517)
Cluster 2 a	Agni Malbhog, Kanthali, Nepali Vannan, Gouria, Kanchi Kela (0342)
2 b	Deshi Kadali, Kanchi Kela (0108), Mas (0181), Octoman, Boddida Bukkisa, Dakshin Sagar, H-6, Mortman, Vella Palayankodan, Poombidiyan, Ban Kela, Ankur-II, Ladisan, Boothibale (0625), Ankur-I, Shahil Baig, Eni Komban, Amrithapani, Dinamalakol, Gera, Chinia (0087), Enna Benian, Shalil Kela, Calananul, Vananth purani, Boothi Bale (0584), Battisa Piro, Bhurkel (0157), Karpooravalli (0173), Jammulapalem Collection, Karpooravalli (0291), Geda, Bhurkel (0551), Mas (0561)
2 c	Bhurkel (0341), Chinia (0347)
2 d	Karpuravalli (0494)

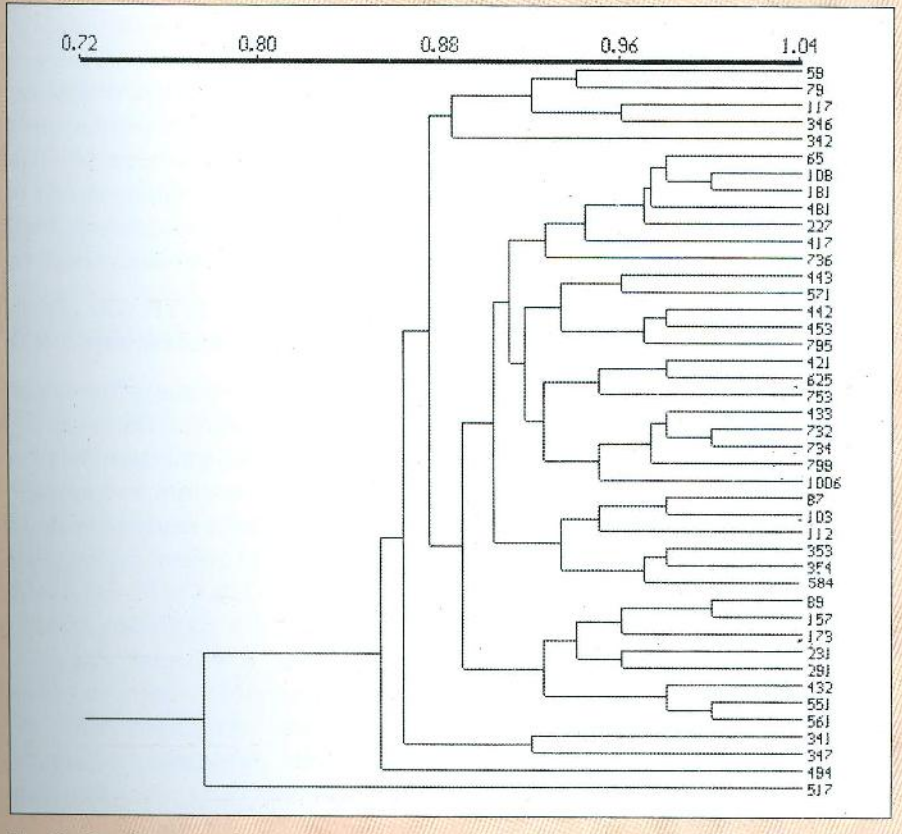


Fig. 3 Dendrogram showing genetic relationships among 43 Pisang Awak (ABB) group accessions using UPGMA cluster analysis.

1.4. Evaluation

Three promising selections of NRCB were evaluated at 8 different locations including Tripura State. The performance of NRCB Sel.01 has been very promising. Results received from all the 5 AICRP (TF) centres showed that NRCB Sel. 01 was the best.

Under International *Musa* Testing Programme (IMTP), a total of 21 accessions were evaluated against Sigatoka and 11 accessions against wilt at two test locations.

1.4.1 Screening against biotic stresses

Crop protection scientists, evaluated germplasm against stem weevils under laboratory conditions, screened against Sigatoka leaf spot diseases and fusarium wilt under field conditions. Screening against nematodes were also under taken under field and green house conditions. The results of the screening test are given in Table 4.

Table 4. List of germplasm accessions screened against stem weevil.

Accession number	Per cent feeding	Susceptibility
0126	27.4	HS
0156	25.0	S
0228	26.6	HS
0395	45.8	HS
0435	35.0	HS
0436	23.0	S
0522	42.0	HS
0652	31.2	HS
0123	31.8	HS
0131	37.3	HS
0172	42.5	HS
0223	24.0	S
0244	21.9	S
0265	14.9	MR
0408	36.3	HS
0409	15.5	MR
0509	17.0	MS

HS-Highly Susceptible, **S**-Susceptible,
MR-Moderately Resistant,
MS - Moderately Susceptible.

Evaluation of *Musa* germplasm agai banana stem weevil, *Odoiporous longico* under laboratory conditions (B.Padmanaba

Seventeen germplasm accessions belonging triploid category were evaluated against st weevil under laboratory conditions. It is s from Table 5 that minimum feeding v recorded in accessions number 0265 (14.9 cent) and maximum feeding was recorded accession number 0395 (45.8 per cent)

Screening of germplasm against Sigatoka l spot disease and Fusarium wilt under fi conditions (R.Thangavelu).

Totally about 700 germplasm, which are bei maintained in the field genebank, w evaluated for their reaction to Sigatoka leaf sp disease as per INIBAP guidelines. T screening studies resulted in the identificati of 9 immune accessions viz. Kalibun (AA 0574 & 0133, Dudhsagar (AAB)-0374, Pisa Rajah (AAB)-0217, Kalibow (AAB)-02 Pisang Seribu (AAB), Thiruvananthapur (AAB)-0125, Thiruvannanthaspulam (AA 0031, Klueteparot (ABB)-0253.

Sick plot of Fusarium wilt of race 1 and were created artificially and germplasm about 257 accessions of 6 categories viz. A AA, BB, AAB, ABBB, AAB unique type from field gene bank were planted and evaluated their reaction to Fusarium wilt Pathogen. It found that 19 accessions mostly belong to A Monthan group were susceptible to this dise and remaining are in the process of evaluatio

Evaluation of IMTP wilt accessions agai Fusarium wilt disease (race-1 & 2)

Totally 20 accessions were evaluated under culture condition. The race 1 & 2 of Fusarium wilt pathogen were multiplied sand maize medium and applied @ 30 g/p The result of the study indicated that out o accessions, 11 accessions viz., FHIA-17, FH 23, GCTCV-119, GCTC-215, Pisang Jwarib Calcutta-4, PA-03, Pisang Mas, Cultivar R Yankambi KM-5 and Pisang Ceylon w found resistant to fusarium wilt as they did show any symptoms both internally externally. Interestingly Pisang Lilin hith resistant has become susceptible to wilt dise (score-2).

Screening of germplasm against Nematodes
(P.Sundararaju)

Totally eighty five banana varieties were screened for their reaction to root lesion nematode, *Pratylenchus coffeae* and root-knot nematode, *Meloidogyne incognita* in pots under greenhouse conditions. The results revealed that five out of 85 varieties namely Singhlal(ABB), Sakkarachayna(AAB), Malaikala(AAB), Manikchampa(AAB) and Karthobium tham(ABB) were found resistant to root lesion nematode followed by eight and 11 varieties were shown moderately resistant and tolerant reaction to *P.coffeae* respectively. None of the varieties tested against root-knot nematode were found resistant.

Screening of IMTP Phase-III Musa accessions against major nematodes infesting banana

Twenty one global hybrids and cultivars of banana under IMTP Phase III were screened for their reaction to root-lesion nematode, *P. coffeae*; root-knot nematode, *M. incognita* and spiral nematode, *H. multicinctus* in pots as well as under field conditions. The results revealed that all the 21 cultivars and hybrids were found susceptible to root-knot nematode. Whereas the root-lesion nematode, *P. coffeae* was recorded in 19 out of 21 cultivars. This nematode was not recorded in cultivars namely Kanai Bansi and GCTCV 215. The spiral nematode, was recorded in 15 out of 21 cultivars in various intensities. The six cultivars namely Anaikomban, Pisang Berlin, Namarai, Hatidat, FHIA 03 and Pisang Ceylan, were found resistant to *H. multicinctus*.

1.5 Germplasm supplied to other centres

During this reporting period NRCB has supplied 109 accessions to NFTCR, NBPGR, New Delhi for *in-vitro* conversation.

Twenty one accessions were supplied to Kittur Rani Channamma College (UAS, Dharwad) under AICRP (TF) for evaluation. Planting materials of two NRCB selections have been provided for evaluation under North-Karnataka conditions.

1.6. Documentation

Database has been updated for 90 accessions using MGIS software.

2. Crop Improvement through Classical Breeding

(**S.Sathiamoorthy,** S.Uma and M.S.Saraswathi)

To improve the seed setting in banana and plantains, a Satellite Breeding Block was established at Sugarcane Breeding --- Research Centre, Agali, Kerala. In the 1st phase planting of 32 unique accessions belonging to the sub groups AA (14), AAA (2), ABB (6), AAAA (1), AAAB (1), ABBB (1), Rhodochlamys (2) and others (5) have been planted.

Screening of germplasm has led to identification of 240 male and 63 female fertile accessions. Screening involved pollen output per anther, pollen fertility and germinability.

Inter diploid crosses were made using 16 'AA' diploids. Crosses involving H-201 (3 way cross) with Pisang Lilin (AA) was made and viable seeds @ 5-7 seeds per fruit were obtained. H-201 was also crossed with cv. Matti (AA) and seed set was 3/fruit.

Crosses involving wild *M.ornata* (Rhodochlamys section) were made with Eumusa diploids and seed set was observed. Crosses made during 2003-04 is furnished in table 5. Totally 675 crosses were made using Anai Komban, Matti, Kanai bansi and Cultivar Rose. Presently 50 hybrids obtained are being evaluated (Table 5).

Table 5. The following crosses were made during 2003-2004

Sl.No.	Cultivars	No. of crosses made	Hybrids under evaluation
1.	Anaikomban x Matti	100	3
2.	Anaikomban x Kanaibansi	150	2
3.	Anaikomban x Cultivar Rose	125	4
4.	Cultivar Rose x Matti	100	8
5.	Cultivar Rose x Kanaibansi	150	14
6.	Matti x Cultivar Rose	50	21
	Total	**675**	**50**

3. Crop improvement through non-conventional approaches

(**S.Uma,** M.S.Saraswathi and S.Sathiamoorthy)

3.1 Establishment of Cell Suspension Culture

The male flower buds and young leaf primordial raised callus were used for the establishment of cell suspension culture. MS Medium with different conc. (i.e., Full strength, half strength and quarter strength) were used for cell suspension culture. Among these three media concentrations half strength MS macro and full strength MS micro elements with 30g/l sucrose were found successful for the establishment of cell suspensions cultures. Callus cultures raised from the above two explants at various growth regulator concentrations were tried. The callus materials raised from 5 mg 2-4D and 1mg/l picloram concentration MS medium from leaf explants successfully transferred to cell suspension medium and survived. The growth regulators plays a major role in the establishment of cell suspension culture. The optimal concentration for establishment of cell suspension is 1.1mg/l 2-4 D and the addition of zeatin 0.25 mg/l has improved the cell division of suspension cultures. The callus cultures established from various concentrations of 2-4D (1,2,3 and 4 mg/l) of leaf explant have failed to survive in the suspension cultures established in the same 2-4 D concentrations from male flower bud also failed to establish the cell suspension cultures. Two-three months required to establish cell suspension cultures irrespective of the explants used for callus induction. Establishment of somatic embryos from these suspension cultures are in progress.

3.2 Establishment of embryo culture

The surface sterilization procedures of banana seeds were standardized. Sodium hypochloride (5%) and Mercuric chloride (0.1%) was found suitable for the sterilization of embryos.

A protocol has been developed to germinate the embryos under modified MS medium (Fig.4). MS medium and modified MS medium with higher concentrations of colchicine (10mM) and knudson medium with lower concentration of colchicines hastened development of embryos. But some cases colchicine suppress the embryos development (eg. Athiakol). Influence of GA3 in shoot

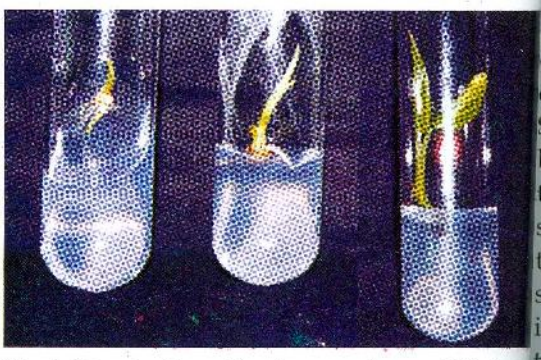


Fig. 4 Germination of embryo under modified MS medium

elongation of germinated shoots was studie Ensete seeds collected from Kodaikanal an wild seeds collected from Andaman an Nicobar Islands were germinated.

Effect of media and Colchicine on embryo germination, development and polyploidisation

Open pollinated fruits of Pisang Jaji (AA) an Athiakol (BB) were harvested at matured sta and the seeds were extracted. Embryos we treated with different concentrations Colchicine viz., 5mM, 7.5mM and 10mM an kept in shakers at 100 rpm for 12 hours an cultured using three different media vi Murashige and Skoog (MS) (1962), Modifi MS Medium (MMS) and Knudson C mediu (1952). MS and MMS at 10mM Colchicine an 5mM of Colchicine in Knudson C mediu hastened development and the rest delay development in Pisang Jaji. But in Athiak Colchicine treatment was found to suppr growth and development of embryos in all t three media tried.

Direct regeneration of shoots from male flo hands of banana

A protocol has been standardized to regener shoots directly from the floral hands a multiply banana shoots. The terminal m flower bud of the banana diploid cultiv Anaikomban (AA) and Kanaibansi(AA) w collected from field grown plants after t completion of the female phase in the bun The bracts were removed carefully and t hands containing flower buds ranging fr 2mm to 10mm were removed without dam to floral hands. The floral hands w inoculated in MS medium containing vari combinations of 6-benzyl adenine (B adenine sulphite (ADS) and naphthalene ac

acid (NAA) at different concentrations. After one month the bulged floral hands produced corm like undifferentiated structures (Fig.5). Shoot formation began with the appearance of bud-like structures from the corm tissues. As the buds grew in size, they became green and in some cases the shoots are white in colour and they turned into green after four weeks. The shoot buds are visible after two months of inoculation of floral hands. In our observation, the floral hands below 0.5cm produced shoot buds and rest of the bigger floral hands differentiated into full flowers and not produced any shoot buds or shoots. It was observed that the shoots were originated from the corm like structures without forming callus tissues. The concentration of growth regulator

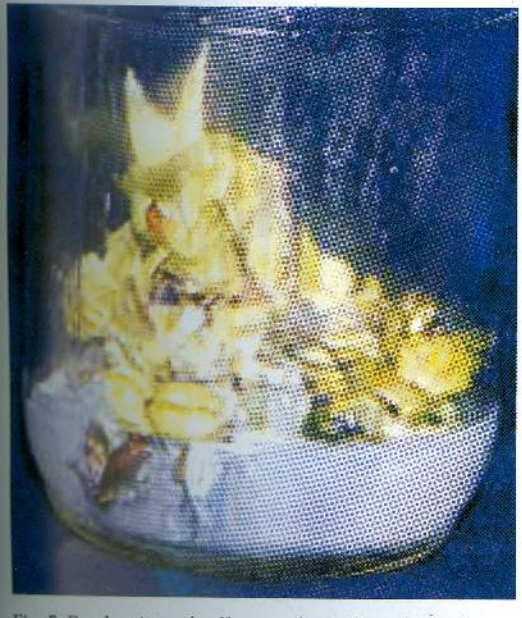


Fig. 5 Production of cell mass from floral hands

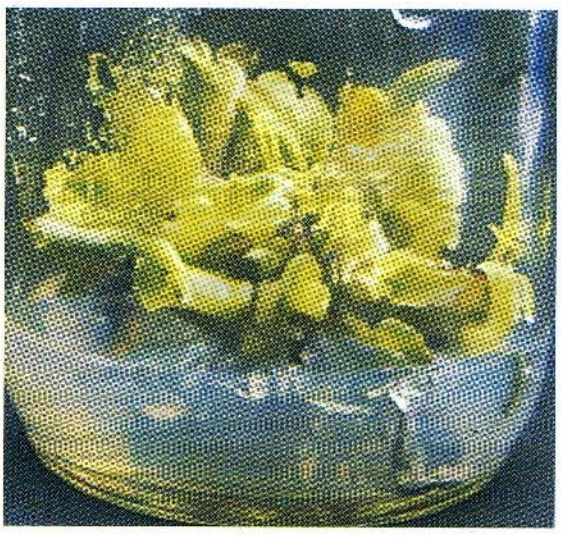


Fig. 6 Shoots produced from floral explants

played a major role in shoot bud production from the floral hands of banana. The increase in the concentration of BA increased the percentage of response and numbers of shoots were produced upto 5 mg/l BA concentrations. The numbers of shoots were increased significantly when ADS were supplemented to the regeneration medium. Few scalpel incisions transferred to the MS medium with reduced concentrations of BA (3 mg/l) improved the multiple shoot production (Fig.6). The multiplication was observed even after five passages. The multiplication ratio of the shoot was about 1:7 and this ratio was observed till the fifth passage of subculture.

II. CROP PRODUCTION

1. Production Techonology

1.1 Standardization of technology for organic banana Production

(**M.M.Mustaffa,** V.Kumar and K.J.Jeyabaskaran)

A field study was conducted to find out the effect of different organic manures on growth and yield of first ratoon crop of Rasthali and Karpuravalli. Among organics, application of compost 2.5kg + 1kg vermicompost + 1kg neem cake + 2.5kg poultry manure per plant at 3rd, 5th and 7th months after planting (T8) recorded the highest plant height, girth, number of leaves and total leaf area at the time of flowering. Maximum bunch weight (15.52 kg), number of hands (6.80) and number of fingers (59.85) were recorded in treatment T8 (combination of all organic manures). In Karpuravalli also, maximum bunch weight (15.6), number of hands (7.22) and number of fingers (65.45) were recorded in T8 (combination of all organic manures). Highest fruit quality was recorded in plants applied with organic manures.

In Rasthali and Karpuravalli, maximum bacterial population (56.33 X 10^3 CFU) and fungi (14.33X 10^6 CFU) were recorded in the treatment 2.5kg compost+ 2.5kg poultry manure applied in 3 splits (T7) followed by T8 (combination of all organic manu application) (Fig. 7&8). Maxim actinomycetes population was recorded in combination of all organic manures. The lo population of bacteria, fungi a actinomycetes were observed in neem c applied @ 2 kg / plant (Fig. 9).

In both cultivars, nine species of bact viz., *Azatobactor vinelandii, Corynebacter xerosis, Esherichia coli, Flavobacterium odorat Micrococcus luteus, Pseudomonas caryophilli diminuta, Proteus vulgaris* and four species *Aspergillus niger, Aspergillus terreus* and species of Azospirillum viz., *Azospiril oryzae, Absidia sp., Achyla sp.,* and *Pencil jasminillum* were recorded.

The major nutrient viz., N, P, K, Ca and concentration were analysed in leaf blade, rib and petiole and maximum concentratio the above nutrients were recorded from 100 cent inorganic fertilizer application in b Karpuravalli and Rasthali. Among the orga manure application, combination of all orga manure (T8) recorded the maximum nutrient contents. The maximum Cu and contents were observed in 100 per c inorganic fertilizer application.

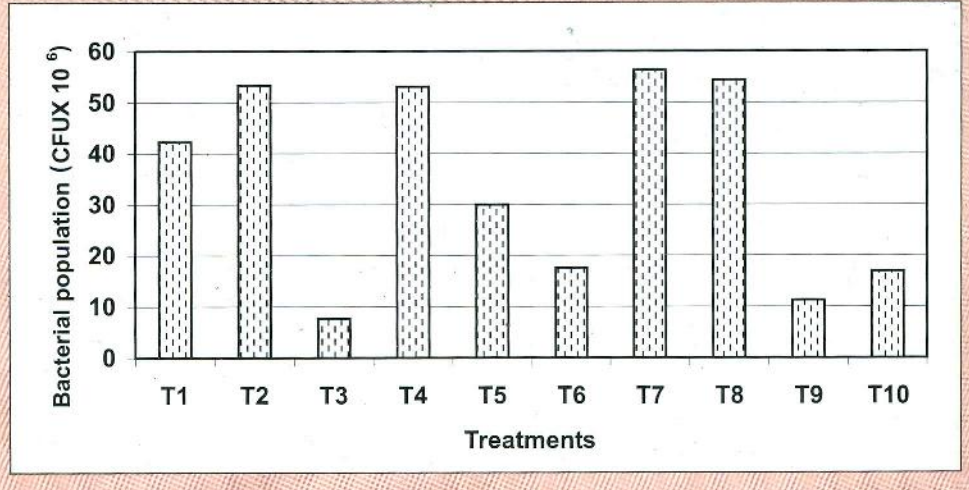


Fig. 7 Effect of different organic manure on bacterial population (CFU X 10^6)

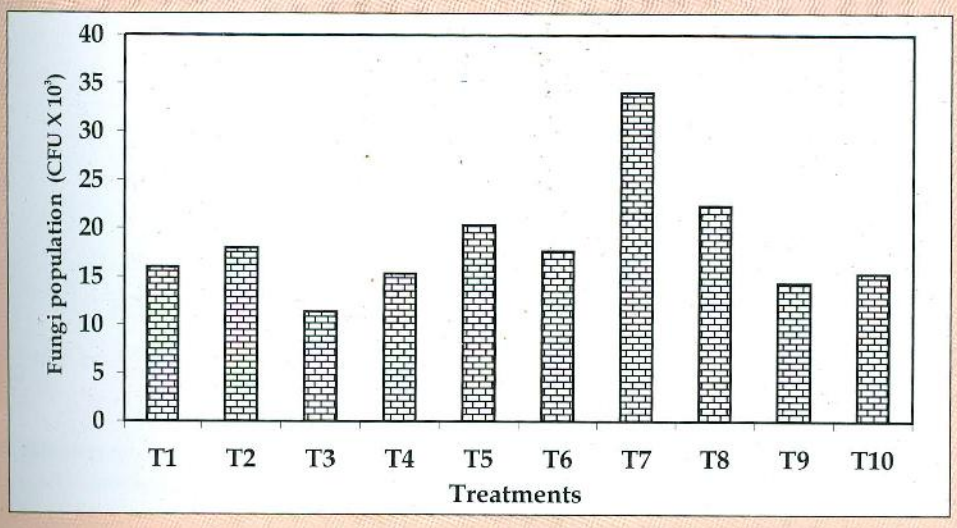


Fig. 8 Effect of organic manure on fungi population (CFU X 10^3)

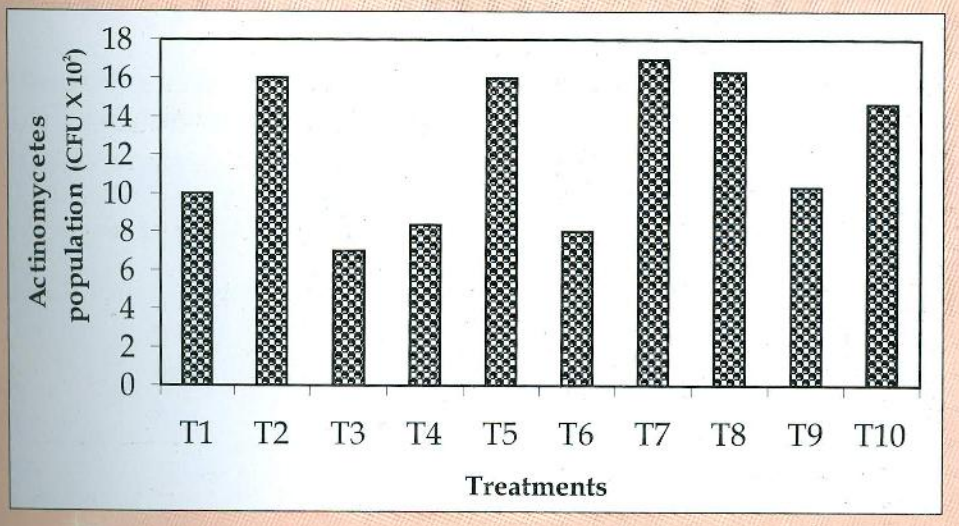


Fig.9 Effect of organic manure on Actinomycetes population

1.2 High density planting and fertigation

(**S.D.Pandey**, K.J.Jeyabaskaran and S. Sathiamoorthy)

Field experiments on high density planting and fertigation were conducted in three banana cvs, Robusta (AAA) (Fig. 12), Rasthali(AAB) and Saba (ABB) cooking banana to study the effect of different fertigation levels and impact of high density planting on growth, yield and quality parameters and nutrient status of soil and leaf.

1.2.1 Effect of different densities and fertigation on growth, yield and quality of Robusta banana (AAA)

The result obtained on growth param under various densities and fertigation levels depicted in table 6 indicated the significant response of densities and fertigation on height and leaf area at 7th month stage. Maximum plant height (2.25 m) and average leaf area (1.12 m) were recorded in conventional planting (1.8 x 1.8 m) with 75 % N & K fertigation. Other growth parameters showed non - significant response to the different combination of densities and fertigation levels.

Table 6. Effect of densities and fertigation on growth (7th month) of Robusta (AAA)

Treatments	Height (m)	Girth (cm)	Functional Leaves	Phyllochron	Leaf area (m
T_1	2.05	66.12	13.64	4.00	1.01
T_2	2.25	68.22	14.18	4.20	1.12
T_3	2.01	67.42	13.54	4.05	1.05
T_4	1.90	65.60	13.60	4.04	1.00
T_5	1.92	67.50	13.56	4.01	0.95
CD @ 5%	10.982	NS	NS	NS	0.065

T_1 Conventional 50% N&K fertigation; T_2 Conventional 75% N & K fertigation; T_3 Conventional 100 N & Fertigation; T_4 2 Suckers / hill 75% N & K fertigation; T_5 3 Suckers / hill 75% N & K fertigation

1.2.2 Effect of different densities and fertigation on growth, yield and quality of Rasthali ban (AAB)

(**S.D.Pandey,** K.J. Jeyabaskaran and M.M. Mustaffa)

Observation recorded on various growth parameters in cv. Rasthali (AAB) is presented in Table 7. The results revealed non significant response of different densities and fertigat levels at 7th month growth stage (Fig. 10&11).

Table 7. Effect of densities and fertigation on growth (7th month) of Rasthali Banana (AAB)

Treatments	Height (m)	Girth (cm)	Functional Leaves	Phyllochron	Leaf area (m
T_1	176.40	59.18	16.10	4.48	0.71
T_2	169.75	56.18	16.90	4.07	0.64
T_3	176.85	55.85	18.50	4.43	0.67
T_4	179.88	54.28	18.88	4.45	0.65
T_5	162.98	50.58	18.78	4.83	0.58
CD @ 5%	NS	NS	NS	NS	NS

T_1 Conventional 50% N&K fertigation; T_2 Conventional 75 N&K fertigation; T_3 Conventional 100 N&K fertigati T_4 Paired row 75% N&K fertigation; T_5 3 Suckers / hill 75% N& K fertigation

Fig. 10 Paired row planting in cultivar Rasthali

Fig. 11 Planting three suckers per hill in cultivar Rasthali

1.2.3 Effect of different densities and fertigation on growth and yield of banana cv. Saba (ABB)

(**S.D.Pandey,** K.J. Jeyabaskaran and M.M. Mustaffa)

An experiment was conducted to evaluate the performance of cooking banana cv. Saba (ABB) under two densities (conventional 3086 plants/ha and paired row 5200 plants/ha) (Fig.13). Conventional planting with 3 fertigation levels of N and K (50, 75 and 100 % of recommended dose 200:300 g / plant) was compared with paired row planting with 75 % fertigation level of N & K. Growth parameters showed non significant response to the various densities with different fertigation levels at 9th month growth stage except number of functional leaves which was recorded maximum in conventional planting with 75 % fertigation of N & K.

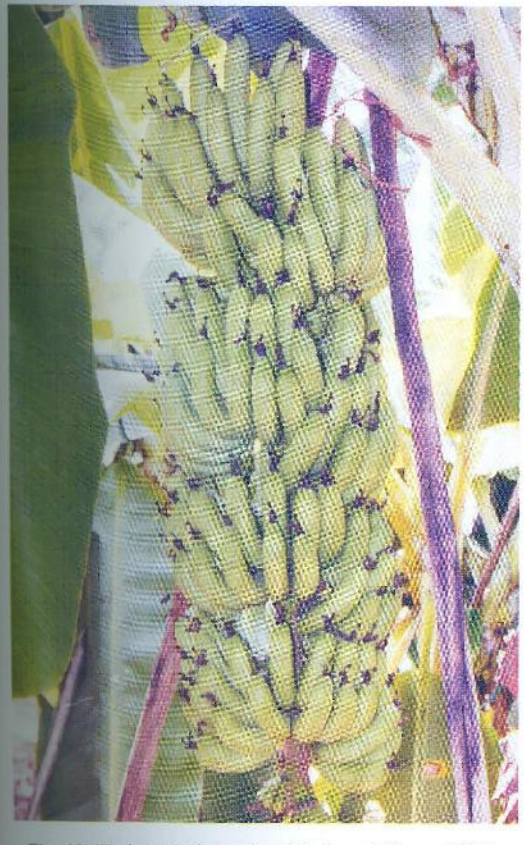


Fig. 12 'Robusta' bunch obtained from 75% N & K fertigation in conventional planting (1.8 m x 1.8 m)

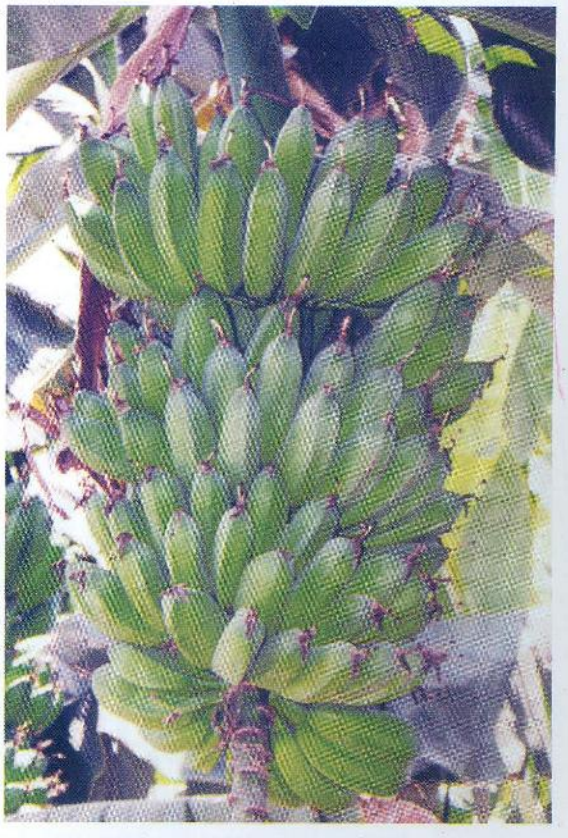


Fig. 13 'Saba' bunch obtained from 50 % N & K fertigation

Table 8. Effect of densities and fertigation on growth (9th month) of banana cv. Saba (ABB)

Treatments	Height (m)	Girth (cm)	Functional Leaves	Phyllochron	Leaf are
T_1	299.10	79.15	16.45	4.00	1.3
T_2	326.68	81.48	16.53	4.00	1.2
T_3	307.98	80.18	15.30	4.00	1.3
T_4	322.28	81.65	15.33	4.00	1.3
CD @ 5%	NS	NS	0.55	NS	NS

T_1 Conventional 50% N&K fertigation; T_2 Conventional 75 N&K fertigation; T_3 Conventional 10 fertigation; T_4 Paired row 75% N&K fertigation

1.3 Studies on micronutrients in banana

(**K. J. Jeyabaskaran,** S.D. Pandey and V. Kumar)

A field experiment was initiated in factorial RBD (3^3) with 3 replications, to compare the foliar application of micronutrients with soil application in banana cv. Karpuravalli, under high pH soil (> 8.5). The experiment was continued with ratoon crop also. In this experiment, Fe, Zn and B were factors and each factor was applied at 3 levels viz., control (0), soil application (1) and foliar spray (2). When the individual factors' (nutrients') levels (method of application) were compared, by masking the effects of other nutrients, soil application of Fe in high pH soil found to be better than foliar spray. But, foliar application of Zn and B was found to be better than soil application, in high pH soil, based on the growth parameters, in ratoon of Karpuravalli.

It was interesting to note that soil applica Zn reduced the P concentration of le ratoon crop of Karpuravalli (Fig. 14).

Under high pH soil, soil application o 5 g Ferrous Sulphate/plant) with application of Zn (as 0.5 % Zinc Sulphate (as 4 ppm Boric acid) recorded highest weight of 12.6 kg, which is 43.2 per cen than that of control (without micronut 6.8 per cent more than that with soil appl of Fe, Zn and B and 5.9 per cent more th with foliar application of Fe (as 0.5 % F Sulphate), Zn and B in ratoon cr Karpuravalli.

The fruit quality parameters like soluble solids (TSS), acidity and TSS/ ratio were significantly influenced b application of soil or foliar applicat micronutrients (Fig. 15). The highes

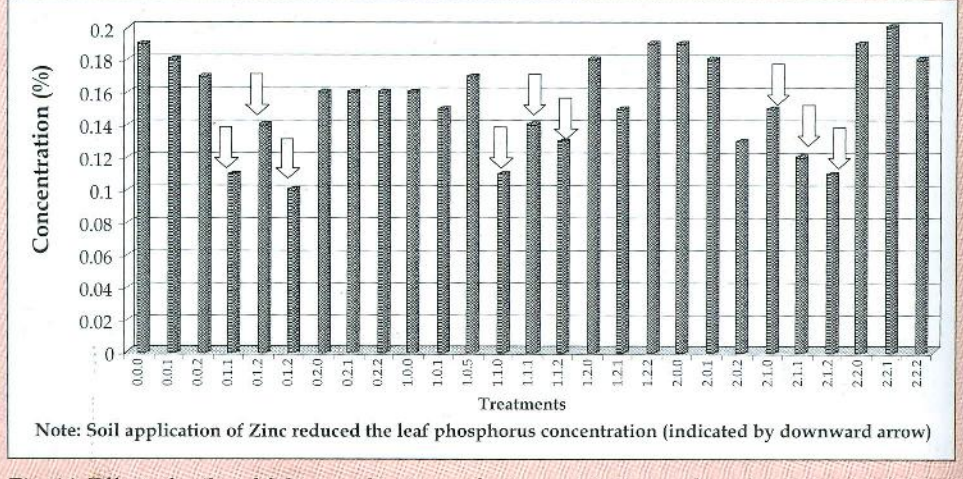


Fig. 14 Effect of soil and foliar applications of micronutrients on phosphorus concentration in leaf of Karpuravalli

lowest acidity and the highest TSS/acidity ratio were recorded in soil application of Fe and foliar applications of Zn and B in ratoon crop of Karpuravalli.

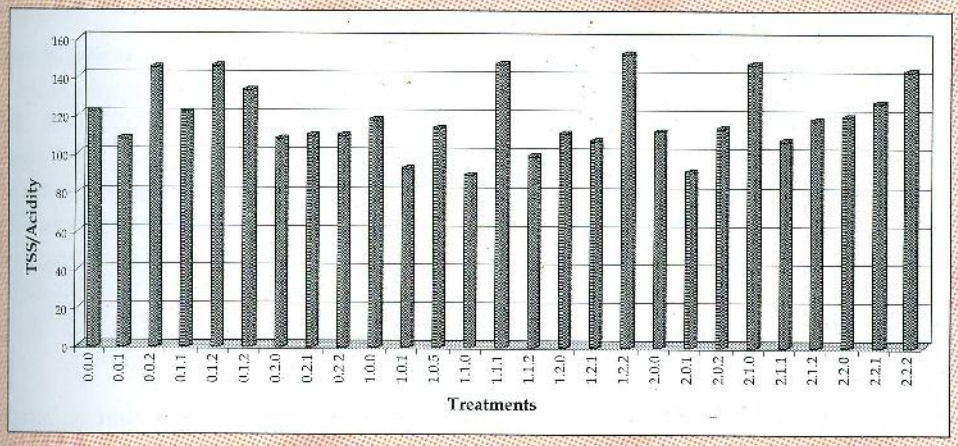


Fig. 15 Effect of soil and foliar applications of micronutrients on TSS/Acidity of fruit of Karpuravalli

1.4 Studies on integrated nutrient management system in banana

(K. J. Jeyabaskaran and S.D. Pandey)

A field experiment was conducted on banana cv. Rasthali to study the integrated effects of different natural manures, bio-fertilisers with graded levels of recommended NPK fertilizers in split-split plot design with three replications. At 6 Months After Planting (MAP), the highest pseudostem height (137.5 cm) and girth (49.3 cm) was recorded in control plot with phosphobacteria application and highest number of leaves (1.02 leaves/week) were produced in vermicompost + Azospirillum applied plot.

At 7 months after planting, the highest plant height of 152.5 cm was observed in vermicompost + Phosphobacteria plot. The highest pseudostem girth was observed in phosphobacteria without organic manures. The lowest phyllochron of 6.86 days/leaf was observed at vermicompost + phosphobacteria. At 8 months after planting, the vermicompost and phosphobacteria application recorded highest plant growth.

Table 9. Effect of soluble fertilizers on soil nutrient concentration in Robusta banana

Treatments	N (%)	P (ppm)	K (ppm)	Ca (%)	Mg (%)	Na (ppm)
T1	0.088	38.71	873.7	2.81	0.06	175.0
T2	0.081	42.06	847.3	2.56	0.05	181.7
T3	0.086	39.71	762.0	2.93	0.05	199.0
T4	0.088	38.17	847.0	2.60	0.07	167.7
T5	0.074	36.38	783.3	2.67	0.05	204.0
T6	0.069	39.49	824.7	2.61	0.05	188.3
T7	0.064	36.99	819.3	2.63	0.07	179.0
T8	0.080	41.81	817.0	2.78	0.07	176.7
T9	0.074	40.44	802.7	2.98	0.04	153.3
CD(p=0.05)	0.0054	NS	NS	NS	NS	NS

1.5 Standardization of nutritional requirements of banana using soluble fertilizers

(**V. Kumar** and K. J. Jeyabaskaran)

A field experiment was conducted to standardize the nutritional requirements of banana using soluble fertilizers in cvs. Robusta and Ney poovan. Treatments were imposed as scheduled and observations were recorded on growth parameters viz., plant height, girth, number of leaves, leaf area, number of suckers, leaf area index etc. at vegetative/ pre-flowering stages. Soil and plant samples were collected and analyzed for macro and micronu concentrations (Table 9, 10, 11, 12). In add soil and root samples were collected and for the assessment of nematode population

The data on growth parameters revе that in Robusta, soil application of recommended dose of NPK i.e, 200:50: plant^{-1} (T1) recorded more vigorous plan terms of highest plant height, girth, numb leaves, mean leaf area and number of suc This was followed by foliar application sprays of 3% Polyfeed (19:19:19) + 10 spra 3% Multi K (13 : 0 : 45) at 15 days inte

Table 10. Effect of soluble fertilizers on soil nutrient concentration in Ney Poovan banana

Treatments	N (%)	P (ppm)	K (ppm)	Ca (%)	Mg (%)	Na (ppm
T1	0.027	71.19	1010.6	0.24	0.16	683.
T2	0.053	51.48	606.5	0.20	0.13	616.
T3	0.037	57.91	613.8	0.24	0.15	566.
T4	0.071	50.96	490.0	0.27	0.14	606.
T5	0.041	56.17	733.7	0.23	0.15	700.
T6	0.069	50.68	668.8	0.13	0.21	916.
T7	0.058	49.41	524.7	0.22	0.14	608.
T8	0.053	45.85	568.5	0.19	0.16	433.
T9	0.070	50.06	572.7	0.21	0.13	583.
CD(p=0.05)	NS	4.337	42.382	0.035	NS	70.8

Table 11. Effect of soluble fertilizers on leaf nutrient concentration of Robusta banana

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)
T1	2.26	0.12	3.97	1.03	0.67	0.5
T2	2.28	0.13	4.07	0.97	0.71	0.6
T3	2.31	0.14	3.63	1.23	0.57	0.5
T4	2.10	0.17	3.47	0.87	0.53	0.4
T5	1.78	0.15	3.93	1.23	0.53	0.6
T6	2.18	0.15	2.73	1.13	1.03	0.5
T7	2.22	0.12	3.60	1.27	0.87	0.7
T8	2.31	0.13	4.33	1.00	0.77	0.5
T9	2.27	0.17	3.73	1.53	0.73	0.5
CD(p=0.05)	0.259	0.033	0.652	0.277	0.299	NS

In Ney Poovan also T1 recorded the highest values for all the growth parameters studied (Fig.16-19).

The soil as well as root samples recorded very low population of *Meloidogyne incognita* and *Helicotylenchus multicinctus* in both Robusta and Ney Poovan bananas.

The plants are at flowering stage and the experiment is in progress.

Table 12. Effect of soluble fertilizers on leaf nutrient concentration of Neypoovan banana

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)
T1	2.48	0.14	3.03	1.07	0.53	0.80
T2	2.57	0.14	3.57	1.30	0.87	0.77
T3	2.39	0.14	2.77	1.07	0.83	0.57
T4	2.69	0.13	2.93	1.00	0.57	0.77
T5	2.31	0.13	3.00	1.07	0.63	0.60
T6	2.27	0.15	2.13	1.40	0.83	0.57
T7	2.38	0.14	2.13	1.30	0.87	0.53
T8	2.22	0.16	2.60	1.03	0.73	0.57
T9	2.35	0.13	2.80	1.00	0.60	0.53
CD(p=0.05)	0.189	NS	0.591	0.251	0.249	0.232

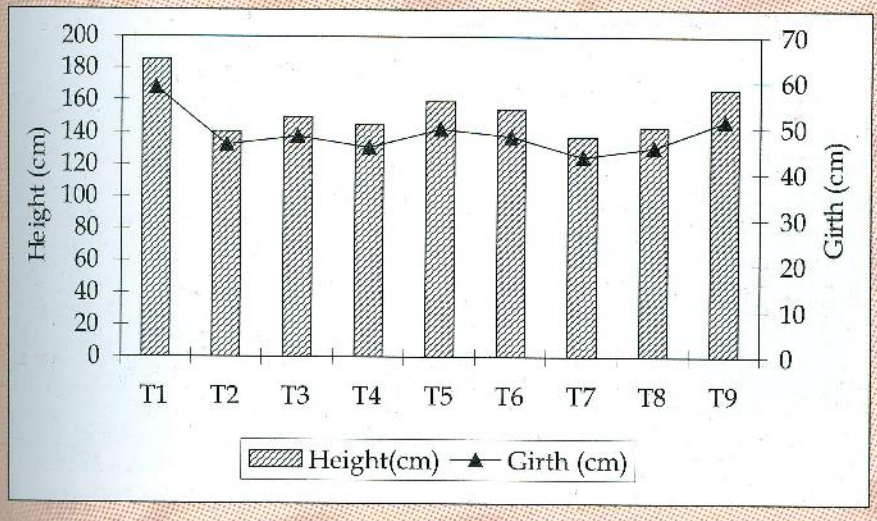


Fig. 16 Effect of soluble fertilizers on Pseudostem height and girth (cm) of Robusta

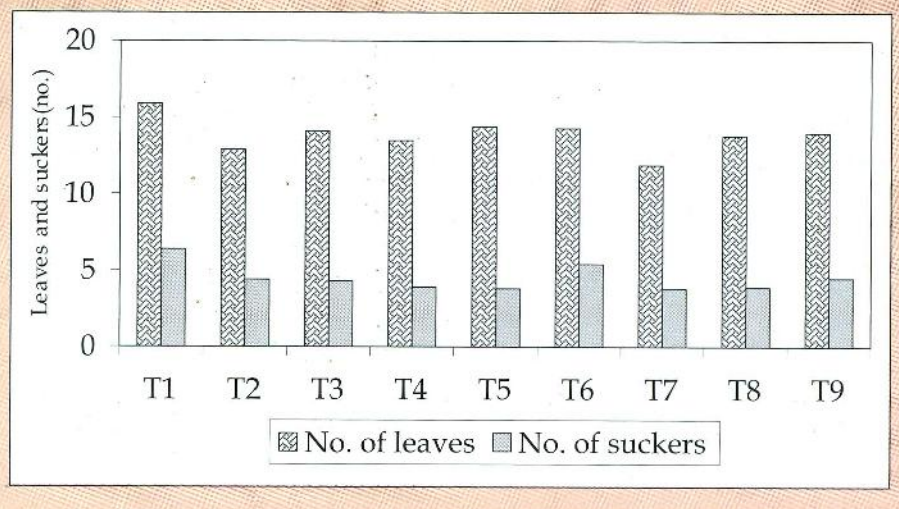


Fig. 17 Effect of soluble fertilizers on number of leaves and suckers of Robusta

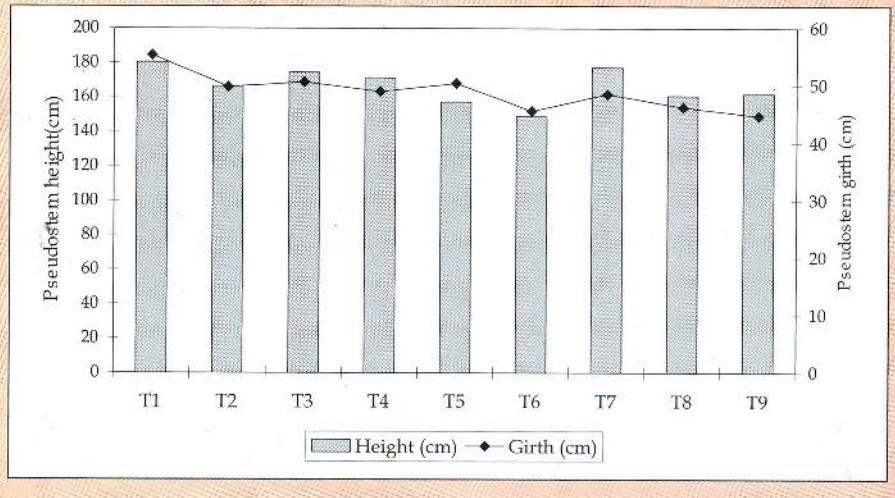


Fig. 18 Effect of soluble fertilizers on pseudostem height and girth of Neypoovan

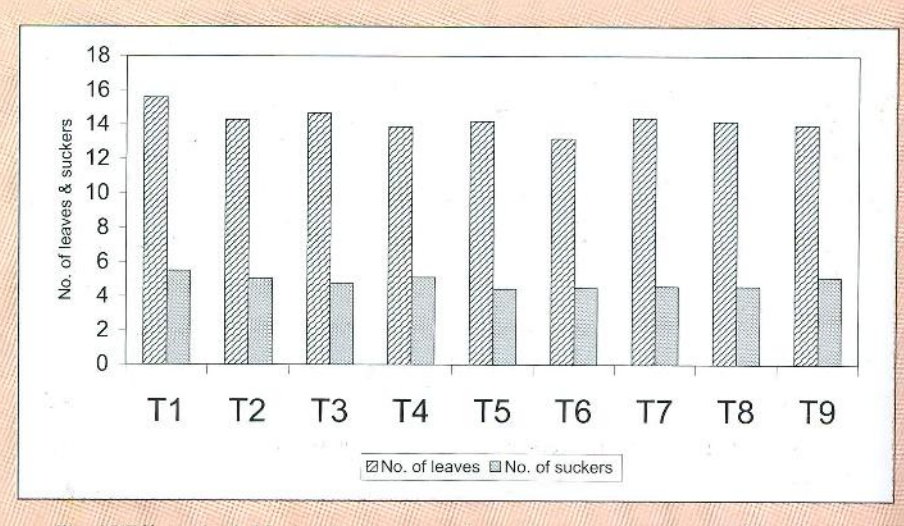


Fig. 19 Effect of soluble fertilizers on number of leaves and suckers of Neypoovan

1.5 Plant Physiology and Biochemistry

(I. Ravi)

1.5.1 Studies on the role of leaf on flowering and fruit development

In spite of the Ney Poovan (AB) is diploid, the growth and development of morphological structures and assimilation of carbon is superior to the triploid variety Karpuravalli (ABB). The Ney Poovan's LA and LAI were on par with Karpuravalli, stomatal frequency, stomatal conductance, transpiration the growth was maintained on par with triploid. The photosynthesis, stomatal conductance and transpiration rate can be measured in the 2nd fully opened leaf of Ney Poovan and 3rd fully opened leaf of Karpuravalli from the top to down the profile in the apical portion of left side of leaf midrib. As the diploid variety Ney Poovan showed early vigour than the triploid Karpuravalli, different management approach is required for better exploitation of production potential of both varieties.

The senescence studies were done on five-month-old tissue culture Robusta (AAA) plants planted at different densities. The density influenced the hastening the senescence. The Ascorbate Oxidase activity was higher in 3 plants/pit than 2plants/ pit and single plant/pit.

1.5.2 Studies on the rhizome and root development

The root studies were conducted in cvs. Ney Poovan (AB), Rasthali (AAB) and Karpuravalli (ABB) in pot culture. The results indicated that the thickness and number of roots vary with ploidy level (Fig.20). The diploid produced more and thinner roots than triploid varieties. However, more thickness and higher root biomass was recorded in Karpuravalli (Fig.21).

Fig. 20 Diploid

Fig. 21 Triploid

III POST HARVEST TECHNOLOGY

1. Studies on handling, storage and processing of banana

(C.K.Narayana and M.M.Mustaffa)

1.1 Effect of vacuum packaging on storage life and quality of Rasthali banana under low temperature conditions

Mature Rasthali were sealed in 400 guage polybags with and without vacuum and stored at 13.5°C along with an untreated control to study the storage life and quality changes. The results showed that the vacuum sealed fruits (Fig.22) though had a 40 days green life at 13.5°C; it failed to ripen when shifted to ambi condition after 20 days of storage. Those sea without vacuum in polybags had a green life 8 days while control had 10 days. After ripeni at room temperature all fruits had 2 d yellow life at room temperature. The moistu content in all treatments showed an increa while the highest was seen in normally sea polybags without vaccum. The pulp to p ratio decreased upto 5th day during storage subsequently increased. The changes in T acidity, sugars and starch indicated t ripening was faster in those sealed polyb without vacuum followed by control (Fig.23

Fig. 22
Vacuum packed Rasthali fruits after 15 days of storage at 13.5°C

Fig. 23
Chilling injury in Rasthali fruits after 15 d of storage at 13.5°C

1.2 The physico-chemical quality status of Karpuravalli, Pachanadan and Rasthali banana

The pulp to peel ratio, TSS, acidity, moisture, reducing sugar, total sugars, starch, carotenoids and vitamin C of Karpuravalli banana were found to be 1.97, 2.96°Brix, 0.075%, 62.7%, 0.45%,0.60%, 24.33%, 572 µg% and 3.98 mg% respectively at harvest. After ripening the pulp to peel ratio, TSS, acidity, moisture, reducing sugar, total sugars, carotenoids and vitamin C increased to 2.89, 28.14° Brix, 0.311%, 64.69%, 14.95%, 24.55%, 549 µg% and 5.0mg% respectively while starch decreased to 1.09%. Pachanadan banana exhibited a P/P ratio of 1.69, TSS of 3.92°Brix, 0.119% acidity, 68.48% moisture, 0.36% reducing sugar, 0.515% total sugars 443 µg% carotenoids and 3.96 mg% vitamin C. Rasthali banana showed 2.68 pulp: peel ratio, 5.17°Brix TSS, 0.13% acidity 65.14% moisture, 0.87% reducing sugar 1.23% total sugar, 26.7% starch, 777 µg/100g caroten and 16.7 mg% Vitamin C in unripe fruits. A ripening these values were 4.03 pulp: peel r 27.56° Brix TSS, 0.38% acidity, 62.94% moist 11.41% reducing sugar, 24.45% total su 1.69% starch and 4.44 mg% vitamin respectively.

1.3 The quality parameters during gro and development in relation to maturit Rasthali banana

The finger length, girth and weight were 6.0 5.0 cm, 5.57 g respectively on 15th day whi 105th day they were 9.67 cm, 11.75 cm and 7 respectively. The moisture, P/P ratio, acidity, total sugars, starch, pulp phenols peel phenols were 87.5%, 0.537, 6.6°Brix, 0.3 2.07%, 2.0%, 0.0%, 0.0675% on 15th day flowering while it was 68.88%, 3.35, 3.67 0.10%, 0.37%, 27.2%, 0.005% and 0.0 respectively at full maturity on 105 days.

1.4 Effect of application of pre-harvest soil amendaments on postharvest quality of Neypoovan banana

(C.K.Narayana and K. J. Jeyabaskaran)

Cement Kiln Flue Dust or Distillery effluent alone or in combination with potassium when applied at preharvest stage did not affect the green life or yellow life significantly as compared to control. Among the various soil amendments used application of distillery effluent + 60-80% recommended potash gave highest total soluble solids, total sugars, starch and moisture while control showed the highest acidity. The taste of fruits was found to be relatively better in CKFD treatment followed by DE treatment.

1.5 Standardization of critical temperature of storage of Rasthali

Modified atmosphere packaging of Rasthali banana in 400 gauge PE bags could control the chilling injury in Rasthali banana even at 10°C. The control exhibited chilling injury even at 13.5°C after 2 weeks of storage.

1.6 Standardization of process for development of fermented banana pickle

The procedure of production of fermented banana pickle was developed using Monthan banana. The fermented pickle showed 25% moisture, 0.7% acidity, 3.19% total chlorides, 38% oil content and 1.54 mg KOH/g acid values. The microbiological examination did not reveal any harmful microbes. The organoleptic score showed that all the treatments of pickle were acceptable.

IV CROP PROTECTION

1. Insect Pest Management

(**B. Padmanaban,** P. Sundararaju and R. Thangavelu)

1.1 Survey for pests and biocontrol agents

Oriental red mite, *Eutetranychus orientalis* (Klein) is a polyphagous pest of citrus, found recently infesting on banana leaves in Thanjavur District of Tamil Nadu. The mites infest on the upper surface of the leaf and colonize in between the veins. Feeding damage results in bronzing and later it changes to black colour. Infestation was noticed on cv. Sakkia and Nendran. This pest has been previously reported infesting banana in New Delhi and Thiruvananthapuram. The other hosts of the mite includes citrus, cotton, grapevines, Tapioca etc., (Fig.26 a,b).

Fig. 26 (a) Mite Infested Leaf

Fig. 26 (b) Oriental red mite, *Eutetranychus orientalis*

Occurrence of *Tetratopas sericans* (Wei (Dryopthoridae: Coleoptera) as a new pest banana.

T. sericans infestation on banana corm w reported from one of the collections Northeastern hill region. The adult and gr makes feeding damage on corm. It is a min pest. The other Dryopthorid weevil infestati on banana corm has been reported from Afr and India (Fig.27)

Fig. 27 *Tetratopas sericans*

1.2 Collection of leaf sheath volatiles

Headspace samples of banana leaf she volatiles from the cultivars such as Pisa Awak, French Plantain and Nendran w collected by air-entrainment technique us resin absorbent. GC-MS analysis of cv. Pisa Awak indicated three major components (i). Aspidospermidin-17-ol, 1-acetyl-19,21 -Pentatricontanol and (iii). Cholestan-3- 2- methylene. The crude extract was tes against the stem weevil indicated we attraction (Fig. 28).

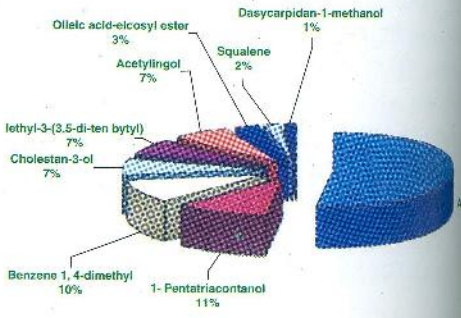


Fig. 28

1.3 Pseudostem trapping studies to control banana weevil

Banana pseudostem trap experiment was conducted at Maharajapuram having in cv. Sakkia approximately 700 plants infested with banana stem weevil. 144 longitudinal stem traps were kept in and around the garden. The traps were changed once in a week. Weevils attracted to stem traps were collected daily and trap catch data was maintained. Observation was recorded for a period of five months.

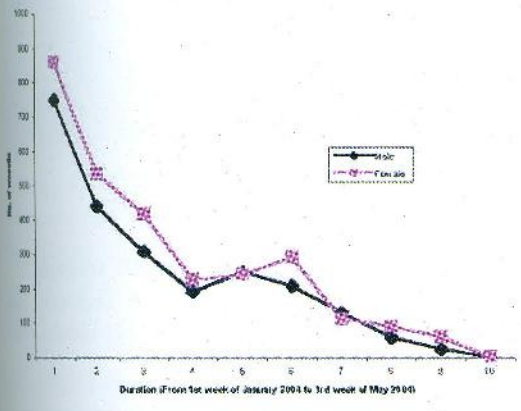


Fig. 29 Banana pseudostem trap catch of banana stem weevil

Weevil trap catch data indicate that 60.0 per cent of the weevil population was collected within one month after initiation of trapping. The trap catch was gradually reduced at 5th month. Weevils were completely eliminated from the garden (Fig. 29).

1.4 Management of rust thrips, *Chatanaphothrips signipennis*

The rust thrips, ***C. signipennis*** causes bronze coloured rust like structure on the peel, which reduces cosmetic value of the fruit. To control the thrips infestation, treatments were imposed and observation on rust thrips incidence was recorded on various treatments during harvest. Bunch cover impregnated with Chloropyrifos + liquid paraffin + adjuvant resulted in bunches free from rust thrips infestation. Bunch covering also reduced the harvest time and improved the finger colour (Fig. 30 a,b,c).

1.5 Extraction of botanicals for screening different parts of *Melia azedarach*

Leaf, bark and kernel of China berry, *Melia azedarach* was collected, shade dried and sequentially extracted using polar and non-polar solvents by soxhlet extraction procedure.

These extracts were evaluated against banana stem weevil adapting leaf sheath technique, 2% seed kernel extract made from ethyl alcohol indicated anti-feedant property.

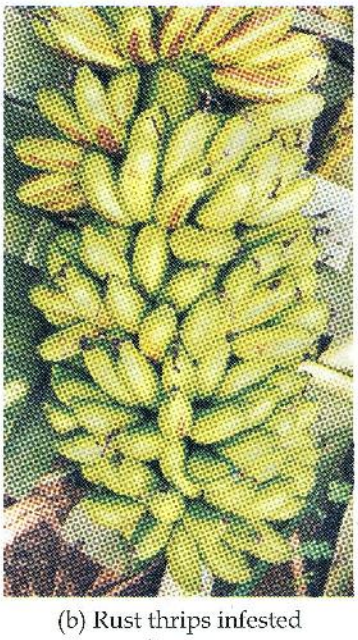
1.6 Pseudostem trap as a delivery system for entomopathogenic nematode, *Heterorhabditis indica*

(B. Padmanaban and P. Sundararaju)

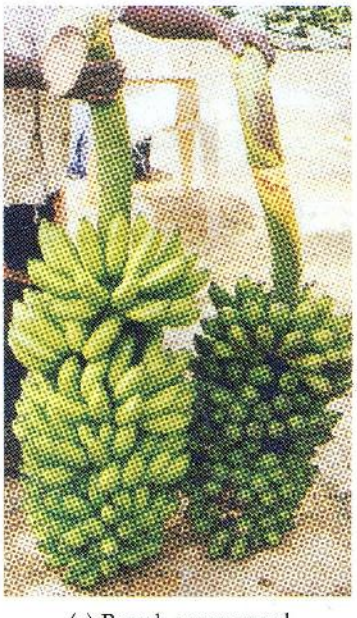
In order to test the banana pseudostem trap as a delivery system for entomopathogenic nematode, *H. indica* was mass multiplied in

Fig. 30

(a) Bunch covered with polythene bag



(b) Rust thrips infested fingers



(c) Bunch cover used and unused bunches

galleria larva. The nematode suspension having infective juveniles was swabbed on the pseudostem and poured on the soil. The released weevils were checked for mortality. Observations indicated weevil mortality and emergence of entomopathogenic nematodes from the cadavers (Fig. 31)

Fig. 31 Emergence of nematodes from stem weevil cadaver

1.7 Isolation and identification of bacteria from soil inhabiting nematodes pathogenic to banana weevils (B. Padmanaban)

Mutualistic bacteria from the soil inhabiting nematodes were isolated by hanging blood drop method in galleria larval haemolymph. Seven bacteria were isolated and identified (Table. 13).

Table 13. List of bacteria isolated from soil inhabiting nematodes pathogenic to banana weevil

S. No	EPN Isolate	Bacteria
1.	NRCB. EN.1&6	*Enterobacter agglomerans*
2.	NRCB. EN.2	*Enterobacter taylorae*
3.	NRCB. EN.3	*Proteus mirabilis*
4.	NRCB. EN.4	*Enterobacter cloaceae*
5.	NRCB. EN.5	*Citrobacter freundii*
6.	NRCB. EN.7	*Enterobacter dissolvens*
7.	NRCB. EN.8	*Serratia marcescens*

1.8 Pseudostem trap as a delivery system for entomopathogenic fungi, *Beauvaria bassiana:*

(B.Padmanaban and R.Thangavelu)

B.bassiana was mass multiplied using maize flour and evaluated under field conditions using longitudinal split banana pseudostem traps as delivery system (longitudinal split). The substrate having fungus was (i). Swabbed on the trap (ii). Diluted with water and swabbed on the trap (iii). Dilute suspension was poured on the soil and the trap was kept over the suspension and (iv). A control trap without fungus. Observation on weevil catch was recorded weekly and the trapped weevil was collected and brought to laboratory to record infestation. Weevil mortality was recorded due to fungal infestation (Fig.32).

Fig. 32 *B. bassiana* fungal growth on pseudostem trapped weevils

2. Studies on banana nematodes and their management

(P. Sundararaju, B. Padmanaban and R. Thangavelu)

2.1 Survey for nematodes in banana

A Survey conducted in Kanyakumari, Coimbatore, Thanjavur, Trichirapalli districts in Tamil Nadu and Alleppey, Quilon, Trissur districts in Kerala revealed that the root-lesion nematode, *Pratylenchus coffeae* was the dominant species occurred in maximum number of root samples (52/70) followed by root-knot nematode, *Meloidogyne incognita* (25/70). Analysis of the soil samples revealed that the presence of seventeen genera of plant parasitic nematodes. The important nematode genera, which are frequently occurred in banana were *Rotylenchulus reniformis*, *Hoplolaimus* sp., *Tylenchorhynchus* sp. and *Xiphinema* sp.

2.2 Studies on biochemical changes due to nematode and host interaction.

A preliminary study was conducted to understand the biochemical and molecular changes associated with resistant/tolerant reaction of banana against root-lesion and root-knot nematodes. Among the five varieties tested, the cultivar Nendran (AAB) showed highest total protein content whereas minimum was noticed in *Musa balbisiana*. Increased protein content was reported in nematode infected Nendran and Robusta cultivars, but the case was reverse in Pisang Jary Buaya and *Musa balbisana*. The activity of Peroxidase (PO) was observed to be higher in cultivar Nendran after nematode infection followed by Robusta whereas lowest was observed in cv. Karthobiumtham. The phenolic accumulation increased by 56% in Nendran after nematode infection whereas it was only 2% increase in Karthobiumtham.

2.3 *In vitro* studies on the efficacy of biocontrol agents against root-knot nematode

A preliminary study was conducted to assess the bioefficacy of four biocontrol agents viz., *Pseudomonos fluorescens*, *Bacillus subtilis*, *Paecilomyces lilacinus* and *Trichoderma viride* under controlled condition against the root-knot nematodes. The results revealed that all the four organisms were found effective in inhibiting the hatching of root-knot nematodes. The activity of juveniles was also arrested by these organisms to a considerable extent. The gall production is also reduced by the toxins production and colonization of the biocontrol agents. Among the four organisms tested *B. subtilis* showed better colonization compared to other organisms.

2.4 Screening of *Musa* germplasms against major nematode pathogens

Eighty-five banana varieties were screened for their reaction to root-lesion nematode, *Pratylenchus coffeae* and root-knot nematode, *Meloidogyne incognita* in pots under greenhouse conditions (Fig. 33). Biometric observations like growth parameters, root characters and nematode populations were recorded from all the 85 *Musa* germplasm screened. Based on the above characters, the following cultivars namely Singhlal(ABB), Sakkarachayan(AAB), Malai Kala(AAB), Manik Cempa(AAB) and Kartobium tham(ABB) were rated as resistant to root lesion nematode followed by eight varieties which were shown moderately resistant to *P. coffeae*. In the case of root-knot nematode, *M. incognita*, none of the varieties were found resistant. However, seven varieties were shown moderately resistant to root-knot nematode (Table 14 & 15).

Fig 33. Varietal screening against major nematode pathogens

2.5 Screening of IMTP Phase III Musa accessions against major nematodes infesting banana

Twenty one global hybrids and cultivars of banana under IMTP Phase III were screened for their reaction to root-lesion nematode, *P. coffeae*; root-knot nematode, *M. incognita* and spiral nematode, *H. multicinctus* in pots (Fig.34&35) as well as under field conditions. The results revealed that all the 21 cultivars were found susceptible to root-knot nematode, *M. incognita* in various intensities. Whereas the root-lesion nematode, *P. coffeae* was recorded in 19 cultivars out of 21. This nematode was not recorded in cultivars like Kanai Bansi and GCTCV 215. The spiral nematode,

Table 14. Biometric observation of 18 promising varieties of banana

Sl. No.	Name of the accn.	Genomic Group	ACC.No	Height (cm)	Plant Weight (kg)	Girth (cm)	No. of leaves	LL x LB	Root weight (g)	Ro leng (cm
1.	Singhlal	ABB	267	95	2.0	24	10	67x28	450	35
2.	Sakkarachayna	AAB	355	60	1.5	18	6	60x24	300	40
3.	Malaikala	AAB	243	90	2.5	23	6	60x20	450	45
4.	Manikcempa	AAB	259	80	2.0	20	9	55x20	400	25
5.	Kartobiumtham	ABB	50	85	2.3	20	6	60x25	150	40
6.	Chakia	ABB	288	70	2.0	20	7	61x32	400	25
7.	Beula	ABB	391	70	2.5	21	7	56x29	450	35
8.	Batissa local	ABB	88	80	1.5	24	10	65x30	350	20
9.	Bersain	ABB	522	65	1.8	20	4	55x25	100	20
10.	Karibale	ABB	129	65	2.0	20	5	55x30	100	20
11.	Kechulepa	ABB	594	80	2.3	20	6	60x20	125	35
12.	Rajapuri India	ABB	468	85	2.0	20	6	65x25	100	40
13.	ATTU Nendran	ABB	488	70	1.0	20	6	60x25	75	20
14.	Karpooravalli	ABB	173	115	2.0	25	8	75x30	400	30
15.	Boddidabukisa	ABB	227	95	2.5	31	10	63x33	400	35
16.	Sappumala Anamulu	AAB	314	80	2.8	20	8	64x26	450	45
17.	Hoobale	AAB	624	70	1.3	15	8	60x20	100	30
18.	Sabari	AAB	512	65	2.5	15	6	70x30	400	35

H. multicinctus was recorded in 15 out of 21 cultivars in various intensities. The six cultivars namely Anaikomban, Pisang Berlin, Namarai, Hatidat, FHIA 03 and Pisang Ceyl were found resistant to *H. multicinctus*.

Fig. 34 Screening of IMTP accessions against major nematode pathogens

Fig. 35
Healthy Root System Nematode Infected Ro

Table 15. Host infestations and nematode population of 18 promising varieties of banana

Sl. No.	Name of the variety	No. of roots	No. of healthy roots	No. of infested roots	*P.coffaea*			*M. incognita*		
					Root	RLI*	Host reaction	Root	RKI*	Host reaction
1.	Singhlal	150	60	90 (60.0)	142	1	R	61	2	MR
2.	Sakkarachayna	90	20	70 (77.8)	112	1	R	187	4	HS
3.	Malai Kala	110	30	80 (72.7)	167	3	T	84	3	T
4.	Manik Cempa	100	25	75 (75.0)	111	1	R	76	2	MR
5.	Kartobiumtham	60	20	40 (66.7)	22	1	R	167	3	S
6.	Chakia	75	20	55 (73.3)	40	5	MR	167	4	HS
7.	Beula	140	50	90 (64.3)	52	3	MR	212	4	HS
8.	Batissa local	100	25	75 (75.0)	74	2	MR	180	3	S
9.	Bersain	50	10	40 (80.0)	65	1	MR	113	3	S
10.	Karibale	30	15	15 (52.0)	32	2	MR	118	2	S
11.	Kechulepa	50	10	40 (80.0)	19	5	MR	99	2	S
12.	Rajapuri India	50	20	30 (60.0)	20	2	MR	198	3	HS
13.	ATTU Nendran	35	15	20 (57.1)	56	1	MR	177	2	S
14.	Karpooravalli	95	15	80 (84.2)	181	3	T	45	2	MR
15.	Boddida Bukisa	100	30	70 (70.0)	125	3	T	56	2	MR
16.	Sappumala Anamulu	110	30	80 (72.7)	145	2	T	39	3	MR
17.	Hoobale	40	15	25 (62.5)	121	2	S	82	2	MR
18.	Sabari	110	30	80 (72.7)	136	4	S	58	3	MR

3. Studies on fungal and bacterial diseases of banana and their management

(R.Thangavelu)

3.1 Screening germplasm for their reaction to Sigatoka leaf spot diseases under field condition.

Totally 700 germplasm, maintained in the field gene bank were evaluated for reaction to Sigatoka leaf spot disease at shooting stage as per INIBAP guidelines. The results indicated that nine accessions viz. Kalibun (AAB)- 0574 & 0133, Dudhsagar (AAB)-0374, Pisang Rajah (AAB) 0217, Kalibow (AAB) 0211, Pisang Seribu (AAB) AAB, Thiruvananthapuram (AAB) 0125, Thiruvananthaspulam (AAB) 0031 and Klueteprad (ABB) 0253 were found immune.

3.2 Evaluation of IMTP wilt accessions against Fusarium wilt disease (race - 1 &2)

Twenty IMTP accessions were evaluated against wilt under pot culture condition. The race 1 & 2 of the fusarium wilt pathogen were multiplied in sand maize medium and applied @ 30 g/pot. The plants were pulled out after 10 months and the internal symptoms of wilt disease appeared were scored based on 0-4 scale. The result indicated that 11 of 20 accessions viz. FHIA-17, FHIA-23, GCTCV-119, GCTCV-215, Pisang Jwaribuya, Calcutta-4, PA-03, Pisang Mas, Cultivar Rose, Yankambi KM-5 and Pisang Ceylon were found resistant. Interestingly Pisang lilin hitherto resistant has become susceptible to wilt disease.

3.3 Evaluation of germplasm against fusarium wilt disease in sick plot.

Sick plot for fusarium wilt pathogens (race 1 & 2) created artificially and 257 accessions of 6 categories viz ABB, AA, BB, AAB ABBB, AAB unique type were planted and evaluated for resistance to fusarium wilt pathogen. Only 19 accessions mostly belong to ABB monthan group were susceptible to this disease.

3.4 Isolation and evaluation of non-pathogenic Fusarium for the management of Fusarium wilt of banana

3.4.1 Isolation of non-pathogenic Fusarium isolates

Totally 15 fungal antagonists were isolated from rhizosphere of different varieties and also

from the banana plants (endophytes) and these were evaluated against the panama wilt pathogen *Fusarium oxysporum* f.sp. *cubense* race-1 under *in vitro* condition by dual culture plate technique. Three of the 15 non-pathogenic *F.oxysporum* isolates inhibited the wilt pathogen significantly.

3.4.2 *In vitro* evaluation of non-pathogenic isolates against Foc race-1 under *in vitro* condition

The non-pathogenic *F.oxysporum* 1 recorded maximum inhibition of 43% over control which was followed by *F.oxysporum* 2 (41.5%) and *F.oxys*porum 3 (38.8%). The degree of over growth was maximum in *F.oxysporum* 1 inoculated plate compared to other isolates.

3.4.3 Testing Non-pathogenic nature of Fusarium isolates

Three *F.oxysporum* isolates were inoculated in tissue cultured plants of Rasthali by root dip inoculation method under pot culture condition. It was found that among the three isolates of *F. oxysporum*, *F.oxysporum* 1 and *F.oxysporum* 2 did not cause any wilt symptoms and are considered non- pathogenic.

3.4.4 *In vivo* evaluation of non-pathogenic Fusarium isolates against Foc race-1

Three isolates of *F. oxysporum* were evaluated for their potential to control the panama wilt pathogen (*Foc* race-1) under pot culture condition using the tissue cultured banana plants cv. Rasthali (Fig.36). The results indicated that in the non pathogenic *F.oxysporum* 1 and *F.oxysporum* 2 inoculated plants, the Foc pathogen inoculation could not cause wilt symptoms and and the score recorded was 0 (Healthy). Whereas in the *F.oxysporum* 3 inoculated plants the wilt symptoms were expressed moderately and t score was 2.

Fig. 36 Effect of non-pathogenic fusarium isolates on Fusarium wilt pathogen.

3.5 Isolation of principle compounds fro botanicals for the management of post harv diseases of banana

3.5.1 Ammonium sulphate fractionati method

Ammonium sulphate fractionations (30, 40, 5 60 70 80, 90 and 100%) and also the fresh le extract of ***Solanum*** sp-1 tested against bo *Colletotrichum musae* and *Botryodiplo theobromae* under *in vitro* condition. The fre leaf extract and 30 per cent ammoni sulpahte concentration inhibited fung growth (1.0 cm inhibition zone). The oth concentrations had very less inhibition fungal growth. The same trend was obser with *C. musae*. As the effect of ammoni sulphate fraction at 30 per cent was same to th of fresh leaf extract and the solutions of oth concentrations recorded very less or n inhibition of fungal growth it was conclud that ammonium sulphate fractionation did n extract the compound from the botanicals.

3.5.2 Using different solvents system

Fractions collected from each step of extracti of compounds from the botanicals viz., *Solan* sp-1 and *Solanum* sp-2 using different solven were tested against both *Colletotrichum mu* and *Botryodiplodia theobromae* under *in v* condition. Out of four ethyl acetate fractions *Solanum* spp-1, the fraction no.4 (final residu showed maximum inhibition zone. (1.5 cm 1.6 cm inhibition zone) and no fractions hexane extraction could inhibit the pathoge In the case of *Solanum* sp-2, fractions of bo ethyl acetate and hexane exhibited inhibition both the fungus tested.

3.5.3 Identification of principle compound thin layer chromatography (TLC).

i) TLC studies for phenols, amino acids a lipids of the final residue obtained from bo ethyl acetate and hexane fractions of *Solan* sp-1 and *Solanum* sp-2 was performed. T bands eluted from phenols and amino acids d not inhibit both the pathogens teste Interestingly, the bands of lipids obtained fr ethyl acetate fractions of *Solanum* sp-1 a hexane extracts of *Solanum* sp-2 inhibited bo the pathogens.

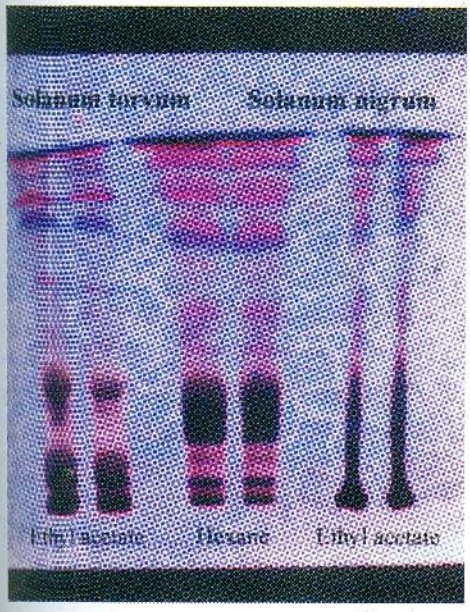


Fig. 37 In vitro screening of lipids (TLC bands) against *Botryodiploida theobromae* & *Colletotrichum musae*

ii) In the case of ethyl acetate fractions of *Solanum* sp-1, the bands having RF value of 0.85 and 0.62 recorded maximum inhibition of both the pathogens compared to other bands. Whereas in the case of hexane extracts of *Solanum* sp-2 all the bands eluted showed inhibition of both the pathogens, but the maximum inhibition was recorded in the bands having RF value of 0.75 and 0.84 (Fig.37).

3.6 Development of consortium of bioagents and botanicals for the management of crown rot disease of banana.

3.6.1 Evaluation of antagonistic microbes on the crown rot disease

3.6.1.1 Different *Trichoderma* spp. were evaluated against *B.theobromae in vitro*. Maximum inhibition of 97.5 per cent was observed due to *T.pseudokoningii* inoculation which was followed by *T.viride*- RT isolate which recorded 93.75 per cent reduction over control. Overgrowth of antagonists on the pathogen was also high in these two *Trichoderma viride* isolates.

3.6.1.2 Among 60 bacterial isolates screened against crown rot pathogen, the bacterial isolates such as *Pseudomonas syringae* (P.s) *P.caryophili*, *P.aeruginosa*, *P.viridiflav* and *Bacillus cereus* were found inhibitory to the pathogen.

The selected antagonists were screened again by the dual culture method against *Botryodiplodia theobromae* under *in vitro* condition. All the *Pseudomonas* spp. and *Bacillus* sp. significantly inhibited the mycelial growth of the pathogen. The percentage inhibition was ranged from 22.22 to 68.88. Among bacterial antagonists *Pseudomonas syringae* recorded maximum growth inhibition of 68.88 per cent followed by *Pseudomonas syringae pathovars1*, *P.aeruginosa* (66.66%) *and P.caryophili* (55.55%).

3.6.1.3 Evaluation of botanicals on the disease severity of crown rot disease *in vivo*

Out of 115 botanicals screened against *B.theobromae in vitro*, only *Solanum nigrum* showed inhibition of mycelial growth. Further, the extract was tested at different concentrations under *in vitro* condition by poison food technique. All the concentrations of extract tested significantly inhibited the mycelial growth of the pathogen.

Fig. 38 Effect of botanicals on crown rot disease of banana

When combinations of different antagonists of extract fungal, bacterial and plant extract were evaluated for their efficacy against crown rot disease and also on the shelf life of banana fruits (cv. Robusta), the results indicated that the plant extract *Solanum nigrum* at 50% conc. completely prevented the disease (score-0) upto 20 days ie till the end of shelf life period followed by *Pseudomonas syringae* (Score 0 upto 12 days) and *T.viride* RT-1 + *Solanum nigrum* at 25% conc (Score 0 upto 11 days) (Fig.38).

3.7 Bio-chemical basis of resistance against crown rot disease caused by *Botryodiplodia theobromae* due to the application of botanical and bioagents.

When the botanical and different bioagents were treated in banana fruits and challenge inoculated with the pathogen *B.theobromae* the following observations were made

a) The PO activity has significantly increased due to the application of antagonists and/ or botanical compared to control. The activity of the enzyme reached the peak on 3rd day and thereafter decreased in all the treatments. In general, the botanical *Solanum nigrum* and the fungus *T. pseudokoningii* induced maximum activity of the enzyme and the increase was three and half times more than the control. One to two fold increase in the activity of enzyme was observed in banana fruits received with combination of different treatments.

b) The activity of 1, 3-glucanase in banana fruits due to the treatment of antagonists (Fungal and bacterial) and also the botanical *Solanum nigrum* increased to 1to 1.5 folds compared to control when treated separately as well as in different combinations. Among different treatments, *Pseudomonas syringae*-1 recorded maximum activity of -1, 3-glucanase followed by *S.nigrum+P. caryophylli* and *S.nigrum+ P. syringae* -1. The activity of this defense enzyme was high on 6th day after inoculation of the pathogen

c) The total phenolic content in banana fruits applied with antagonists and or/ botanical increased significantly from 3rd day after treatment and reached the maximum at 6th day after inoculation of the pathogen. About 2 to 3 fold increases in the phenolic content was observed on 3rd day after inoculation and 6 to 9 fold increase on 6th day after inoculation in most of the treatments. However, the phenolic content in fruits was maximum in *Trichoderma viride*- RT1 applied fruits followed by *Solanum nigrum* + *P. syringae*-2, *Solanum nigrum* + *P. syringae*-1, *P. syringae*-2. The total phenolic content of banana fruit was less when bacteria *Bacillus cereus* was sprayed.

d) With regard to O.D phenols, generally all the treatments increased the content significantly compared to control and the maximum content of O.D phenol was observed in *P. syringae*-1 treated fruits and the increase was more than 16 folds compared to control. This was followed by *S. nigrum* + *P.caryophilli* and *S. nigrum* + *viridiflava*. Interestingly, the O.D phen was very less in the pathogen *B.theobro* treated fruits. The increase in O.D pheno content was maximum at 6th day af pathogen inoculation.

3.8 Mass production of *Trichoderma viride*

A method of mass production of *Trichoder viride* using rice chaffy grains has be developed. This technology can be direc adopted by farmer in their farm holdings its The required quantity of *Trichoderma* can produced within 4 days with very less cost. T cfu of ***Trichoderma*** per gram of material w 10^{09} which are several folds higher than t normal formulation available in the mar This method of multiplication is useful organic banana growers.

3. 9 Isolation of effective antagonists agai different pathogens of banana

Among several *Trichoderma* spp. isolated fr rhizosphere soils of different varieties banana, the *Trichoderma viride* isolates Rt1 a Np1 were found to be effective agai Fusarium wilt pathogen- FOC, Basidiomyce pathogen, crown rot and anthracn pathogens such as *Botryodiplodia theobromae* a *Colletotrichum musae* under *in vitro* condit Similarly among several bacterial antagon isolated, the isolates such as 15c, 5c, 1c, 3a a 4d against *C.musae* and 1c, 15c, 3a & 5c agai Fusarium wilt were effective under *in v* condition.

3. 10 Evaluation of different fungicides a bioagents against Basidiomycetes fung (Trichy wilt pathogen)

Among different fungicides (Carbendazi Propiconazole, Tridemorph, Mancozeb -W Mancozeb -flowable) tested at differe concentrations ie from 0.01 to 0.40 per cent, fungicide mancozeb flowable was fou superior to other fungicides as the fungi completely arrested the growth of the patho at all concentrations tested. Among fun antagonists tested *T. viride* Rt1, *T. hamatum* a *T. pseudokoningii* were found effective arresting the growth of the patho (Basidiomycete fungus).

4. Studies on viral diseases and their management

(R. Selvarajan)

4.1 Survey

A survey was conducted for banana viruses at different locations of Trichy, Karur, Tanjore, Coimbatore and Lower Palani hills for banana viruses (Table 16). In Thirukattupalli, choking of bunches in Poovan (locally called as ***Vikkal***) has been noticed and presence of BSV in all the samples was confirmed. High incidence of BBTV has been recorded both in plains (Karur and Tanjore) and hills of Lower Palani in Dindugal district. As high as 15 % BBTV has been recorded in Nadukaveri, Tanjore.

Table 16. Per cent disease incidence in Poovan in Karur and Tanjore district

Location	BSV (%)	BBTV (%)
Karur district		
Melamayanur	45	3.0
Kattur	64	7.75
Thirukampuliyur	67	12.0
Krishnarayapuram	44.75	8.60
Mahathanapuram	54.4	9.60
Lalapet	33	6.0
kallapalli	72	0.00
Karuppathur	56	5.00
Keelavathiyam	42	2.0
kulithalai	28.5	3.16
Thanjavur District		
Thirukattupalli	27	5.6
Kandamangalam	32	7.0
Senthalai	60	4.0
Karuppur	46	1.0
Nadukaveri	45.33	15.6

4.2 Diagnosis

A duplex PCR has been developed for detecting DNA viruses of banana. In this technique BSV and BBTV were simultaneously detected in PCR (Fig. 39). A single step DNA protocol is sufficient to detect both the viruses. Multiplex PCR has been developed to simultaneously detect three-banana viruses viz., BBTV, Bract Mosaic and Banana streak virus. cDNA developed for the RNA, isolated from Bract Mosaic infected plants was used as a template along with the DNA isolated from dually infected (BBTV + BSV) banana sample. This technique reduces the cost of the test by one third.

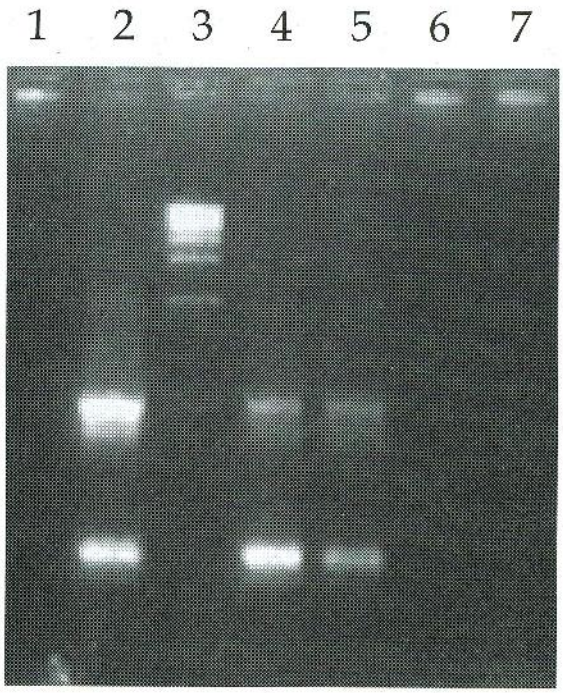


Fig. 39 Duplex PCR

Lane 1 - Healthy; Lane 2 - Infected; Lane 3 - Marker; Lane 4 - Infected; Lane 5 Infected; Lane 6 & 7 - Healthy

RT- PCR technique has been developed for detecting Banana Bract Mosaic Virus (Fig. 40). Prior to this an isolation protocol has been developed for total RNA isolation from infected banana plants. Proper sampling technique has also been standardized for detection. Non-radioactive probes for DNA viruses have been prepared and Nucleic acid spot hybridization technique has been developed for detecting the DNA viruses.

The diploids viz., Matti, Venkadali, Sanna Chenkadali and Kunnan used for polyploidization under DBT project were found free both episomal and integrant form of BSV viral genome. It is a necessary step to ensure the polyploids free of virus.

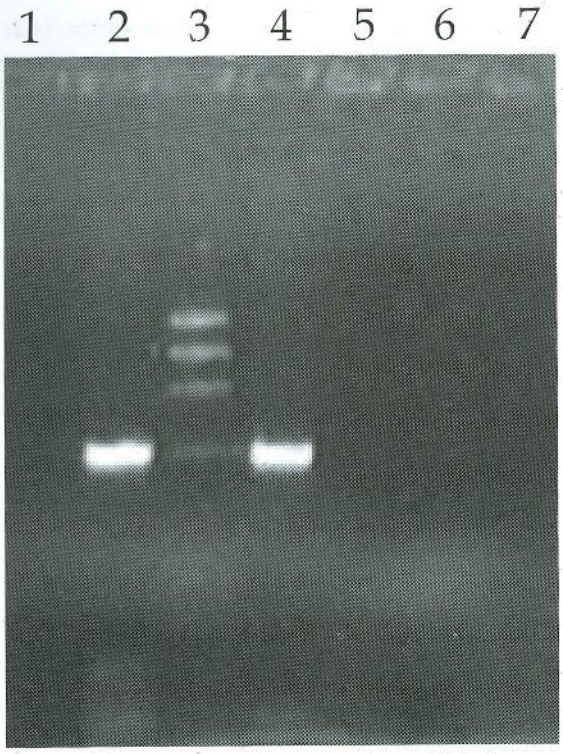


Fig. 40 Reverse Transcription - PCR for detection of BBMV

Lane 1, 5, 6 & 7 - Healthy; Lane 2 & 4 -Infected; Lane 3 Marker

Fig. 41

Mealy bug feeding on pseudostem

Mealy bugs feeding on infected leaf

4.3 Transmission

Banana streak virus has been detected in mea bugs (*Ferrisia virgata*) by PCR technique (Fig a&b & 42). *Ferrisia virgata* found to transfer t virus from banana to banana. For efficie transmission of BBTV by banana aphid t minimum acquisition access period was foun to be 10 min. First visible symptom in aphi transmitted plants was noticed at 24 days af inoculation feeding. After acquisition acce the virus was detected by PCR even in a sing aphid and the amplification was more wi increasing number of aphids (Fig 43).

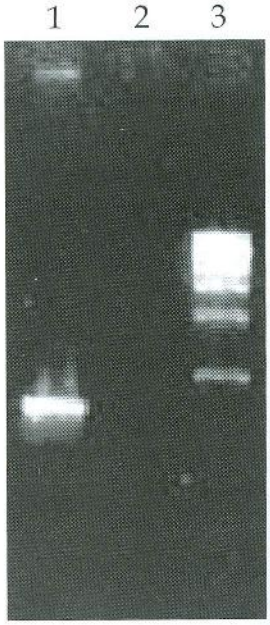


Fig. 42 Detection of BSV from vector mealy bug (*Ferrisia virgata*)

Lane 1 - DNA extracted from mealy bug after acquiring B from infected plant; Lane 2 - DNA extracted from mea bug fed on healthy plant; Lane 3 - Marker

4.4 Characterization of BSV

Eighteen BB accessions maintained in the fi gene bank of NRCB have been characteriz Six sets of primers have tried and foun variation in amplification. Eight of th accessions were positive for integration of BS which was confirmed by using mixed prime (One from Musa genome and another from BS genome).

RFLP analysis was done for BB clone EcoRI, Hind III were used for digesti Fragments having BSV integrants have be detected using probes made for BSV geno segments.

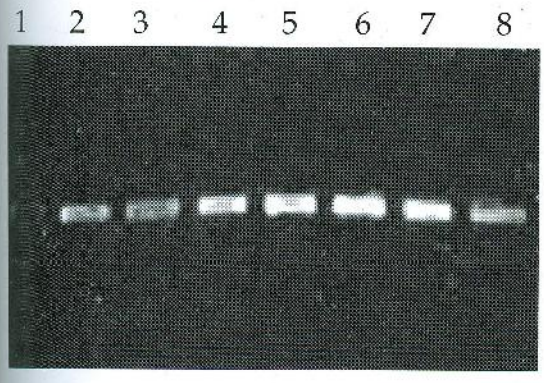


Fig. 43 Detection level of BBTV CP gene from its vector population

Lane1- Single aphids; Lane 2- Two aphids; Lane 3-Three aphids; Lane 4 - Four aphids; Lane 5- Five aphids; Lane 6 - Six aphids; Lane 7 - Seven aphids; Lane8 - Eight aphids

A non-radioactive probe has been made for part of the BSV genome and all the BB clones have been diagnosed for integrants and also for episomal virus. Dot blot hybridization test has confirmed presence of BSV in many of the AB, ABB and AAB-Mysore accessions. Comparison on detection using dot blot technique with two different probes has been made.

Ten diploids have screened for resistance to BSV and none found infected with the virus. Further confirmative work is in progress. One RAPD marker has been identified for differentiating the BSV infection / or integration in Poovan.

4.5 Cloning and characterization

Banana bract mosaic virus has been partially purified and part of the cp gene has been amplified from it were cloned and sequenced. The sequence has been submitted to NCBI. Similarly the BSV was partially purified from Poovan plants. The DNA isolated was used for amplification of six partial segments. The six PCR products were cloned in p-GEM -T vector and the clones have been sequenced and submitted in the NCBI. BBTV cp gene also cloned and sequenced for the Indian isolate.

4.6 Management of viruses

An attempt was made to eliminate BSV from Poovan banana through meristem tip culture. Meristem size of 0.5 to 0.7 mm found to eliminate the virus but culturing such small meristem in tissue culture ended in failure.

Preliminary study has been conducted to evaluate botanicals on management of viral diseases of banana. Three botanicals namely *Pongamia glabra, Bogainvillia spectablis,* and *Crotolaria juncea* have been found increasing the defense enzymes on both infected and healthy plants. Similarly chemicals have also been tested for BBMV control. BABA was found effective in inducing polyphenol oxidase enzyme in infected banana plants (Table 17).

Thermo therapy attempt was made for eradication of BBMV, but did not yield any positive results. Dry heat treatment of suckers at 55, and 60 for 30 and 60 min and isolating the meristem from those plants did not eliminate the virus. Various sizes of the meristems were 3-5 mm used not eliminating BBMV as confirmed by RT-PCR.

Table 17. effect of treatment of different chemicals at different concentrations on induction of polyphenol oxidase in bbmv infected and healthy banana plants

Chemicals	CONCENTRATION											
	10mM				30 mM				60mM			
	I.T	I.U.T.	H.T.	H.U.T.	I.T	I.U.T.	H.T.	H.U.T.	I.T	I.U.T.	H.T.	H.U.T.
BABA	0.5600	0.0450	0.0943	0.0340	0.0723	0.0450	0.0813	0.0340	0.0070	0.0450	0.0713	0.0340
	CD at 5% = 0.0210											
GABA	0.0373	0.0450	0.0660	0.0340	0.0963	0.0450	0.0456	0.0340	0.0240	0.0450	0.3900	0.0340
	not significant											
SA	0.0506	0.0450	0.0553	0.0406	0.0467	0.0450	0.0963	0.0340	0.0040	0.0450	0.2703	0.0340
	not significant											

I.T-Infected Treated; I.U.T- Infected Untreated; H.T- Healthy Treated; H.U.T- Healthy Untreated

DBT-Project

Developing Sigatoka leaf spot resistant bananas through polyploidy breeding

(S. Uma, S. Sathiamoorthy and M.S. Saraswathy)

The diploid cultivars Matti, Sanna chenkadali, Vadakkan Kadali and Kunnan were multiplied *in vitro* conditions. The multiple shoot buds were used to initate cell suspension cultutres and polyploidization. Cell suspension cultures were imitated from the callus cultures derived from leaf explants and male flower buds. The regeneration of plantlets from the cell suspension is under progress.

Using shoot meristem and actively dividing shoots carried out the polyploidizations of these diploid cultivars. The polyplidizing chemicals colchicines and oryzalin were used. The lethal dosages for two explant types in all the diploid cultivars were determined. The lethal dose of colchicines for the shoot meristem and actively growing buds was 10mM and 60µM for oryzalin.

The polyploidization were carried out, by treating both shoot meristems and actively dividing buds with 2.5, 5.0, 7.5mM colchicines and 10, 20, 30, 40 and 50µM for oryzalin. Shoots were regenerated form these treated cultures, rooted in rooting medium and acclimatized in the net house. The confirmation of the ploidy of these plants flow cytometry and root tip squash method is under progress.

NATP Projects

Sustainable management on plant diversity

(PI: S. Uma and Co. PI: S. Sathiamoorthy)

Totally 3 explorations were conduc including Western Ghats of Karnat Kodaikanal hills of Tamil Nadu and Anama hills of Kerala which resulted in the collec of 9 accessions.

New species of Ensete with orange colou pulp was recorded from Kodaikanal hills Tamil Nadu whose species status is to ascertained. A new type *Musa acuminate* collectd from Anamalai hills of Kerala whic found to be free of leaf spot.

Through secondary sources 208 accessio were collected from NBPGR, Thirusur.

The project was successfully completed December 2003.

Utilisation of Cement Kiln Flue Dust a Distillery Effluent as potassium source banana production

(PI: K.J. Jeyabaskaran and Co. PI: S.D. Pandey)

In case of Ney Poovan, the treatme combination Kiln Flue Dust (CKFD) an Distillary Effluent (DE) with 60 per ce recommended K (as KCl) recorded highe bunch weight of 13.59 kg, which is 25.25 p cent more than that (10.85 kg) at 100 per ce

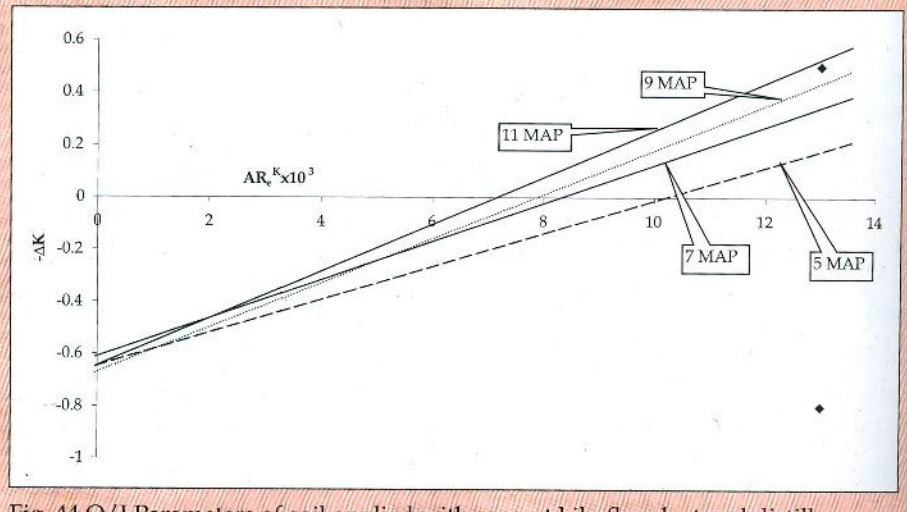


Fig. 44 Q/I Parameters of soil applied with cement kiln flue dust and distillery effluent with 100 per cent potassium at different crop growth stages

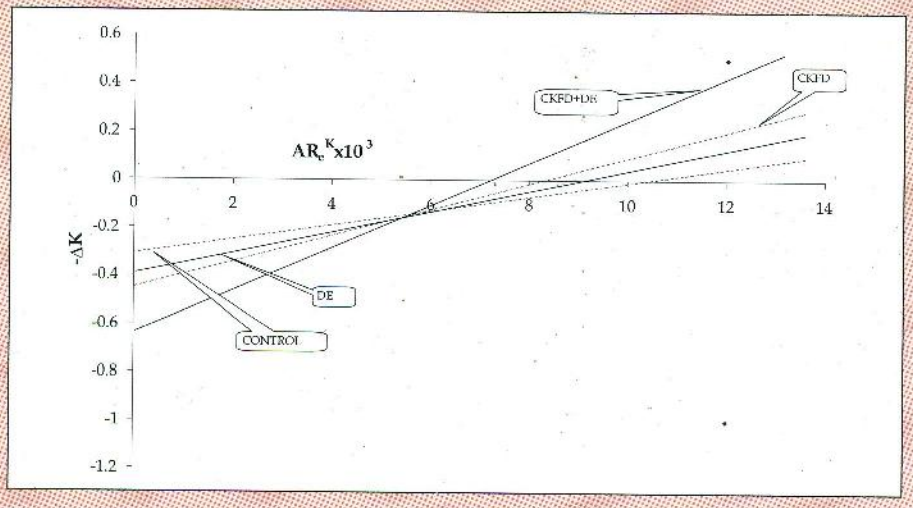


Fig. 45 Q/I Parameters of soil applied with cement kiln flue dust and distillery effluent with 100

recommended commercial K fertilizer alone (control). Thus, CKFD + DE substituted 40 per cent of the recommended K fertilizers and produced 25.25 per cent more yield in Ney Poovan banana. Application of CKFD + DE at the above rates, which produced 25.25 % more yield and saved 40 % commercial K fertilizer, could generate Rs. 31,450/ha as additional profit, in Ney Poovan banana.

Application of CKFD @ 0.5 kg/plant + DE @ 30000 lit./ac with 60 per cent recommended K (as KCl) recorded the highest bunch weight of 15.9 kg (26 per cent more than that with only 100 per cent recommended K as KCl) in first ratoon crop of Ney Poovan banana (Fig.46). This accrues an additional profit of Rs. 37,000/ha.

No harmful effects of CKFD and DE on post harvest soil were observed. The bulk density was reduced by 14.3 % and the porosity was increased by 8.1 % due to the application of both CKFD and DE. The soil pH and electrical conductivity were not affected significantly by the application of cement kiln flue dust and distillery effluent. A significant increase in organic carbon content, cation exchange capacity, available N, P and K, and DTPA-extractable Fe, Mn was observed with the application of CKFD and DE.

In the studies on K dynamics in soil applied with CKFD and DE, the CR-K (Constant Rate K), Step-K, -ΔK (Available K in the labile pool), AR_e^K (Activity ratio of K under equilibrium) and PBC-K (Potential Buffering Capacity of soil for K) were estimated in all the main treatment plots at different crop growth stages like 5 Months After Planting (MAP), 7 MAP, 9 MAP and 11 MAP. The maximum PBC-K of 87.5 cmol $kg^{-1}.(M/l)^{-0.5}$ was observed at the application of both CKFD + DE with 100 % recommended K, at 11 MAP. Thus, application of both CKFD and DE at the above rates in the soil maintained highest potential buffering capacities of soil for K (PBC-K), throughout the crop growth period, when compared to CKFD alone, DE alone and control (Fig. 44 & 45).

Regression and correlation of PBC-K, ΔK and AR_e^K of soil at 5, 7, 9 and 11 months after planting with bunch weight were worked out (Table 18). Significant and positive correlations of PBC-K and ΔK were observed with bunch weight. But, the correlation between AR_e^K and bunch weight was significant and negative. Thus, the increase in bunch weight was attributed to increase in PBC-K and ΔK and decrease of AR_e^K with the application of cement kiln flue dust and distillery effluent. The correlation coefficients of PBC-K and ΔK with bunch weight were higher during vegetative phase (5, 7 and 9 months after planting) than that in reproductive phase (11 months after planting). Thus, these observations clearly indicated that application of cement kiln flue dust and distillery effluent adjusted the PBC-K and ΔK of soil in a manner that the potassium-releasing pattern of soil exactly matched with potassium requirement pattern of banana crop, through out its growth period.

Table 18. Linear regression equations and correlation coefficients between bunch weight (Y) and Q/I parameters of soil K (X) at different plant growth periods.

S.No.	Plant growth period	Linear regression equations	Correlation coefficients
Bunch weight versus ΔK			
1.	5 month after planting	Y = 9.00 + 7.77 X	0.7014**
2.	7 month after planting	Y = 8.79 + 8.40 X	0.7698**
3.	9 month after planting	Y = 9.57 + 6.72 X	0.7026**
4.	11 month after planting	Y = 10.15 + 5.72 X	0.5924**
Bunch weight versus AR_e^k			
5.	5 month after planting	Y = 20.31 0.76 X	-0.8863**
6.	7 month after planting	Y = 19.26 0.74 X	-0.9208**
7.	9 month after planting	Y = 18.12 0.72 X	-0.7849**
8.	11 month after planting	Y = 17.73 0.72 X	-0.6899**
Bunch weight versus PBC-K			
9.	5 month after planting	Y = 9.25 + 0.08X	0.7907**
10.	7 month after planting	Y = 9.38 + 0.06 X	0.8157**
11.	9 month after planting	Y = 9.55 + 0.06 X	0.7959**
12.	11 month after planting	Y = 10.07 + 0.05 X	0.6827**

**Significant at 1% probability level.

Fig. 46 Neypoovan bunches obtained by applying CKFD and DE

Identification of nematode resistant breeding lines in *Musa*

(PI: P. Sundararaju and Co. PI: S. Sathiamoorthy)

Survey conducted from different varieties of banana viz., Nendran, Poovan, Ney poovan, Red banana, Matti, Sanna chankadali, Robusta, Karpuravalli and Pacha nadan grown in Kanyakumari, Coimbatore, Thanjavur and Trichirapalli districts in Tamil Nadu, Alleppey, Quilon and Trissur districts in Kerala revealed that the root-lesion nematode, *Pratylenchus coffeae* was the dominant species occurred in maximum number of root samples (52/70) followed by root-knot nematode, *Meloidogyne incognita* (25/70). Analysis of the soil samples revealed that the presence of seventeen genera of plant parasitic nematodes. The important nematode genera, which are frequently occurred in banana were *Rotylenchulus reniformis*, *Hoplolaimus* sp., *Tylenchorhynchus* sp. and *Xiphinema* sp.

Eighty banana varieties were screened for their reaction to root-lesion nematode, *Pratylenchus coffeae* and root-knot nematode, *Meloidogyne incognita* in pots under greenhouse conditions. The results revealed that five out of 80 varieties, Singhlal, Sakkarachayan, Malai Kala, Manik Cempa and Kartobiumtham were found resistant to root-lesion nematode followed by eight and 11 varieties were shown moderately resistant and tolerant reaction to *P. coffeae* respectively. The remaining 56 varieties were found susceptible to *P. coffeae*. In the case of root-knot nematode, *M. incognita*, none of the varieties were found resistant to this nematode.

A Preliminary work was carried out to understand the role of enzymes and phenols in resistant reaction to plant parasitic nematodes. Five varieties viz.., Nendran, Robusta, Pisang lilin Buaya, *Musa balbisiana*, and Karthobium tham were selected for biochemical analysis. The results indicated that the activity of poly phenol oxidase was 25% higher in variety Karthobiumtham compared to Nendran infected plants, where as Phenol accumulation was 22% higher in infected Nendran plant compared to Karthobiumtham. Even though the phenol accumulation is high in infected Nendran plants, but the poly phenol oxidase activity is found to be very less, which leads to the lower ratio between Mono phenol and polyphenol. This is responsible for the susceptible reaction of this variety.

Development of diagnostic kit for banana bunchy top nano virus infecting bananas and plantains in India

(PI: R. Selvarajan and Co. PI: S. Sathiamoorthy)

The bunchy top virus isolates collected from different geographical locations are being maintained in the Glasshouse. Partial purification of BBTV has been made for antiserum production. Non-radioactive nucleic acid labeled probe was developed for cp gene and DNA component 3 was found to be more sensitive than DAC-ELISA. Multiplex PCR has been developed to simultaneously detect three-banana viruses viz., BBTV, Bract Mosaic and Banana streak virus. cDNA developed for the RNA, isolated from Bract Mosaic infected plants was used as a template along with the DNA isolated from dually infected (BBTV + BSV) banana variety. Immuno-capture PCR was developed for detection of different strains of BBTV and also from symptom less samples (latent infection) (Fig. 47). This technique is more sensitive and reliable.

Dispatching the samples to long distances for indexing is one of the important step for which care should be taken up. The virus may degrade during the transit. We have developed a technique using calcium chloride, which is not spoiling the viral DNA for PCR detection purposes. The coat protein gene of the BBTV Indian isolate has been cloned and sequenced. The amino acid sequence is deduced from it.

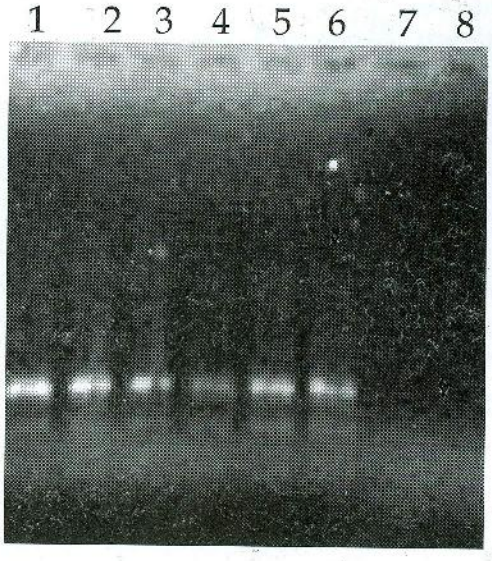


Fig. 47 Detection of BBTV by Immuno Capture - PCR

Lane1-5 - Samples; Lane 6 - Positive control;
Lane 7 & 8 - Healthy .

A protocol has been developed to isolate DNA in a shortest time (15 min) for PCR analysis for BBTV and BSV. BBTV has been found to express visual symptoms only 23 to 25 days after inoculation under standard conditions and it could be detected first from young roots or cortex tissue than the new leaf. Recently the germplasm explored by crop improvement division of NRCB was screened for BBTV; the positive samples intercepted were eliminated. Eight of the 45 accessions received from NBPGR regional station, Thrissur was found positive for BBTV in dot blot hybridization test. Healthy planting material for a few commercial clones has been initiated by indexing the high yielding clones and confirmed them as negative.

5 TECHNOLOGY ASSESSED AND TRANSFERRED

1. Released three promising NRCB selections, NRCB sel.01, NRCB sel.02 and NRCB sel.03 in AICRP (Tropical Fruits) meeting held at Sri Venkateshwara Agricultural University, Tirupathi during February 2004. These three selections have proven successful in farmer's field.
2. The Technical know-how of production of products like enzyme clarified banana juice, banana biscuits, banana fig, banana jam, sauce, sweet chutney, pickle and thokku were transferred to M/s Geeta Industries, Junagadh, Gujarat on 19.06.2003 and to M/s Dorven Agro-Eco-Bio Ventures Pvt.Ltd, Chennai on 24.09.2003 on non-exclusive basis. The technical know how of production of banana pickle/ thokku and fig were transferred to Sri.S.Sundaram, Kailash Illam, Trichy-17 on 7.10.2003.
3. Visual diagnostic techniques on virus indexing were taught to 150 horticulture officers, Agriculture officers and Assistant Agrl. Officers of Tamil Nadu.

Participation in Exhibition/Farmer's Meet

1. Dr.S. Sathiamoorthy, Dr.P. Sundararaju, Dr.B. Padmanaban, Dr.C.K. Narayana, Dr.R. Thangavelu and Mr.P. Ravichamy attended the Banana Seminar on "Hi-Tech banana cultivation" organized by SPIC Agro Biotec on 2nd April, 2003 at Thuckalay, Kanyakumari District.
2. Dr.M.M. Mustaffa, Dr.P. Sundararaju, Dr.B. Padmanaban and Dr.R. Thangavelu attended the Banana Seminar organized by EID Parry Ltd. and spoke on various aspects of "Improved production and management on banana" on 5th July, 2003 at Sanisanthai, Erode.
3. Dr.M.M. Mustaffa, Dr.P. Sundararaju, Dr.B. Padmanaban, Dr.S.D. Pandey, Dr. C.K.Narayana, Dr.R. Thangavelu and Mr.P. Ravichamy attented the "National Seminar on Banana Cultivation" jointly organized by Department of Horticulture and Plantation Crops, Tamil Nadu and FAO on 9th August 2003 at Salem.
4. Dr.M.M. Mustaffa, Dr.B. Padmanaban, Dr.C.K. Narayana Dr.S.D. Pandey, Dr.V. Kumar, Dr.R. Selvarajan, Dr.I. Ravi and Mr.P. Ravichamy attended the Seminar on the eve of Farmers day at Tiruchirapalli on 14th February 2004.
5. Dr.C.K. Narayana attended the Seminar on "Anna Marumalarchi Thittam" organized by District Industries Centre, at Thiruchendure Tuticorin district, Tamil Nadu on 24th February, 2004.
6. DrB. Padmanaban participated and delivered a lecture to Farmers and Farm women on "Insect Pest Management in Banana" organized by Central IPM Centre (Ministry of Agriculture, Govt. of India), Tiruchirapalli, 24th September 2003.

The Scientist of the Centre were involved in guiding the P.G. Students for their project work and also in guiding Ph.D./M.Phil. students from various Universities.

S.No	Project Guide	Name of the student	College/University
1.	Dr.M.M.Mustaffa Principal Scientist	Mr.M. Saravana Kumar, (M.Sc., Microbiology)	Thanthai Hans Rover College, Perambalur. Bharathidasan University
		Miss.N.Thenmozhi, (M.Sc., Microbiology)	J.J. College of Arts and Science, Pudukkottai. Bharathidasan University
2.	Dr.P.Sundararaju Principal Scientist	Miss. Usha Nandhini, (Ph.D. - Nematology)	Annamalai University, Chidambaram
		Miss.T. Kayalvizhi, (M.Sc., Microbiology)	Bharathidasan University, Trichy
		Miss.Pondy Suba, (M.Sc., Biotechnology)	Alagappa University, Karaikudi
3.	Dr.B.Padmanaban Senior Scientist	Ms. D.Hema, (M.Phil)	Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu
4.	Dr.C.K.Narayana Senior Scientist	Miss.G. Priyamahalakshmi (M.Sc., Biotechnology)	Holy Cross College, Bharathidasan University, Trichy
5.	Dr.R.Thangavelu Senior Scientist	Mr.G.Gurusamy, (M.Sc., Biochemistry)	Thanthai Hans Rover College, Perambalur, Bharathidasan University
		Mr.M. Parthiban, (M.Sc., Microbiology)	Thanthai Hans Rover College, Perambalur, Bharathidasan University
		Miss.R. Suguna, (M.Phil)	Ponnaiyah Ramajayam Arts & Science College, Thanjavur. Bharathidasan University
		Miss.A. Jayanthi, (M.Sc., Microbiology)	Dhanalakshmi Srinivasan College of Arts and Science for women, Perambalur, Bharathidasan University
		Mr.A.Thirumurugan, (M.Sc., Biochemistry)	Thanthai Hans Rover College, Perambalur, Bharathidasan University
6.	Dr.R. Selvarajan Senior Scientist	Miss.B. Geetha lavanya, (M.Phil)	Ponnaiyah Ramajayam Arts & Science College, Thanjavur, Bharathidasan University
		Miss.M.Theenulhutha, (M.Phil)	Ponnaiyah Ramajayam Arts & Science College, Thanjavur, Bharathidasan University
		Miss. J. Nancy Florida Suganthi, (M.Sc., Biotechnology)	Bishop Heber College, Trichy, Bharathidasan University
		Miss. S. Rupa, (M.Sc., Biotechnology)	Bishop Heber College, Trichy, Bharathidasan University
		Miss.D.Brindha, (M.Sc., Microbiology)	Shrimathi Indira Gandhi College, Trichy Bharathidasan University

S.No	Project Guide	Name of the student	College/Institute
		Miss.P.Mohana, (M.Sc., Microbiology)	Shrimathi Indira Gandhi College, Trich Bharathidasan University
		Mr.A.J. Visaga Dhaththan, (M.Sc., Biotechnology)	Andavar Arts & Science College, Trichy, Bharathidasan University
7.	Dr.I. Ravi Senior Scientist	S. Kulanthaivelu, (M.Sc. Biochemistry)	Thanthai Hans Roever College, Perambalur, Bharathidasan University

7 AWARDS AND RECOGNITION

1. Dr. B. Padmanaban has been recognised as a Fellow of Entomological Society of India (FESI) by the Entomological Society of India, IARI, New Delhi-110 112
2. Dr. B. Padmanaban has been recognised as a Co-guide by the Bharathidasan University, Tiruchirapalli for Supervising the Ph.D., thesis entitled "Chemical characterization, synthesis and field evaluation of bio-active compounds" by Mr.S. Palani chamy, Lab.Technician, National Research Centre for Banana, Tiruchirapalli.
3. Dr.S. Uma has been assigned a **contract as Technical Editor** by FAO, Rome to write a technical bulletin on 'Farmers knowledge on Indigenous wild *Musa* diversity in India.
4. As a token of appreciation, the Rotary Club of Tiruchirapalli presented achievement award to the National Research Centre for Banana (NRCB) on 16th Feburary, 2004 for carrying out various research activities on banana including the development of many value added products and given training for the benefit of rural entrepreneurs. Dr.M.M. Mustaffa, Principal Scientist, NRCB received the award from Tiruchirapalli Mayor Mrs. Sarubala R. Thondaiman.

Dr. M.M.Mustaffa, receives a appreciation award presented by the Rotary Club for the Centre from the Mayor , Trichy

8 LINKAGES AND COLLABORATION IN INDIA AND ABROAD

NRCB is collaborating with the International Network for the Improvement of Banana and Plantain (INIBAP) and the Flemish Office for Development Cooperation and Technical Assistance (VVOB) for carrying out Two Ph.D programmes on "Screening for nematode resistance in *Musa*" and "Development of nematode resistance in *Musa* lines through breeding" at NRCB, Tiruchirapalli and at Tamil Nadu Agricultural University, Coimbatore.

In collaboration with International Network for the Improvement of Banana and Plantains (INIBAP), France, NRCB has organized 2nd Global Promusa Breeders meet at Coimbatore during 23-27 June, 2003. In this breeders meet 7 resource persons from outside India (FHIA-Honduras, CARBAP-Cameroon, CIRAD-FLOHR, INIBAP, France) and 7 Indian resource persons were participated.

NRCB has collaboration with INIBAP in ***Musa* Germplasm Information System (MGIS)** to build up Global Database Net work. Till date 965 accessions for passport data and 290 accessions for complete characterisation data and photographs for 50 accessions have been updated for global database network.

9 RESEARCH PUBLICATIONS

a) Papers Published in Journals

Jeyabaskaran, K.J., S.D. Pandey and G. Gomadhi. 2003. Effect of potassium-rich cement kiln flue dust and distillery effluent as substitute for potassium fertilizers on growth, yield and quality of "Ney Poovan" banana (*Musa paradisiaca*). *Indian J. Agric. Sci.*, **73**(12): 641-644.

Jeyabaskaran, K.J., S.D. Pandey and G. Gomadhi. 2004. Integration of potassium-rich cement kiln flue dust and distillery effluent in potassium fertilization for increasing banana production. *Andhra Agric. J.*, **50** : 418-420.

Nahif, A.A., **Padmanaban, B.**, P.Sundararaju and S.Sathiamoorthy 2003 Ultra structure of mouthparts, elytra and tarsus of the Banana Stem Weevil, *Odoiporus longicollis*. *Entomon* **28**(1): 45-49.

Narayana, C.K., M.M.Mustaffa and S.Sathiamoorthy. 2002. Effect of postharvest application of calcium chloride on ripening, shelf life and quality of banana cv. Poovan. *South Indian Hort.* **50**(4-6): 308-316.

Narayana, C.K., P.Krishnan and S.Sathiamoorthy. 2004. Effect of various postharvest treatments on ripening, storage life and quality of Rasthali banana during low temperature storage. *Andhra Agric. J.* **50**(Spl): 385-89.

Narayana, C.K., S.Sathiamoorthy and A.Evelin Mary. 2002. Studies on ready-to-serve beverage from enzyme clarified banana juice. *Progressive Hort.* **34**(1): 65-71.

Narayana, C.K., S.Sathiamoorthy and D.Ramajeyam. 2002. Effect of ethylene absorbent and hot water treatment on storage life and quality of Rasthali banana. *Current Research* **31**(7-8): 131-134.

Narayana, C.K., S.Sathimoorthy.A.Evelin Mary.2002. Osmotic dehydration of banana and changes in its quality during storage. *Beverage and Food World.*, **30**(6): 30-31.

Padmanaban, B. and M.Daniel 2003 Biology and bionomics of palm white grub, *Leucopholis burmeisteri* Bren. Coleoptera: Scarabalidae: Melonothinae) *Indian.J.Ent.*,**65**(4):444-452

Padmanaban, B. and M.Daniel 2003 Natural enemies of the oriental yellow scale, *A.orientalis* (Newstead) (Homophero: Diaspidae) *Indian.J.Ent.*,**65**(3):422-424

Padmanaban, B., M.Kandasamy and S.Sathiamoorthy 2003 Survival of Banana weevil borers in banana plant residues *Indian J.Ent.* **65**(3): 424-425

Padmanaban, B., P.Rajan and M.Daniel 2003 Biocontrol agents recorded from palm white grubs *Indian.J.Ent.*,**65**(4):434-438

Padmanaban, B., R.Selvarajan, M.Kandasamy and V.Balasubramanian 2003 Occurrence of fungi, *Scopulariopsis brevicaulis* (Saccardo) Bainer and *Aspergillus flavus* Link as entomopathogns of Banana stem weevil, *Odoiporus longicollis* (Curculionidae: Coleoptera) *Entomon* **27**(4): 411-413

Sundararaju, P and Kumar, V. 2003. Management of root-lesion nematode, *Pratylenchus coffeae* in six commercial cultivars of banana through organic and inorganic amendments. *Infomusa* **12**:35 38.

Sundararaju, P. and Jeyabaskaran, K. J. 2003. Evaluation of different soil types on multiplication of *Pratylenchus coffeae* and growth of banana seedlings var. Nendran. *Nematol. Medit.* **31**:151-153

Sundararaju, P. Cannayane, I. and Sathiamoorthy, S. 2003. Occurrence of *Meloidogyne incognita* on *Ensete superbum*. *InfoMusa*. **12**: 43-44.

Sundararaju, P., B. Padmanaban and S.Sathiamoorthy 2003 Efficacy of certain botanicals against root lesion nematode, *Pratylenchus coffeae* in banana. *Nematol. medit* **31**: 201-205.

Sundararaju, P., Cannayane, I., Pandey, S.D. and Sathiamoorthy, S. 2002. Effect of population levels of plant parasitic nematodes on high density planting with fertigation levels in banana cv. Robusta. *Pratylenchus coffeae* infecting banana. In: Emerging trends in pests and diseases and their management (Eds. Sabitha Doraisamy *et al.*, 2002). Tamil Nadu Agricultural University, Coimbatore.337-341

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Colletotrichum musae using plant extracts. *J.Hort.Sci. and Biotech.* **79** (4) 664 668.

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Uma, S, Dayarani, M, Singh, H.P. and Sathiamoorthy, S., 2002. Genetic variability studies in banana-1. Mysore subgroup (AAB). *Indian J. Plant Genetic. Resources* **15**(3): 275-277.

Uma, S., Selvarajan, R., Sathiamoorthy, S. Ramesh kumar and P.Durai. (2003). Evaluation of banana germplasm for the leaf industry and for suitability to different growing environments in India. *International Plant Genetic Resource Newsletter.* **134**: 26-32

Uma, S, R.Selvarajan, S.Sathiamoorthy, A.Ramesh Kumar and P.Durai, 2003. Evaluation of Banana Germplasm for Leaf Industry and their suitability to different production profiles in India. *International Plant Genetic Resource Newsletter* **134**:41-44.

Uma, S, Sathiamoorthy, S, Singh, HP and Dayarani, M, 2002. Crop improvement in Musa-Evaluation of germplasm for male and female fertility. *Indian J. Plant Genetic. Resources* 15: 137-139.

b) Popular Articals

Jeyabaskaran, K.J. 2003. "Kalium Potassium Aanathu Eppadi?" (in Tamil), *Valarum Velanmai*, **29**:26.

Jeyabaskaran, K.J. 2003. "Vaazhnthaal Vaazhai, Veezhnthaal Ezhai" (in Tamil), *Naveena Velanmai*, **9**:13-14.

Jeyabaskaran, K.J. 2003. Cement factory kiln flue dust and alcohol distillery effleutent alternate potassium source for banana. *Kisan World*, **30**:63-64.

Jeyabaskaran, K.J. 2003. Soil suitability classification for bananas and plantains. *Kisan World*, **30**:64.

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Jeyabaskaran, K.J., S.D. Pandey and M.M. Mustaffa. 2003. "Vaazhaiyin Valamaikku Potassium" (in Tamil), *Valarum Velanmai*, **29**:19-24.

Jeyabaskaran, K.J., S.D. Pandey, G. Gomadhi, M.M. Mustaffa and T. Anitha Sree. 2003. "Vaazhaikku Maattru Potash Urangal" (in Tamil), *Valarum Velanmai*, **29**:32-35.

Mustaffa, M.M, Selvarajan, R and S.Sathiamoorthy (2004), 40% Athiga vilaichal tharum Adar nadavu vazhai sagupadi. Thamizhaga vivasayee Ulagam, PP 10-11

Narayana, C.K., Pandey, S.D., Sathiamoorthy, S. and Ramajayam, D. 2003. Kele Ke Upayogi Utpaad. (Hindi) *Phal Phool.* **26**: 15-17.

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Pandey, S.D., K.J. Jeyabaskaran, C.K. Narayana, M.M. Mustaffa and S. Sathiamoorthy. 2003. "Keley kee vyaavasaayik jaathiyaang - I" (in Hindi). *Krishak Duniya*, 4-10, August, 2003: 6.

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Sathiamoorthy, S, S.Uma, R.Selvarajan and P.Durai, 2002. Ornamental Bananas (*Musa* ssp) of India with Export Potential. In the proceedings of XXIII Flower Vegetable and Fruit Show, Pondicherry. Pp 33-36

c) Technical Bulletins/Reports etc

Technical Bulletins

Sundararaju, P., Cannayane, I. and Sathiamoorthy, S. 2004. Nematode management in bananas and plantains. Technical bulletin No.10 NRC for Banana, Trichy pp.14.

Sundararaju, P. and Sathiamoorthy S. 2004. Nematode management in bananas and plantains. Technical bulletin No.11 (Tamil) NRC for Banana, Trichy pp.18.

Folders

Extension folder No.4 (2004). Burrowing nematode of banana. **Sundararaju, P.** and Sathiamoorthy, S.

Extension folder No.5 (2004). Root-lesion nematode of banana. **Sundararaju, P.** and Sathiamoorthy ,S.

Extension folder No.6 (2004). Root-knot nematode of banana. **Sundararaju, P.,** Sathiamoorthy ,S. and Swarnakumari, N.

Extension folder No.7 (2004). Spiral nematode of banana. **Sundararaju, P.,** Sathiamoorthy ,S. and Swarnakumari, N.

Extension folder No.8 (2004). Burrowing nematode of banana. (Tamil). **Sundararaju, P.** and Sathiamoorthy, S.

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Extension folder No.11 (2004). Spiral nematode of banana. (Tamil). **Sundararaju, P.** and Sathiamoorthy, S.

Papers Presented In Seminars / Workshop / Symposium

International

1. Masdek, N., Mahmood, M., Molina, A., Hwang, S.C., Dimyati, A., **Thangavelu, R.** and Omar,I. 2003. Global significance of Fusarium wilt in Asia. 2nd International symposium on Fusarium wilt on banana held at Salvador de Bahia, Brazil, 22-26 September 2003. page no. 11 (Abs)

2. **Mustaffa, M.M.** and S.Sathiamoorthy.2003. Current status of banana research in India. Proceedings of BAPNET meeting, Jakarta 6-8th October 2003.

3. **Padmanaban, B.**, 2003 " Screening of *Musa* germplasm for banana weevil resistance" presented at the II International Promusa breeders meet jointly organized by INIBAP, France, NRCB and TNAU at TNAU, Coimbatore, 23-27 June 2003.

4. **Selvarajan, R.**, 2003 "**Status of Banana Streak Virus in Indian Germplam**" presented at the II International Promusa Breeder's meet jointly organized INIBAP, France, NRCB and TNAU TNAU, Coimbatore, 23-27 June, 2003.

5. **Selvarajan, R.**, 2003 "**Molecular diagnos and biotechnological approaches f management of banana viruses in Indi** In. manual on Biotechnological approach for the management of plant pathogens export oriented horticultural crop Organized by Dept. Plant Pathology, CPP TNAU, Coimbatore from 2-22nd Dec. 2003

6. **Sundararaju, P.**, 2003 " Screening of *Mus* germplasm against major nematod pathogens infesting banana " presented the II International Promusa Breeder's mee jointly organized by INIBAP, France NRCB and TNAU at TNAU, Coimbatore 23-27 June, 2003.

7. **Sundararaju, P.**, Shanthi, A and Sathiamoorthy, S. 2003, "Status report o nematode problems in India and their management". Paper presented in the Regional Training Workshop o "Enhancing Capacity for Nematode Management in Musa" during 1-5 December, 2003 at Institute of Plant Breeding, College of Agriculture, UP, Los Banos, Philippines.

8. **Sundararaju, P.** 2004. "Status of nematode problems on banana in India". Lecture delivered to the participants of the International Training cum Workshop on "Recent advances for Eco-friendly Management of Nematodes in Banana organised at NRCB, Trichy held on 16-18 March, 2004, pp 3-14.

9. **Sundararaju, P.** 2004. "Nematode survey and collection of samples". *Ibid.* pp 20-27.

10. **Sundararaju, P.** 2004. "Nematode extraction from roots and soil". *Ibid.* pp 28-36.

11. **Sundararaju, P.** 2004. "Eco friendly management of plant parasitic nematodes". *Ibid.* pp 37-46.

12. **Sundararaju, P.** 2004. "Identification of plant parasitic nematodes associated with *Musa*". *Ibid.* pp 53-85.

13. Padmanaban, B., and **Sundararaju, P.** 2004 Entomopathogenic Nematodes- A potential Bio-Control Agent for Insects. *Ibid.* pp 102-110.

14. Swarnakumari, N. and **Sundararaju, P.** 2004. "Methods of microtechniques in nematology". *Ibid.* pp 111-123.

15. **Uma, S.** 2004. "Status paper on PGR activities on banana". *Ibid.* pp 124-131.

16. **Thangavelu, R.** 2003. A new basidiomycete wilt disease of banana. Global significance of Fusarium wilt in Asia. 2nd International symposium on Fusarium wilt on banana held at Salvador de Bahia, Brazil, 22-26 September 2003. Page no. 36(Abs).

17. **Thangavelu, R.**, 2003 "**Screening of germplasm against Sigatoka leaf spot and Fusarium wilt diseases on banana**" presented at the II International Promusa Breeder's meet jointly organized by INIBAP, France, NRCB and TNAU at TNAU, Coimbatore, 23-27 June, 2003.

18. **Thangavelu, R.,** Velazhahan, R and Sathiamoorthy, S. 2003. Bio controls of Fusarium wilt disease. Global significance of Fusarium wilt in Asia. 2nd International symposium on Fusarium wilt on banana held at Salvador de Bahia, Brazil, 22-26 September, 2003. Page no. 34 (Abs).

19. **Thangavelu, R.,** Velazhahan, R and Sathiamoorthy, S. 2003. Genetic diversity of Fusarium oxysporum f.sp. Cubense isolates from India. Global significance of Fusarium wilt in Asia. 2nd International symposium on Fusarium wilt on banana held at Salvador de Bahia, Brazil, 22-26 September, 2003. Page no. 14(Abs).

National

1. **Jeyabaskaran, K.J.**, S.D. Pandey and G. Gomadhi. 2003. Integration of potassium-rich cement kiln flue dust and distillery effluent in potassium fertilization for increasing banana production. Paper presented in the National Seminar on Resource Management for Sustainable Agriculture, held at the Agricultural College, Bapatla, during 28-30, Jan., 2004.

2. **M.M.Mustaffa**, V.Kumar, P.Sundararaju, B.Tanuja Priya, K.C.Sivakumar and S.Sathiamoorthy, 2003. Organic farming in Rasthali banana. 6th Agricultural Science Congress, IISS, Bhopal.

3. **Mustaffa, M.M.**, A.Padmavathi, B.Tanuja Priya and P.Sundararaju, 2003. Studies on soil microbes under organic farming in Karpuravalli banana. National Symposium on "Organic Farming in Horticulture for Sustainable Production". August 29-30, 2003, CISH, Lucknow. 66-67p.

4. **Mustaffa, M.M.**, B.Tanuja Priya, V.Kumar and D.Dhanasekar, 2003. Studies on organic manures influence on yield and fruit quality of Karpuravalli banana. *Ibid.*

5. **Padmanaban, B.** 2004 Influence of Natural plant kairomone Sources in the management of banana weevil. Abstract, National Seminar on Trends in pheromone Research and Technology, February 6-7, 2004 held at NRCG, Junagadh

6. **Padmanaban, B.** and Sundararaju, P. 2004. "Entomopathogenic nematodes-A potential biocontrol agent for insects". *Ibid.* pp 102-110.

7. **Padmanaban, B.**, A.R.Prasuna, R.Rajeshwari and A.R. Prasad 2004 Electroantennogram Response of Banana Stem Weevil, *O.longicollis* to host plant volatiles (Coleoptera: Curculionidae.) *Ibid.*

8. **Padmanaban, B.**, P.Sundararaju and S.Sathiamoorthy 2004 Pheromone: Its scope in IPM in Banana. Souvenir, National Seminar on Trends in pheromone Research and Technology, *Ibid.*

9. **Padmanaban, B.**, 2004. Trapping studies on Banana corm weevil using pheromone at the National symposium on frontier areas of entomological research organized by the Entomological Society of India, IARI, New Delhi, 5-7 November 2003.

10. **Pandey, S.D.** K.J. Jaybaskaran and M.M. Mustaffa, 2003. Kele Utpadan Takaneeki. Poster presentation in Hindi seminar held at NRCB, Trichy on 16th September 2003 under Official Language Implementation Programme.

11. **Selvarajan, R.** 2003. "Molecular diagnosis and biotechnological approaches for management of banana viruses in India". In. manual on Biotechnological approaches for the management of plant pathogens in export oriented horticultural crops". Organized by Dept. Plant Pathology, CPPS, TNAU, Coimbatore from 2nd Dec. to 22nd Dec. 2003.

12. **Sundararaju, P.** and Cannayane, I.2003. Evaluation of different biopesticides against major nematode pathogens infesting banana cv. Nendran. National Symposium on "Organic Farming in Horticulture for Sustainable Production". August 29-30, 2003, CISH, Lucknow. 66-67p.

13. **Sundararaju, P.**, Sasikala, T and Cannayane, I.2003. Effect of *Verticillium chlamydosporium* on second stage juvenile mortality and egg hatching of *Meloidogyne incognita* under *in vitro* conditions. *Ibid*.67p.

14. **Thangavelu, R** and Sathiamoorthy, S. 2004. Opportunities in microbial diversity and role of biological resource centers. NBAIM-CAB international, UK, joint workshop on Isolation, preservation and conservation of agriculturally important micro organisms and use of potential molecular tools for their identification. March 16-17, 2004, IARI, New Delhi, India. Page.27.

15. **Thangavelu, R.**, Velazhahan, R and Sathiamoorthy, S. 2003. Induction of defense mechanisms in banana by plant growth promoting microbes, plant activators and inoculation with *Fusarium oxysporum* f.sp.*cubense*. Proceedings of 6th international workshop on plant growth promoting Rhizobacteria, 5-10 October 2003, Indian Institute of Spices Research, Calicut, India. Pages 617-626.

10 LIST OF APPROVED ON-GOING PROJECTS

1. CROP IMPROVEMENT

Management of genetic resources of banana (S.Uma)

Crop improvement of banana through conventional breeding (S.Sathiamoorthy)

Crop improvement through non conventional approaches (S.Uma, S.Sathiamoorthy and M.S. Saraswathi)

2. CROP PRODUCTION AND POST HARVEST TECHNOLOGY

Standardization of agro techniques for banana production and productivity (S.D. Pandey)

Standardization of technology for organic banana production (M.M. Mustaffa)

Standardization of nutritional requirements of banana using soluble fertilizers (V. Kumar)

Integrated nutrient management in banana (K.J. Jeyabaskaran)

Studies on micronutrients in banana (K.J. Jeyabaskaran)

Studies on handling, storage and processing of banana (C.K. Narayana)

3. Crop Protection

Insect pest management in banana (B. Padmanaban)

Studies on banana nematodes and their management (P. Sundararaju)

Investigation on fungal and bacterial diseases of banana and their management (R. Thangavelu)

Studies on viral diseases of banana and their management (R. Selvarajan)

11 CONSULTANCY, PATENTS AND COMMERCIALIZATION OF TECHNOLOGY

1. Flemish Office for Development Cooperation and Technical Assistance (VVOB), Belgium provided funds to NRCB Trichy for upgrading the Nematology Laboratory and operational costs, scholarships for two Ph.D. students and the costs of the training cum workshop. Two Ph.D. students from TNAU, Coimbatore, have already initiated the research programmes on "Screening for nematode resistance in *Musa*"at NRCB, Tiruchirapalli and TNAU Coimbatore" under the guidance of Dr.P. Sundararaju.

2. Total finaelf company-France funded a project on Evaluation of Paraffinic oil Banole (TRE) for the management of Sigatoka leaf spot disease of banana in cvs. Nendran and Robusta. Dr.R. Thangavelu, has carried out the project. The summary of results obtained is given below.

   A Field trial was laid out in 2003 -2004 to test the effect of paraffinic oil at different concentrations and along with some effective fungicides at different combinations for the management of Sigatoka disease of banana in varieties viz., Nendran (AAB) and Robusta (AAA). When compared to last year trial, this year the effective fungicides such as Propiconazole and Companion and oil 2.5 and 5% concentrations alone were included for further testing. The results of the study indicated that in var. Nendran spraying of oil alone and in combinations of half the dose of fungicides drastically reduced the Sigatoka leaf spot incidence in all the phases of banana growth (ie. vegetative, shooting and harvest phases). The per cent reduction was ranged from 29.07 to 52.1 per cent and the maximum per cent reduction in disease severity was observed due to spraying of oil 5% in combination with propiconazole 0.05 %. The per cent increase in YLS value more (29.70) in oil 2. 5% + Propiconazole .05% sprayed plot followed by oil 2.5% + Companion 0.05% and oil 5% + propiconazole 0.05 %.

   In the case of Robusta among various treatments, the highest reduction in disease severity over control (52.79 %) was observed in oil 5% + Propiconazole 0.05% sprayed treatment which was followed by oil 5% + companion 0.05% (46.70 %). Interestingly oil 2.5% alone recorded 46.53 per cent reduction in disease severity compared to control and the effect was on par with oil 5% + companion 0.05%. Generally the value of YLS-0 increased significantly due fungicide and oil spray and also in combination of both. The maximum of YLS-0 was observed due to spray with oil 2.5% + companion .05% (34.11) followed by oil 2. 5% alone (29.76).

3. PI industries Ltd, Hyderabad funded a project on Evaluation of Shield 2.62% SC for the management of Sigatoka leaf spot disease of banana in variety Robusta and Nendran which is being carried out by Dr.R. Thangavelu. The midterm results are furnished below.

   Field trial conducted to evaluate Shield chemical at 0.1, 0.2 & 0.3 per cent concentrations and also different fungicides such as Kavach (2gm/lit), Mancozeb(2.5 gm/lit), Blue copper (3gm/lit), Carbendazim (1gm/lit) and Propiconazole (1ml/lit) in cvs. Robusta and Nendran indicated that Shield at 4ml/lit significantly reduced the severity of the disease compared to control. However the maximum reduction in disease severity was observed in propiconazole sprayed plot followed by Carbendazim 0.1% in both the varieties tested. But in the case of YLS 0, the effect of Shield at 4ml/ lit was on par with Propiconazole in the variety Robusta and the effect of Propiconazole was more than Shield in var. Nendran at shooting stage of evaluation.

4. Dr.R. Selvarajan conducted a training on virus indexing in banana sponsored by FAO, Rome.

5. Under contract service virus indexing of tissue culture banana plants from private laboratories and testing of soil / water samples were done by Dr. R. Selvarajan and Dr. K. J. Jeyabaskaran respectively.

12 RAC, MANAGEMENT COMMITTEE, SRC, QRT etc. MEETINGS WITH SIGNIFICANT DECISIONS

Sixth Research Advisory Committee Meeting

The 6th RAC Meeting was held on 28.01.2004. Dr.H.K. Jain, Chairman-RAC chaired the session and conducted the proceedings. Dr. S. Sathiamoorthy, Director NRCB welcomed the Chairman and RAC Members. Then 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 on-going research projects on banana under the following major topics were presented by the Section-In charges concerned.

1. Crop Improvement : Dr.S. Uma
2. Crop Production : Dr.M.M. Mustaffa
3. Crop Protection : Dr.P. Sundararaju
4. Post Harvest Technology : Dr.C.K. Narayana

After detailed discussions on 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 in time.

List of RAC Members

Chairman

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

Members

Dr.B.M.C. Reddy
Project Coordinator-Tropical Fruits,
Indian Instt. Of Horticultural Research,
Hessaraghatta Lake PO,
Bangalore 560 089.

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

Dr. Akilesh Tyagi
Professor,
Dept. of Biotechnology,
Delhi University South Campus,
New Delhi.

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

Dr.S.N. Pandey
Asst. Directore General (H),
Indian Council of Agril. Research,
Krishi Anusandhan Bhawan-II,
Pusa, New Delhi 110 012.

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

Dr.S. Sathiamoorthy
Director,
National Research Centre for Banana,
Tiruchirapalli 620 102.

Member Secretary

Dr.M.M. Mustaffa
Principal Scientist,
National Research Centre for Banana,
Tiruchirapalli 620 102.

INSTITUTE MANAGEMENT COMMITTEE MEETING

Seventh Institute Management Committee Meeting

The 7th IMC meeting was held on 23rd December, 2003 under the Chairmanship of Dr. S. Sathiamoorthy, Director NRCB, Tiruchirapalli. He welcomed the Management Committee Members and briefed the research achievements of NRCB. Mr.B. Vijayakumar, AAO has presented the action taken report on the proceedings of the 6th management committee meeting. After detailed discussion the IMC members have approved the proceedings. During the meeting various policy decisions were taken for the overall development of the centre.

List of IMC Members

Chairman

Dr.S. Sathiamoorthy,
Director, NRC (Banana) Trichy.

Members

Dr.S.N. Pandey,
ADG(Hort.) ICAR New Delhi.

Shri. Dhanavel, IAS,
Director of Horticulture and Plantation Crops, Govt. of Tamil Nadu, Chennai.

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

Dr.Sathiaseelan,
Addl. Director of Agriculture,
Dept. of Agriculture, Govt of Pondichery

Dr.M.M. Mustaffa,
Principal Scientist NRC(Banana), Trichy

Dr.P. Sundararaju,
Principal Scientist NRC(Banana), Trichy

Dr.S. Uma,
Senior Scientist NRC(Banana), Trichy

Non Official Member

Shri. Subha Somu,
Vice Chairman,
Coconut Development Board

Member Secretary

Shri.B. Vijayakumar,
AAO NRC(Banana), Trichy

STAFF RESEARCH COUNCIL MEETING

The Eighth Staff Research Council meeting was held on 8th and 12th December, 2003 in the Committee room under the Chairman Dr.S. Sathiamoorthy, Director of National Research Centre for Banana, Tiruchirapalli. The Member Secretary welcomed the Chairman and Members of the SRC. Then the progress of the various on-going projects and technical programmes were discussed. All the Scientists of NRCB attended the meeting. There were four Technical Sessions on the research progress of on-going research projects was presented by the respective project leaders. The work done under the NATP and an Adhoc projects were presented by the respective Principal Investigators and reviewed the physical and financial research accomplishments.

Quinqunnial Review Team

Indian Council of Agricultural Research, New Delhi constituted the Quinqunnial Review Team (QRT) for reviewing the progress of work made during the period between 1994 and 2002. The QRT made its final sitting at NRCB during 4-6th August, 2003 and prepared its final report. The chairman-QRT submitted the final report to the Council during December, 2003.

List of QRT members

Chairman

Dr.B.S. Chundawat
Vice-Chancellor (Rtd.),
Gujarat Agrl. University,
Anand, Gujarat.

Members

Dr.H.C. Das
Director (Rtd.),
National Research Centre for Citrus,
Nagpur.

Dr.P. Das
National Professor,
Bhubaneshwar, Orrisa

Dr. Jeyarajan
Prof & Head (Rtd.),
Dept. of Plant Pathology TNAU,
Coimbatore.

Dr.T. Thangaraj
Dean,
HC&RI, TNAU,
Periyakulam.

Member Secretary

Dr.M.M. Mustaffa
Principal Scientist,
National Research Centre for Banana,
Thogamalai Road, Thayanur PO,
Tiruchirapalli 620 102.

PARTICIPATION IN SEMINARS / SYMPOSIA / CONFERENCE / WORKSHOP ETC.

Name of Scientist	Name of Seminar/ Symposia/ Conference/ Workshop	Period
International		
Sathiamoorthy, S., Mustaffa, M.M., Sundararaju, P., Padmanaban, B., Narayana, C.K., Uma, S., Thangavelu, R., Selvarajan, R., Saraswathi, M.S.	2nd Global Promusa Breeders Meet at TNAU, Coimbatore	23-27th, June, 2003
Thangavelu, R.	2nd International symposium at Brazil	22 - 26th, Sep, 2003
	6th international workshop at Calicut, India	5-10th, Oct, 2003
	Round table conference organized by NBAIM- CAB international,UK at New Delhi, India	16 -17th, Mar, 2004
National		
Sathiamoorthy, S.,	XIX ICAR Regional Committee-VIII meeting at UAS, Bangalore	29-30th, Dec, 2003
Mustaffa, M.M., Sundararaju, P., Pandey, S.D.	National Symposium on Organic Farming in Horticulture for Sustainable Production at Lucknow	29 - 30th, Aug, 2003
Padmanaban, B.,	National symposium on frontier areas of entomological research at New Delhi	5 - 7th, Nov, 2003
	IV Annual discussion meeting at Chennai	29th Nov,2003
Pandey, S.D.,	ICAR sponsored winter course at Faizabad UP	03-23rd, Dec, 2003
	NATP finance review meeting at Mumbai	3rd March 2004
	National Seminar on Jaivik Kheti for Sustainable Production at Lucknow	23-25th, Mar, 2004
Narayana, C.K.,	National Consultative Committee Meeting on Food Park at Virudhunagar.	24th, Nov, 2003
Sathiamoorthy, S., Uma. S., Pandey, S.D.,	All India Coordinated Research Project at Tirupathi	7-11th, Feb, 2004
Jeyabaskaran, K.J.,	National Seminar on Resource Management for Sustainable Agriculture at Bapatla	28 - 30th, Jan, 2004

TRAINING COURSES/MEETING ATTENDED

Name	Title/Venue/Organized by	Date
International		
Dr.P. Sundararaju	Regional Training Workshop on Enhancing Capacity for Nematode Management in *Musa* at Los Banos, Philippines.	1-5th, Dec, 2003
Dr.V. Kumar Dr. S.D. Pandey	Belgium funded International Training Cum Workshop on "Recent advances for Eco-friendly Management of Nematodes in Banana" at NRCB, Trichy	16-18th Mar, 2004
National		
All Scientists	Farmers Day programme on banana organized by College of Agriculture, ALR, Trichy.	14th, Feb, 2004
Dr.K.J. Jeyabaskaran	ICAR sponsored training programme on "Rehabilitation and Reconstruction of Polluted Agricultural Eco-system, held at the Department of Soil Science and Agricultural Chemistry at Coimbatore	21 - 30th, Jul, 2003
	Training programme on Impact Assessment of Agricultural R and D at Hyderabad	4 -10th, Dec, 2003
	Networking planning workshop on Total Factor Productivity and Impact Assessment for Field and Horticultural Crops in India at NBPGR, New Delhi	17th Feb, 2004
Dr.C.K. Narayana	Training programme on "Integrated Post Harvest Management of Fruits and Vegetables" at Bangalore	15 - 26th Dec 2003
	State Level Banana show at Cuddapah, Andra Pradesh.	7-8th, Jan, 2004
Dr. I. Ravi	Training Programme on "Application of stable Isotopes in crop improvement" at Department of crop Physiology, UAS, Bangalore.	2 - 22nd Dec 2003
Mr.P. Ravichamy, T-3 Tech Asst., (Journalism)	HRD Programmee on Short-Term Training Course in Library Automation and Resource Sharing at NISCAIR, New Delhi.	5 - 9th, Jan 2004

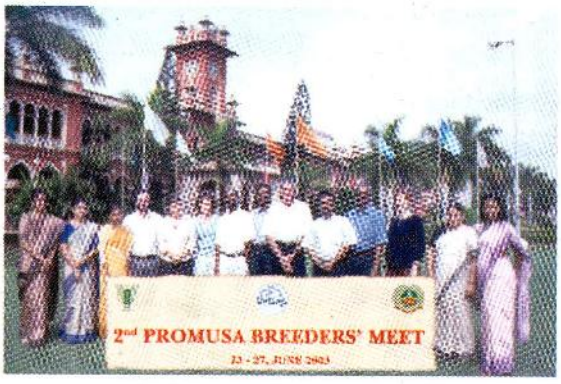
Radio Talks

1. **Jeyabaskaran, K.J.** 2003. Natural manures in banana cultivation (in Tamil). Broadcasted on 5-5-2003 from AIR, Trichy.
2. **Thangavelu, R.** 2003. Management of Sigatoka Leaf Spot Disease (in Tamil). Broadcasted on 22-2-2003 from AIR, Trichy.

WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMERS DAYS, ETC. ORGANISED AT THE CENTRE

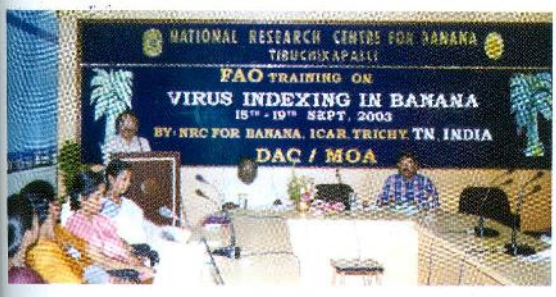
1. NRC for Banana, Trichy in Collaboration with INIBAP, France organized "**2nd Global PROMUSA breeders meet**" during 23-27th June, 2003 at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The meeting was inaugurated on 23rd June, 2003 by Dr. G. Kalloo, D. D. G. (Hort.), ICAR, New Delhi and presided by Dr. C. Ramasamy, Vice Chancellor, TNAU, Coimbatore. Dr. Jean Vincent Escalant from INIBAP, France delivered an overview during the inauguration. Banana breeders and scientists from various parts of the world consisting of six international scientists from France (2), Cameroon, Guadeloupe, Honduras and Philippines and seven scientists from India attended the meeting.

Dr.G.Kalloo, DDG (Hort) is releasing NRCB publications in the Breeders' Meet



A view of banana breeders participated in the Promusa Breeders' Meet

2. Training on Virus Indexing in Banana has been organised at NRCB, Tiruchirapalli from 15-19th Sep 2003. In this training programme 15 participants from different Tissue Culture industries involved in banana mass propagation have participated. This training programme was sponsored by FAO, Rome and Ministry of Agriculture, GOI, New Delhi. A manual was prepared, which covers both theoretical and practical aspects of virus testing in banana. Detailed illustrations have been covered for all four-banana viruses. The manual was released by the Director on the occasion of the training programme. Dr.R. Selvarajan, Senior Scientist was the Course Director of this training.



Dr.S.Sathiamoorthy delivering inaugural address in the FAO sponsored training programme

Participants of Virus Indexing training

3. International Training Cum Workshop on "Recent Advances for Eco-friendly Management of Nematodes in Banana" funded by Flemish Office for Development Cooperation and Technical Assistance (VVOB), Belgium was organized at NRCB, Trichy, during 16-18th March, 2004. During the meeting a training manual has been prepared which covers the entire information on the nematode management on banana. The Director on the occasion of the VVOB released the manual. About 15 participants from various departments /Universities were attended the training programme. Dr.P. Sundararaju, Principal Scientist was the Course Director of this training.

Dr. P. Sundaraju, Course Director, welcoming the participants of International Training cum Workshop on 'Recent Advances for Eco-friendly management of Nematodes in Banana'

4. NRCB, Tiruchirapalli along with TNAU and State Department of Agriculture jointly organized a Farmer's Day programme on 14th Feb, 2004 at ADAC&RI Kuttapattu, Trichirapalli. 500 Farmer's from different parts of Tamil Nadu have participated in the Farmer's Day programme. An Interactive session exclusively on Banana Production Technology was also conducted in the same venue along with AIR, Tiruchirapalli. Dr.S. Sathiamoorthy, Director chaired the meeting. Dr.M.M. Mustaffa, Dr.B. Padmanaban, Dr.C.K. Narayana Dr.S.D. Pandey, Dr.V. Kumar, Dr.R. Selvarajan, Dr.I. Ravi and Mr.P. Ravichamy attended the Farmers day at Tiruchirapalli. An exhibition was also conducted on the same occasion in which Banana Value added Products, High Density Planting, Fertigation and pest and diseases were exhibited.

Dr. S. Sathiamoorthy receiving a certificate from Agriculture Minister Govt. of Tamil Nadu for the Best Stall in the exhibition held during Farmers Day programme at ADAC & RI, Kuttapattu, Trichy

Director, NRCB is explaining about banana value added products developed at NRCB to delegates

Dr.C.K. Narayana, Senior Scientist, Post harvest Technology Lab, NRCB organised one-day training programmes on Banana on the following periods.

1. Training given to 20 Assistant Engineers and Junior Engineers of Dept. Agricultural Engineering, Govt. of Tamil Nadu on 2.9.2003 and 21.1.2004.
2. Training given to 20 participants in collaboration with Industrial and Technological Consultancy Organization of Tamil Nadu (ITCOT) from 29.12.2003 to 30.10.2004.
3. Training given to 50 self help group women in Cuddapah, Andhra Pradesh between 7 and 8th of January, 2004.

DISTINGUISHED VISITORS

S. No	Name & Designation	Institute	Date of Visit
1.	Dr.B.S. Chundawat, Vice Chancellor	GAU, Gujarat	4-6th August, 2003
2.	Dr.H.S. Das, Ex-Director	NRC Citrus, Nagpur	4-6th August, 2003
3.	Dr.P. Das,	M/s. Reddy Research Lab., Hyderabad	4-6th August, 2003
4.	Dr.Jeyarajan, Rtd. Prof.&Head	TNAU, Coimbatore	4-6th August, 2003
5.	Dr.T. Thangaraj, Director	RRL, Bhubaneshwar	4-6th August, 2003
6.	Dr.Jose C. Samuel, Dy. Commisnor (SWC-E)	Ministry of Agriculture GOI	9th November, 2003
7.	Dr.S.N. Pandey, ADG (Hort)	ICAR, New Delhi	23rd December, 2003
8.	Dr.Anbu, Dean (Hort)	HC & RI, Periyakulam	23rd December, 2003
9.	Shri.Subha Somu, Vice Chairman	CDB, Tiruchirapalli	23rd December, 2003
10.	Dr.H.K. Jain, Ex-Director	IARI, New Delhi	28th January, 2004
11.	Dr.S.J. Singh	Pune	28th January, 2004
12.	Dr.B.M.C. Reddy, PC-TF	IIHR, Bangalore	28th January, 2004
13.	Dr.Akilesh Tyagi, Dept. of Biotech,	Delhi University, Delhi	28th January, 2004
14.	Dr.D.K. Das Gupta	Defence Food Research Lab., Mysore	28th January, 2004
15.	Dr.O.P. Srivastava, Director	Institue of Agricultural Sciences, Varanasi	28th January, 2004
16.	Dr.Inge Van den Bergh, INIBAP Associate Scientist,	INIBAP, Philippines	15-18th March, 2004

Dr. S. N. Pandey ADG (Hort.) along with the Director, NRCB at exhibition hall

16 PERSONNEL

PERSONNEL

RESEARCH MANAGEMENT

Dr.S.Sathiamoorthy, M.Sc., (Ag.) Ph.D.	Director

SCIENTIFIC

Dr.M.M.Mustaffa, M.Sc.(Ag.), Ph.D.	Principal Scientist (Hort.)
Dr.P.Sundararaju, M.Sc., Ph.D.	Principal Scientist (Nema.)
Dr.B.Padmanaban, M.Sc., Ph.D.	Senior Scientist (Ento.)
Dr.S.D.Pandey, M.Sc.(Hort.), Ph.D.	Senior Scientist (Hort.)
Dr.C.K.Narayana, M.Sc.(Hort.), Ph.D.	Senior Scientist (Hort.)
Dr.S.Uma, M.Sc.(Hort.), Ph.D.	Senior Scientist (Hort.)
Dr.I.Ravi, M.Sc., M.Phil., Ph.D.	Senior Scientist (Pl. Physio.)
Dr.R.Thangavelu, M.Sc.(Ag.), Ph.D.	Senior Scientist (Pl.Path.)
Dr.R.Selvarajan, M.Sc.(Ag.), Ph.D.	Senior Scientist (Pl.Path.)
Dr.V.Kumar, M.Sc.(Hort.), Ph.D.	Senior Scientist (Hort.)
Dr.K.J.Jeyabaskaran, M.Sc.(Ag.), Ph.D.	Scientist (SS) (Soil Science)
Mr.R.Natarajan, M.Sc., M.Phil.	Scientist (Eco.Botony)on study leave
Mrs.M.S.Saraswathi, M.Sc.(Hort.)	Scientist (Hort.) on study leave

TECHNICAL

Mr.Raghuraman	T-5 Technical Officer
Mr.S.Palanichamy	T-4 Lab Technician
Mr.P.Durai	T-4 Field Technician
Mr.P.Ravichamy	T-3 Technical Assistant
Mr.D.Ramachandramurthy	T-3 Civil Overseer
Mrs.C.S.Jacqueline	T-3 Computer Programmer
Mrs.T.Anitha Shree	T-3 Lab Technician
Mr.R.Pitchaimuthu	T-2 Field Technician
Mr.N.Marimuthu	T-2 Lab Technician
Mr.V.Selvaraj	T-2 Field 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

ADMINISTRATION

Mr.B.Vijayakumar	Assistant Administrative Officer
Mr.R.Krishnamurthy	Upper Division Clerk
Mrs.S.Durgavathy	Lower Division Clerk
Mr.M.Devarajan	Lower Division Clerk
Mr.M.Krishnamoorthy	Personal Assistant to Director
Mr.R.Sridhar	Stenographer Gr.III

AUDIT AND ACCOUNTS

Dr.S.D. Pandey	AFAO Incharge
Mr.T.Satya Narayana Murthy	AFAO from 29.12.2003 to 03.02.2004
Mr.M.Balu	Assistant
Mr.R.Neela Mega Shyamala Kannan	Stenographer Gr.III

PERSONNEL

SUPPORTING

Mr.R.Mohanraj	Mali SSG-II
Mr.V.Pandiyan	Mali SSG-II
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

New Entrant

Dr.I.Ravi, Senior Scientist was transferred from Central Rice Research Institute, Cuttack and joined on 09.07.2003.

Mr.S.Palanichamy, T-4 Lab Technician was transferred from Central Soil Salinity Research Institute, Karnal and joined on 06.05.2003.

Appointment

Er.D.Ramachandramurthy has been appointed as T-3 Civil Overseer at the Centre and joined duty on 11.08.2003.

Transferred

Mr.T.Satya Narayana Murthy, Assistant Finance&Accounts Officer transferred to Central Institute of Brackishwater Acquaculture, Chennai and relieved on 03.02.2004.

Study Leave Granted

Mr.R.Natarajan, Scientist (Eco.Botony) was granted Study Leave for three years from 7.04.2003 to 06.04.2006

Mrs.M.S.Saraswathi, Scientist (Hort.) was granted Study Leave for three years from 08.11.2003 to 07.11.2006

Promotion

Name of the staff	promoted to the post of	w.e.f.
Dr.I.Ravi	Senior Scientist	12.04.2002
Dr.R.Thangavelu	Senior Scientist	21.07.2002
Dr.R.Selvarajan	Senior Scientist	25.07.2003
Dr.V.Kumar	Scientist (Selection Grade)	05.08.2002
Dr.V.Kumar	Senior Scientist	06.02.2004
Mr.R.Mohanraj	SSG-II Mali	19.03.2004
Mr.V.Pandiyan	SSG-II Mali	19.03.2004
Mr.V.Thangaraju	SSG-II Messenger	19.03.2004
Mr.P.Kamaraj	SSG-II Mali	19.03.2004

17 ANY OTHER RELEVANT INFORMATION SUCH AS SPECIAL INFRASTRUCTURAL DEVELOPMENT

Hindi Day

Hindi week was celebrated on NRCB during 14-20th September, 2003. On this occasion a Poster presentation competition in Hindi on different aspects of banana cultivation and postharvest management was conducted on 16th September 2003. Mrs.Amuthavalli, Deputy Director, Central Hindi Teaching Scheme, Tiruchirapalli, was the Chief Guest for the valedictory function and distributed the prizes on the winners of various events viz., Hindi dictation, essay, recitation, singing, quiz and poster presentation etc.

Dr. M. M. Mustaffa delivering inaugural address in Hindi Day celebration

Scientists and the Director, NRCB at Hindi Poster competition

Science Day

NRCB celebrated the National Science Day on 28th February, 2004. On this occasion students from diffent schools and colleges visited the centre and learnt the scientific advancements in banana research.

School students visited NRCB exhibition on the occasion of Science Day

METEROLOGICAL DATA

Month/Year	Temperature in °C		Relative Humidity		Total Rainfall (mm)
	Min	Max	Min	Max	
April 03	25.32	37.36	22.24	84.62	18.2
May 03	26.14	37.48	31.91	81.39	124.8
June 03	26.70	38.78	32.77	78.52	16.4
July 03	24.11	36.47	33.5	72.98	30.2
August 03	25.92	36.93	36.73	81.20	57.8
September 03	25.60	38.62	29.32	79.97	42.3
October 03	23.49	33.82	49.81	92.54	169.2
November 03	21.97	29.52	59.13	91.62	163.2
December 03	21.62	32.01	45.41	93.7	0.2
January 04	19.39	31.91	42.28	95.0	0.5
February 04	19.46	33.47	29.71	91.6	0
March 04	22.00	37.87	23.82	89.99	0


NATIONAL RESEARCH CENTRE ON BANANA