PMEC

Annual Report
2004 - 2005
वार्षिक प्रतिवेदन

NRC Banana

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

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राष्ट्रीय केला अनुसंधान केन्द्र
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Front Cover Page : A bunch of *Musa velutina* belongs to Rhodochlayms section

Back Cover Page : A view of wetland banana cultivation system

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PREFACE

It gives me immense pleasure to present the Annual Report of the centre for the year 2004-05. The centre as in the past, carried out many innovative programs in order to enhance the production and productivity of banana through basic and applied research, to act as a centre for giving training on production technology to the banana farmers from all over the country besides paid training programs given for the interested entrepreneurs.

The centre possesses the world's largest collection of *Musa* germplasm conserved at NRCB field genebank and at Agali, Kerala. A new species in banana, named as *Musa swarnaphalya* a unique type has been identified during an exploration made in the NEH region. The program on crop production, which draw major attention are the drip irrigation and fertigation. Soil application of Fe with foliar application of Zn and boric acid gave higher yield in Karpuravalli banana. The major achievement under Post Harvest Technology is the storability of Robusta and Rasthali bananas for 136 and 121 days respectively by adopting the best post harvest treatments like heat shock and modified atmospheric packing.

Some of the important achievements under crop protection are the profuse use of biocontrol agents against insect pests, nematodes and diseases. Entomopathogenic nematode, *Heterorhabditis indica* and entomopathogenic fungus, *Beauveria bassiana* are the successful biocontrol agents against banana weevils. Botanicals like *Abutilon indicum, Azadirachta indica and Solanum torvum* are found effective on root-knot and lesion nematodes. Bio agents viz., *Trichoderma viride, Pseudomonas* spp., *Bacillus* spp. and *Azospirillum* sp. are found effective against Fusarium wilt pathogen. The crown rot incidence is reduced significantly with the application of *T.viride* isolates and *S.torvum* extract. Banana Bunchy Top Virus (BBTV) remains a major problem in hill banana cultivation in Tamil Nadu. Banana Bract Mosaic Virus (BBMV) has been recorded for the first time in Siliguri, West Bengal. RT-PCR based on diagnostic technique developed for CMV.

In transfer of technology, agreements have been signed with Govt. of Andhra Pradesh for establishing a virus testing facility at Biotechnology centre, Hyderabad and with Gujarat State Fertilizer and Chemical Ltd. (GSFC), Ahamedabad for transferring Ready To Serve (RTS) juice technology. Technologies like manufacture of pickle and juice have been commercialised. Under NATP a training was offered to researchers and personal involved in commercial tissue culture propagation on virus indexing in banana.

NRCB is directly helping the banana growers to upgrade their production systems and played a vital role in organising the "Tamil Nadu State Federation of Banana Growers Association" for effective marketing and exporting bananas.

I express my sincere thanks to Dr.Mangala Rai, Secretary, DARE & Director General, ICAR and Dr.G.Kalloo, Deputy Director General (Hort. & C.S.) for their constant encouragement and guidance in carrying out the targets assigned to the centre. My thanks are also due to Dr.S.N.Pandey, ADG (Hort.) for his timely help and valuable suggestions for the betterment of the centre. I am also grateful to the members of the QRT, RAC and IMC for their guidance in carrying out successfully the programmes of the centre. I thank Dr. S.K. Singh for helping in translating the executive summary in Hindi. I appreciate the efforts made by the Editorial and Publication Committee and all the staff members for their cooperation.

(S.SATHIAMOORTHY)
Director

Tiruchirapalli
August, 2005

Mandate of the National Research Centre for Banana

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

1 OVERVIEW

Banana is an important fruit crop of India, accounting for 31.7% of the total fruit production. It is widely cultivated in a variety of agro-climatic regions under different systems of production. Recognizing the important role of banana in commerce, food security, health and nutrition, a task force was constituted by the Indian Council of Agricultural Research (ICAR) for establishing a National Research Centre to strengthen the basic, applied and strategic research and to solve problems and threats due to many biotic and abiotic stresses in bananas and plantains. The salient research achievements during the year under report have been discussed in brief.

Crop improvement

A total of 46 accessions belonging to acuminata (8), *balbisiana* (1), ABB (1), ABBB (1), Ensete (1), Rhodochlamys species (9), other species (10) and 15 unclassified were collected during the period under report from Assam, Meghalaya and Arunachal Pradesh of North-Eastern India. Local accessions, semi wild and exotic accessions totaling 42 were collected from primary and secondary collections. A new species in banana, named as *Musa swarnaphalya* a unique type has been identified during an exploration made in the NEH region. The morphotaxonomic parameters of the new species were described based on "Musa descriptor" of INIBAP IPGRI. Exotic accessions (IB 104, Pisang Rejang) and a AA-wild type collected during the exploration have good breeding potential. Phylogenetic relationship have been worked out among wild accessions from NEH region and 'B' genome rich accessions. Thirteen wild accessions from North Eastern states of India along with 2 of BB genome, 3 of AA genome and a *Ensete superbum* as reference cultivars by using RAPD analysis indicated three major clusters.

Satellite Pre-breeding block was established at Agali, Kerala. Germplasm collected from primary and secondary sources were being conserved at NRCB field gene bank maintained at pre-breeding Block, Agali, Kerala. All the available germplasm were screened against Sigatoka leaf spot diseases and nematodes and the accessions Sanna chenkadali, Pisang Lilin, Cultivar Rose, Lairawk, *Musa ornata*, Chendawk, *Musa laterita*, ITC 0168 and Yangambi KM 5 did not show any incidence of leaf spot diseases. Among 20 banana accessions screened against major nematodes, exotic clones FHIA-23, ITC-1437, ITCMB 168, Pisang Mas and Pisang Berlin and the local variety Monthan have been found free of nematode infestation under field conditions. The exotic accessions FHIA-1 and FHIA-17 have been found least susceptible to root-knot nematode, *M.incognita*.

Ploidy status has been assessed for 36 accessions by Flow Cytometry, in collaboration with Laboratory of Molecular Cytogenetics and Cytometry, Czech Republic. Passport data have been updated for 200 accessions and complete characterization using MGIS was done for 35 accessions. Efforts are made to initiate Embryogenic Cell Suspension (ECS) for 22 Indian cultivars.

Crop production

Application of 2.5 kg compost + 1kg vermicompost + 1kg neem cake + 2.5kg poultry manure plant^{-1} at 3rd, 5th and 7th month after planting recorded maximum yield which was on par with inorganically grown banana. In addition organically grown banana had the highest TSS, Vitamin C, total sugars, reducing & non- reducing sugars, compared to banana grown using inorganic sources. Microbial population recorded in rhizosphere of organic banana was more (40%) than inorganic banana. High density planting has been standardized for cultivars Robusta, Rasthali and Saba. Drip irrigation and fertigation were found very effective in increasing the growth, vigour and bunch weight. Application of fifty per cent recommended levels of N and K recorded average bunchy weight of 31kg, which was at par with other fertigation levels. The cultivar Saba could be recommended for marginal lands replacing the cultivar Monthan which is one of the popular cooking banana of Tamil Nadu, due to higher yield under drip irrigation and fertigation. Five sprays of 3% polyfeed (19:19:19) and five sprays of 3% multi K (13:0:45) along with 50% of recommended dose of NPK as soil application was the best treatment to achieve highest yield in shortest period in cultivar Robusta. The nematode population was within the economic threshold level in this treatment.

Under high pH soil, soil application of 5g $FeSO_4$/ plant with foliar application of 0.5% $ZnSO_4$ and boric acid @ 4ppm / plant gave 41.3 per cent more yield in Karpuravalli banana. Spraying boric acid was found better than soil application in high pH soil based

on the growth parameters observation recorded in second ratoon of Karpuravalli. It was also found that soil application of Zn reduced the P concentration of leaves of second ratoon crop of Karpuravalli. In addition, the fruit quality parameters like total soluble solids (TSS), acidity and TSS/acidity ratio were significantly influenced by the application of soil or foliar application of micronutrients. The highest TSS, lowest acidity and the highest TSS/acidity ratio were recorded in the treatment of soil application of Fe and foliar applications of Zn and B in second ratoon crop of Karpuravalli.

Application of 10kg Rice husk ash + 25g phosphobacteria per plant gave an additional profit of Rs.29,250 per hectare in Rasthali banana . A chart of Diagnosis and Recommendation Integrated System (DRIS) was constructed for monitoring status of N, P and K of Nendran banana by developing norms of DRIS through an extensive survey for soil and leaf N, P and K in Nendran banana of Tamil Nadu. To achieve a fixed target yield in Nendran, equations were developed for calculating required fertilizers in Nendran and an users friendly basic program has been developed for this purpose. In Neypoovan (AB) photosynthesis rate was higher after one month of leaf clipping at flowering stage than in control (unclipped). Pre-flowering stored product in the corm has also mobilized more (26.4%) in leaf clipped plants than in control (unclipped).

Post harvest technology

Robusta and Rasthali bananas could be stored for 136 and 121 days respectively by combining best post harvest treatments like heat shock, modified atmosphere packing and low temperature storage. Procedures for preparing fermented fruit pickle and banana flour have been standardized. Packing the fruits in 400 gauge polybags controlled the injury and they ripened well with ethrel even after 35 days of storage at low temperature. 75 and 90% mature Rasthali banana suffered chilling injury after 23 days at 10°C and after 28 days at 12°C. Providing modified atmosphere packaging both at 10 and 12°C controlled the chilling injury. These fruits ripened with normal eating quality when treated with ethrel.

Crop Protection

Volatile components collected from leaf sheath of Pisang Awak and Wild *Musa balbisiana* have been identified by GC-MS. Entomopathogenic nematode, *Heterorhabditis indica* evaluated (@ 500 IJ's to 10,000 IJ's / weevil) against banana stem weevil under laboratory conditions indicated that the nematodes @ 500 IJ's /weevil gave 83 per cent mortality. Subsequently, the EPN *H. indica* and entomopathogenic fungus, *Beauveria bassiana* evaluated under field condition using longitudinal and split pseudostem as a delivery system against banana weevils gave the mortality rate of 25 and 36% in EPN and EPF respectively. Use of bunch sleeves impregnated with 0.1 per cent solution of Chlorpyrifos + Paraffin oil + adjuvant evaluated under field conditions against banana thrips, *Chaetanaphothrips signipennis* resulted in blemish free fingers with improved finger size and colour.

Survey for nematodes in Kerala, Tamil Nadu and Pondichery indicated the wide spread occurrence of root-lesion nematode, *Pratylenchus coffeae* (40.4%) followed by 26.3, 21.5 and 11.5 per cent with respect to root-knot, spiral and burrowing nematodes respectively. All the banana varieties screened were susceptible to either one or more nematodes. Root-knot nematode @100 nematodes per plant is considered to be minimum threshold level (MTH). Maximum plant growth and reduction in root-knot nematode population were recorded in plants inoculated with VAM. Botanicals *Abutilon indicum, Azadirachta indica and Solanum torvu*m recorded cent per cent mortality of root-knot and lesion nematodes even at 24 hour. Among 85 cultivars screened, Singhlal, Sakkarachayna, Malai Kali, Manik Champa, Madavazhai, Kartobiumtham and Marabale were resistant to root-lesion nematode. Karthobium tham and *Musa balbisiana* showed the highest protein and phenol content. Enzymes like peroxidase, polyphenol oxidase and PAL also increased significantly and thus exhibiting resistant reaction to *P.coffeae.*

Twelve isolates of *Trichoderma viride* and three isolates of *Pseudomonas* spp., *Bacillus* spp. and *Azospirillum* sp. were found effective in inhibiting the mycelial growth of *Fusarium oxysporum f.* sp. *cubense* (Foc) pathogen. Application of *Trichoderma viride* in cv. Rasthali gave maximum reduction in wilt disease severity (Score 1.8) which was on par with the chemical treatment (Propiconazole) applied as drenching and injection. In the third year trial in cv. Robusta on evaluation of paraffinic oil against Sigatoka disease at different concentration in combination with half the dose of fungicides namely Propiconazole and Companion showed that spraying oil at 2.5% and 3% in combination with Propiconazole (0.05%) had maximum reduction in disease severity followed by oil 3% along with companion (0.05%). The YLS was also maximum in these treatments compared to control. Effective fungal and bacterial antagonists against *F. oxysporum f.* sp. *cubense* , the wilt pathogen were

identified through *in vitro* and pot experiments. Combination of *Solanum spp.* extract either with *Trichoderma viride* or *Bacillus* sp. drastically reduced the wilt in cv. Rasthali. The crown rot incidence was significantly reduced by 67.3 % and 66.5 % with respect to the application of *T.viride* isolates and *S.torvum* extract.

Maximum inhibition of pathogen (80%) was observed due to both *T.viride* –R and *T.viride*-M. *In vivo* evaluation of the *T. viride* isolates against crown rot pathogen under room temperature condition showed that the maximum reduction of disease severity (66.25%) of crown rot was due to *T.virens* isolate which was followed by *T.viride* (Poovan) and *T. viride* –RT-1 isolates. In the case of low temperature conditions *T. hamatum* was better followed by *T. viride* –R and *T.viride*-RT-1 (58.40%). Maximum inhibition (73.17%) was recorded in the bacterial isolates isolated from the cv. Poovan followed by a bacterial isolate from cv. Monthan (68.29%). These effective bacterial isolates belong to genera, *Pseudomonas, Bacillus, Azospirillum, and Sporosarcina.* The population of these isolates were found to be high in cv. Karpuravalli (ABB) followed by Poovan and Rasthali. The spore germination assay conducted for *Colletotrichum musae* using the lipids bands of *Solanum* sp. indicated that the bands having Rf values 0.60 and 0.67 recorded 91% and 97 % inhibition respectively. Out of 700 germplasm evaluated, 9 were immune to leaf spot disease in field screening experiment. Pisang lilin, a diploid resistant donor parent has become susceptible to wilt pathogen. PSB-19 an isolate of phosphate solubilising bacteria increased plant growth parameters.

BBTV remains a major problem in hill banana cultivation in Tamil Nadu. Bract mosaic recorded for the first time in Siliguri, West Bengal. RT-PCR based diagnostic technique developed for CMV. NASH with chemiluminescent detection is more sensitive for BBTV, detection. Ten diploids were screened for resistance to BSV and none found infected with the virus. One of the diploids tested showed a mild symptom, but it was confirmed to be negative. Three aphid spp. acquired BBMV after short probes on infected plants. Virus infected samples can be dried or desiccated and stored for 30 days without losing detectable virus by PCR.

Vacuum packing of banana fingers increased green life of banana upto 41 days as compared to 20 days in control. ELISA, PCR and NASH based diagnostic kits have been developed for BBTV detection under NATP-MM project. Polyploidised plantlets of Cultivar Rose and Kanai Bansi have been multiplied. FHIA-01, FHIA-03, FHIA-23 (global hybrids) and Saba-landrace /cultivated clone were identified to be more promising and suited to tropical and subtropical regions of India.

Transfer of Technology

For the dissemination, the technology developed at NRCB 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. Technologies like pickle, juice and manufacture have been commercialized. Agreements have been signed with Govt. of Andhra Pradesh for establishing a virus testing facility at Biotechnology centre, Hyderabad and also with GSFC, Ahmedabad for transfering RTS juice technology. Under NATP a training was offered to researchers and personal involved in commercial tissue culture propagation on virus indexing in banana.

Human Resource Development

Scientists and technical personnel were deputed for short and medium term training to upgrade their knowledge in different areas of specialization within India and abroad.

2 SALIENT ACHIEVEMENTS

CROP IMPROVEMENT

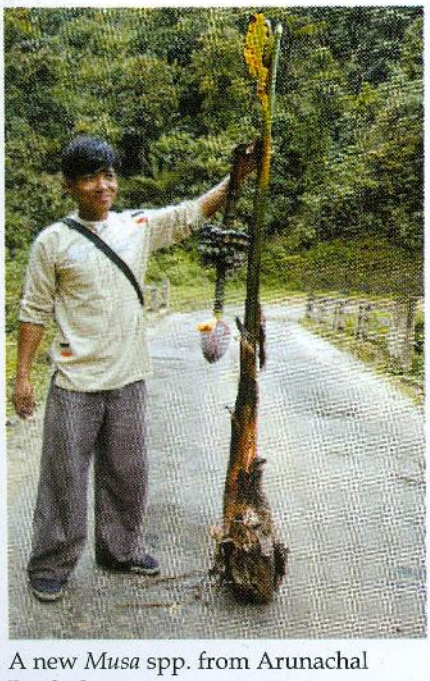
Germplasm exploration and collection

A new *Musa* spp. from Arunachal Pradesh

A total of 46 accessions belonging to *acuminata* (8), *balbisiana* (1), ABB (1), ABBB (1), *Ensete* (1), *Rhodochlamys* species (9), other species (10) and unclassified (15) were collected from Assam, Meghalaya and Arunachal Pradesh of North-Eastern India. Local accessions, semi wild and exotic accessions totaling 42 were collected from primary and secondary collections. Two new species of banana have been identified with unique features. The new species identified in 2002-2003 has been found to be unique and named as *Musa swarnaphalya*. Th exotic accessions, IB 104 and Pisang Rejang (AA) with good breeding potential have been introduced. Forty two exotic accessions have been received from NBPGR, New Delhi as replenishing cultures. These include Fei' Bananas of the section *Australimusa*, *Musa acuminata* x *Musa schizocarpa* (From ITC, Belgium).

List of accessions collected during 2004-2005

Source	Name of the accessions
Primary	NIC – 23506, NIC-775, GP-14, NIC-7749, BDS – 2361, RS – 43, BDS-2365, Wild banana, GP-15, NBPGR collection, *M.acuminata* wild (8), *E.glaucum*, Bhatmanohar, *M.velutina*, *M.nagensium*, Intersectional hybrid, *M.sikkimensis* type I and II, Sessa wild - I, Sessa wild-II, *M.swarnaphalya*, Kuppi wild, Kechulepa, Bhimkol, *M.itinerans* (5), *M.aurantiaca* (3), *Musa*-wild-I and II, *M.velutina*-hybrid (2), Pakte.
Secondary	Madhukar, Kullan, Alpon, KBS-4,
Exotic	SH 3436-9, SH 3436-6, Gros Michel, *Musa ac.* ssp. *burmannicoides*, *Musa ac.* ssp. *microcarpa* type Borneo, TMB x 5295-1, Cachaco, *Musa maclayi* ssp.*ailuluai*, Giant Cavendish, Chines Cavendish, *Musa acuminata* ssp. *banksii* x *M.schizocarpa*, GCTCV-119, TMBx 1378 (BITA-1), SH-3640, FHIA 18, FHIA 21, CRPB 39, FHIA 25, FHIA 02, Williams, Pisang Ceylan, 2390-2, Safed Velchi, Rajapuri India, Ambiri, Bata Bata, Kluai Namwa Khom, Cocos, Cultivar Rose, Tani (*M.balbisiana*), *Musa acuminata* ssp. *zebrina*, Vudi Wai Wai, Pisang Awak, Wain, IB 104, Pisang Rejang, Prata, FHIA 03, Cachaco, Williams, Pisang Raja Udang, Sambrani Monthan, H-2, Matti.



A new *Musa* spp. from Arunachal Pradesh

Conservation

Germplasm explored from primary and secondary sources are conserved at NRCB field gene bank as well as maintained at Satelite Breeding Block, Agali, Kerala.

Characterisation

Characterisation of germplasm with Morphological characters

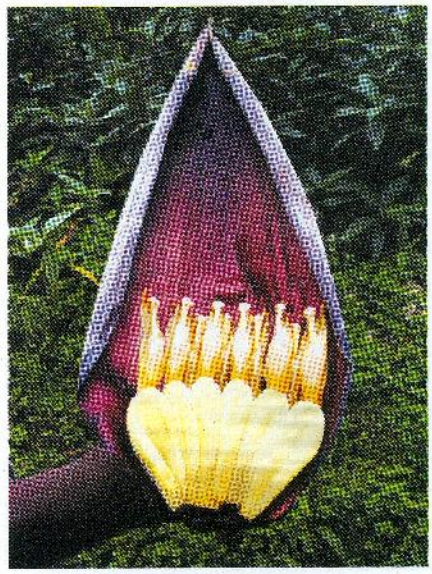
Twenty accessions were characterized for 120 morphotaxonomic parameters using, *Musa* descriptor from INIBAP, France/IPGRI, Rome and added to the NRCB database.

The new species *M.swarnaphalya* is characterized as robust statured, 8.0–8.5 m in height with maroon coloured pseudostem. Leaves are dark green, 150–170 cm long having round laminar bases. Intensely wax coated petioles (50–60 cm) are tightly clasped on the pseudostem. Petiolar canal is closed and the margins are erect, sometimes overlapped. Peduncle is short, 15–20 cm long, glabrous, green, slightly angular in position. Male axis is pendulous, barren and bract scars are not predominant. Male bud is lanceolate in shape, greenish yellow in colour and heavily wax coated, deeply imbricate, outer face of the bract is greenish yellow and inner face is pale orange yellow in colour. Bract tip is blunt as in the case of *M. balbisiana* and tinted with purplish brown on its outer side (Fig 3). Bracts open 1-2 at a time and do not revolute. Male flowers are yellow, 3.5-4.0 cm long, compound tepal and lobes are yellow. Free tepal is rectangular in shape, 1.6-1.8 cm long with smooth margins; its apex is also smooth and pointed. Ovary is straight 1.2-1.3cm long, yellow in colour, style is straight and translucent white and stigma is orange yellow. Fruits are ashy green (before maturity), biseriate, 3.0-3.5 cm long, pedicel is unusually long with 1.2-1.5 cm and 6-8 fruits per hand. Pollen is fertile and germinability is more than 80 per cent. As per the local tribes of Arunachal Pradesh, the plants are supposed to have prolonged vegetative phase and bear fertile seeds.

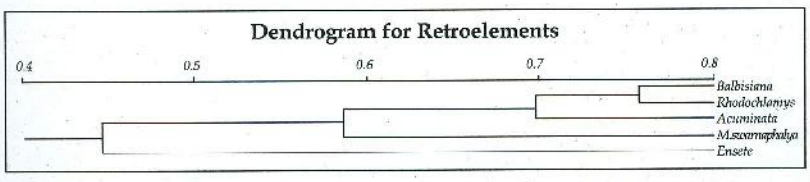
A new species in banana, named *Musa swarnaphalya*, a unique type has been identified during a exploration made in the NEH region.

Molecular characterization of *Musa swarnaphalya* using retro-elements

Molecular characterization of *M.swarnaphalya* was done using pure *Musa balbisiana*, *Musa acuminata*, *Rhodochlamys* and *Ensete* as control. Three Inter Retro element Amplified Polymorphism (IRAP) primer combinations namely Sukula + LTR 6149, Nikite + LTR 6150 and Sukula + LTR 6150 were tested for DNA amplification. The genetic similarity estimated was found to range from 0.44 to 0.76 among the five test accessions. The five accessions were grouped into four clusters. *M.balbisiana* and *Rhodochlamys* were grouped in one and the same cluster with 76% similarity. When *M.balbisiana* and *Rhodochlamys* sharing 76% similarity falls under two different sections *M.swarnaphalya*, which share only 58% similarity with *Eumusa* and *Rhodochlamys* could be a separate species. Further *M.swarnaphalya* is not related to *Ensete*, as it stood distinct with less than 50% similarity.



Clasped female flowers of *M.swarnaphalya*



Molecular characterization using RAPD markers

Forty three samples consisting of 13 pure wild accessions from North-Eastern States and 10 each from Bluggoe (ABB), Monthan (ABB) and Peyan (ABB) group accessions respectively were subjected for RAPD marker analysis to study the genetic diversity and phylogenetic relationship.

Phylogenetic relationship have been worked out among wild accessions from NEH regions and 'B' genome rich accessions.

Cluster Analysis among 'B' genome rich accessions

Bluggoe (ABB)

Two major clusters were noticed wherein all the test accessions and most of the reference cultivars were pooled in one, while in the other, only *Musa acuminata* ssp. *burmannica* and *Musa acuminata* ssp. *burmannicoides* were clustered distinctly. But the fact that Bluggoe cultivars clustered away from these two subspecies, suggests that wild accessions like Lairawk and Pisang Jajee could have contributed more for their evolution along with various wild *balbisiana* clones.

Clustering pattern – Bluggoe (ABB)

Clusters	Sub clusters	Members
I	1	Birbutia, Kothia, Kapur, Gauria, Sakkai, Vennuttu Mannan, Kanchi, Bangrier, Saba, Burro Cemsa
	2	Pisang Jajee, Lairawk, Athiakol, Bhimkol, Attikol, Manohar, *M.balbisiana* (A&N)
II		*M.acuminata*.ssp. *burmannica*, *M.acuminata* ssp. *burmannicoides*

Monthan (ABB)

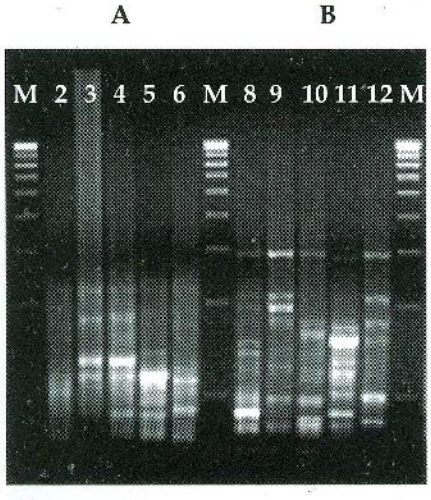
The result revealed two distinct clusters between these groups. Cluster I encompassed most of the test clones with two distinct minor sub clusters. Of these, Pidi Monthan was collected from Karnataka and other two from Kerala. Geographical vicinity could have contributed to their common lineage and progenitors in the second sub cluster, Sommarani Monthan of Bihar is grouped with Pacha Bontha Batheesa and Ashy Batheesa. This suggests that dual origin theory of cultivated clones simultaneously occurred at North Eastern India and Western Ghats. In both these places, *M. acuminata* and *M. balbisiana* were grown in wild and natural introgression could have been a possibility. The overall genetic variation for ABB clones itself could be limited even though they exhibit marked morphological variations. In cluster II, all the *M.acuminata* clones clustered together.

Clustering pattern – Monthan (ABB)

Clusters	Sub clusters	Members
I	1	Karim Bontha, Pidi Monthan, Boothi Bale, Erode Kai, Kostha Bontha Gaukar, Sommarani Monthan, Pacha Bontha Batheesa, Ashy Batheesa, Bhimkol
	2	Athiakol, Attikol, Manohar, *Musa balbisiana* (A & N)
II		*M.acuminata.spp.burmannica*, *M.acuminata. ssp. burmannicoides*, Pisang Jajee, Lairawk

Peyan (ABB)

Results revealed two major clusters and cluster I with three minor sub clusters. All these clones must have been originated in one of the three Southern states and distributed to others. But Chera Padathi of Gujarat is a collection, which must have been originally collected from Kerala. By nature, Gujarat has no diversity for either wild or cultivated bananas.



Amplification products generated by IRAP primer pairs Sukkula+LTR 6149 Lane 2-6 (A); Nikita+LTR 6150 Lane 8-12 (B).

Key : M-500 bp DNA ladder marker;

Lane Nos.

2,8 = Bhimkol (BB);
3,9 = M.acuminata ssp. burmannicoides (Calcutta 4);
4,10 = M.ornata;
5,11 = Ensete superbum;
6,12 = M.swarnaphalya (newly identified species)

Clustering pattern – Peyan (ABB)

Clusters	Sub clusters	Members
I	1	Peyan, Nukkala Bontha, Madavazhai, Chera Padathi, *M.acuminata.ssp.burmannica*, *M.acuminata.ssp.burmannicoides*, Pisang Jajee, Lairawk
	2	Bhimkol, Attikol, Manohar, Athiakol, *M. balbisiana* (A & N)
	3	Peyan, Madavazhai
II		Boothi Bale, Bluggoe

Collections from North Eastern states of India

The present research was undertaken to study the intersectional and intra-sectional genetic diversity. Thirteen wild accessions from North Eastern states of India along with 2 of BB genome, 3 of AA genome and a *Ensete superbum* as reference cultivars were used for RAPD analysis. Nine primers were selected after standardization for the diversity analysis. Results clearly indicated three major clusters. Cluster I had three sub clusters comprising members of both sections *Rhodochlamys* and *Eumusa*. Similarly cluster II had mixture of members from both the sections. Cluster III had two members, Lairawk and *Ensete superbum*. They neither belong to same area of diversity nor to the same genera. In general, although *Rhodochlamys* and *Eumusa* members show morphological distinctness from each other, genetically they seem to overlap. Possibly, during evolution process, they would have been derived from the same progenitors and they share the same basic chromosome number (2n = 22).

Clustering patterns of test accessions and reference cultivars

Clusters	Sub clusters	Members
I	1	Sessa wild, *M. velutina*, *M. itinerans*, *M. rosacea*
	2	Adhikopak, *M. kola*
	3	*M. aurantiaca*, *Musa swarnaphalya*
II	1	H - 5, Kuppa, *M. ornata*, *M. nagensium*, *M. itinerans*
	2	Athiakol, Bhimkol, *M.acuminata. ssp. burmannicoides*, *M. acuminata.ssp. burmannica*
III		Lairawk *Ensete superbum*

It is concluded from the RAPD results that all the primers do not behave similarly in the characterization of *Musa* germplasm. Either inclusion of more number of primers or use of highly reproducible markers like those of AFLP and SSR might remove such ambiguities and is expected to give more specific clustering and distinct phylogenetic tree.

Ploidy analysis using Flow Cytometry

Ploidy analysis using Flow Cytometry enables the rapid detection of ploidy status of new accessions and hybrid progenies and the results are highly reliable. Thirty six accessions including synthetic tetraploids, wild and cultivated accessions were subjected to Flow cytometry analysis in collaboration with Laboratory of Molecular Cytogenetics and Cytometry, Czech Republic and the ploidy status

of the above 36 ambiguous accessions have been confirmed. Kanai Bansi has been grouped into a triploid, which was considered as diploid earlier.

Ploidy status has been assessed for 36 accessions by flow cytometry, in colloboration with Laboratoy of Molecular Cytogenetics and Cytometry, Cezech Republic.

Sl. No.	Name of the accession	Measured ploidy results
1.	Ensete species type Kodai	2x
2.	*Musa balbisiana* type Chouldhari 12	2x
3.	Simulu Manohar 796	4x
4.	*Musa swarnaphalya*	2x
5.	*Musa balbisiana* type Chouldhari	2x
6.	*Musa balbisiana* type Mt. Harriet	2x
7.	Lophu	2x
8.	Changdawt	2x
9.	Pisang Berlin	2x
10.	Kanaibansi (colchicine treated)-1	3x
11.	*Musa laterita* - D	2x +4x
12.	Matti (colchicine treated)	2x
13.	Thiruvananthapuram	3x
14.	Kanai Bansi (colchicine treated)-2	3x
15.	*Musa truncata*	4x
16.	Pagalapahad wild -1182	2x
17.	Bangrier	3x
18.	*Musa balbisiana* type Arakku	2x
19.	Lairawk	2x
20	Cultivar Rose (colchicine treated)-2	2x + 4x
21.	Sannachenkadali (colchicine treated)	2x
22.	Sunkarametta wild	2x
23.	Cultivar Rose (colchicine treated) -1	2x
24.	*Musa balbisiana* type Hasmathabad	2x
25.	Wild hill	3x
26.	Khunsang wild-1168	2x
27.	Pagalapahad (3)-1184	2x
28.	*Musa balbisiana* (A & N)	2x
29.	BITA - 2	4x
30.	Neokhom	3x
31.	Octoman	2x
32.	Dina malakol	3x
33.	Matti (oryzalin treated)	2x
34	Pihima wild – 1186	3x
35	*Ensete* (Hyderabad)	Not-measurable
36.	Pagalapahad wild-2 (1183)	2x

Evaluation

Screening of germplasm against leaf spot

Thirty two germplasm accessions maintained at Agali, Kerala were evaluated against leaf spot diseases. The result indicated that accessions Sanna chenkadali, Pisang Lilin, Cultivar Rose, Lairawk, *Musa ornata*, Chendawk, *Musa laterita*, Imbago and Yangambi KM 5 showed no incidence of any leaf spot diseases. Among the accessions, the maximum incidence (17.94%) was observed in Bhat Manohar followed by Namarai (15.86%) and Saba (15.66%). With regard to YLS-0, the maximum of 17 was observed in Chendawk (which recorded

no incidence of leaf spot diseases) followed by Pisang Jari Buaya (16.57), Imbago, NRCB sel.1 (15) and Chinia (14).

Screening of germplasm against nematodes

Screened 20 banana accessions which were maintained at Agali, Kerala against major nematodes. The results revealed that exotic varieties FHIA-23, Pisang Mas and Pisang Berlin and local variety Monthan were found free from nematode infestation under field conditions. The exotic accession FHIA-1 and FHIA-17 were found to be least susceptible to root-knot nematode, *M.incognita*.

Screened germplasm against sigatoka leaf spot and nematodes.

Exchange of banana germplasm

NRCB has supplied 5 accessions to NFTCR, NBPGR, New Delhi for *in-vitro* conservation. Two exotic accessions were supplied to Gujarat State Fertilizers Ltd., Gujarat for on farm evaluation. Ten accessions were supplied to Tamil Nadu Agricultural University, Coimbatore.

Documentation

Passport data has been updated for 200 accessions and 35 for complete characterization data using MGIS software.

Passport data for 200 accessions updated.

Conventional Breeding

'Satellite Breeding Block' at Agali, Sugarcane Breeding Institute Research Centre, Coimbatore was established with more than 60 accessions and 800 plants have been planted for utilization in the breeding programme.

As a part of classical breeding, synthetic diploid enhancement through reciprocal crossing has been done. Diploids namely Cultivar Rose, Pisang Lilin, Namarai, Kanai Bansi, Sannachenkadali, Matti, Anaikomban, Pisang Berlin, Pisang Jajee, Pisang Mas, Tongat, Lairawk, and *Musa ornata* and *Musa laterita* of Rhodochlamys section have been used for the reciprocal crosses.

The following crosses were made to develop synthetic diploids (AA) with better traits and the successful hybrid seeds were sown for germination.

Female parent	Male parent	No. of crosses
Anaikomban (AA)	Lairawk (AA)	990
	Pisang Jajee (AA)	770
	Pisang Lilin (AA)	660
	Chendawak (AA)	440
	Sannachenkadali(AA)	320
	Cultivar Rose(AA)	430
Matti (AA)	Lairawk (AA)	800
	Pisang Jajee (AA)	140
	Pisang Lilin (AA)	140
	Sannachenkadali (AA)	150
	Cultivar Rose (AA)	140
	Anaikomban (AA)	1400
Sannachenkadali(AA)	Lairawk (AA)	420
	Pisang Jajee (AA)	1400
	Pisang Lilin (AA)	140
	Matti (AA)	700

Satellite Breeding Block established at Sugarcane Breeding Institute's research centre at Agali, Kerala.

Female parent	Male parent	No. of crosses
	Chendawak (AA)	550
	Anaikomban (AA)	280
	Pisang Jari Buaya (AA)	270
Cultivar Rose (AA)	Lairawk (AA)	240
	Pisang Jajee (AA)	1040
	Matti (AA)	600
	Chendawak (AA)	120
	Anaikomban (AA)	600
	Sannachenkadali (AA)	130
Kanai Bansi (AA)	Pisang Jajee (AA)	440
	Sannachenkadali (AA)	200
	Anaikomban (AA)	220

The following parental lines were used in breeding programme to develop improved Bluggoe and Pisang Awak cultivars.

Female	Male	No. of crosses
Bangrier (ABB)	Lairawk (AA)	140
	Pisang Jajee (AA)	140
	Chendawak (AA)	380
	Anaikomban (AA)	130
Karpuravalli (ABB)	Pisang Jajee (AA)	240

Intersectional hybridization for imparting Sigatoka resistance

The following Eumusa cultivars and Rhodochlamys species were used in the breeding programmes to develop intersectional hybrids.

Female	Male	No. of crosses
Anaikomban (AA) [E]	*Musa ornata* [R]	105
Matti (AA) [E]	*Musa ornata* [R]	140
Cultivar Rose (AA) [E]	*Musa ornata* [R]	130
Kanai Bansi (AA) [E]	*Musa ornata* [R]	120
Musa laterita [R]	Pisang Jajee (AA) [E]	20
Musa ornata [R]	Pisang Jajee (AA) [E]	18
Musa laterita [R]	Pisang Jari Buaya (AA) [E]	18

Also triploid x diploid crosses were made using triploids like Monthan, Chakkia, Burro Cemsa, Chinia, Saba, Robusta and the tetraploid x diploid crosses were made using tetraploids like FHIA-01, FHIA-03, FHIA-23, ITC 1437 and ITC 1261 as female parents.

Embryogenic Cell Suspension (ECS)

Efforts have been made to initiate ECS for 22 Indian cultivars using floral buds and meristem scalps as explants as per the protocol published by INIBAP, France and KUL, Belgium.

CROP PRODUCTION

Organic banana

Different levels of organic manures along with inorganic fertilizer as control were applied to the second ratoon crop of Rasthali and Karpuravalli banana plants. The growth parameters like height, girth, no of leaves, and leaf areas were recorded at flowering stage. The results indicated that application of 2.5kg compost + 1kg vermicompost + 1kg neem cake + 2.5 kg poultry manure plant^{-1} at 3rd, 5th and 7th month after planting recorded the maximum growth and yield parameters which were on par with inorganic fertilizer application. The quality of fruits viz., TSS, acidity, ascorbic acid and sugars were the highest in organic manures applied fruits as compared to inorganic fertilizer applied plants.

Organically grown banana had highest TSS, Vitamin C, total sugars, reducing & non reducing sugars as compared to banana grown under inorganic source.

The soil microbes in the rhizosphere was studied and found that the population of soil fungi, microbes and actinomycetes were maximum in organics applied soils as compared to in - organic fertilizer applied soil.

In the plant crop of Robusta banana, application of vermicompost @ 5 kg/plant recorded the maximum growth parameters like height, girth, number of leaves and leaf area. The bunch parameters like number of hands and fingers, finger length and girth, weight and bunch weight were recorded. The results indicated that application of 5 Kg vermicompost in 3 splits was on par with inorganic fertilizer application. The quality of the fruits indicated that organically grown banana fruits recorded the highest TSS, vitamin C, total sugars, reducing and non-reducing sugars as compared to inorganically as grown banana fruits.

Good microbial population recorded in rhizosphere of organic banana than inorganic banana.

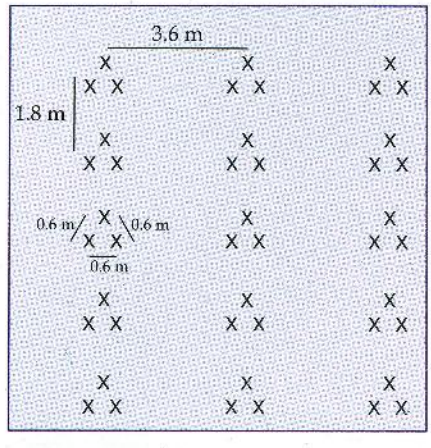
High density planting and fertigation of banana

Study was conducted in cv. Robusta, Rasthali and Saba on different fertigation and densities to see the effect on growth, yield and storage life. Results obtained are summarized as under.

Plant crop

Robusta banana

Tissue cultured plants of Robusta were procured and planted as per schedule. Different fertigation treatments were imposed at weekly intervals. The growth performance of Robusta banana upto 6th month stage was on per with conventional planting. In high density planting (3 suckers/pit) plant height was observed significantly more than in conventional planting. Plant receiving 150g N and 250g K through drip (75% of recommended dose through urea and MOP) produced maximum yield of 103.5 tonnes/ha with an average bunch wt of 34.50 kg /plant with plant population of 3086 plants /ha (1.8 x 1.8 m). Although in high density planting yield was recorded more but individual bunch fetch more price in conventional planting as compared to the high density planting.

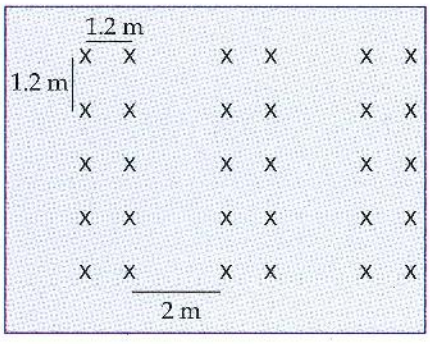


High density planting : 3 plants per pit

Rasthali banana

Application of 100 g N and 150 g K / plant through drip (50 % of recommended dose through urea and MOP) produced 16.40 kg bunch/plant with 41.90 tonnes yield/ha in conventional planting (2500 plants /ha) and 55 tonnes /ha in Paired row system (5200 plants /ha). Although yield was obtained more in paired row system but B: C ratio was at par in both the densities with 50 % fertigation level.

High density planting has been standardised for cultivars Robusta, Rasthali and Saba.



High density planting : Paired row system

Saba variety could be recommended in marginal lands replacing Monthan cultivar, which is one of the popular cooking banana of Tamil Nadu.

Five sprays of 3% polyfeed (19:19:19) and five sprays of 3% multi K (13:0:45) along with 50% of recomended dose of NPK as soil application was the best treatment to achieve highest yield in shortest period in cultivar Robusta.

Foliar application of soluble fertilizers could be a better substitute for soil spplication of nutrients especially during drought / water scarce situatations

Saba banana

Drip irrigation and fertigation was found very effective in increasing the growth vigour and bunch wt. Fifty percent of recommended dose of N and K recorded average bunch wt of 31kg, which was at par with other fertigation levels. In paired row system of planting 50 % N and K fertigation recorded the bunch wt of 24.66 kg. In terms of the yield 93 tonnes / ha yield was recorded in conventional planting with 50 % N and K and 123.3 tonnes / ha in paired row system of planting. Considering the nutrient requirement and production cost, cultivation of Saba variety could be recommended in marginal lands replacing Monthan cultivar, which is one of the popular cooking banana of Tamil Nadu.

Ratoon Crop

In ratoon crop of Robusta , Rasthali and Saba with same set of treatment was continued.

In ratoon crop of cvs. Robusta and Rasthali at 7th month stage 75 % N and K fertigation recorded highest values of growth parameters i.e. height, girth, number of leaves, leaf area and leaf emergence rate, in conventional as well in high density planting whereas in cv. Saba 50 % N & K fertigation recorded similar values as in the case of 75 % and 100 % N and K fertigation.

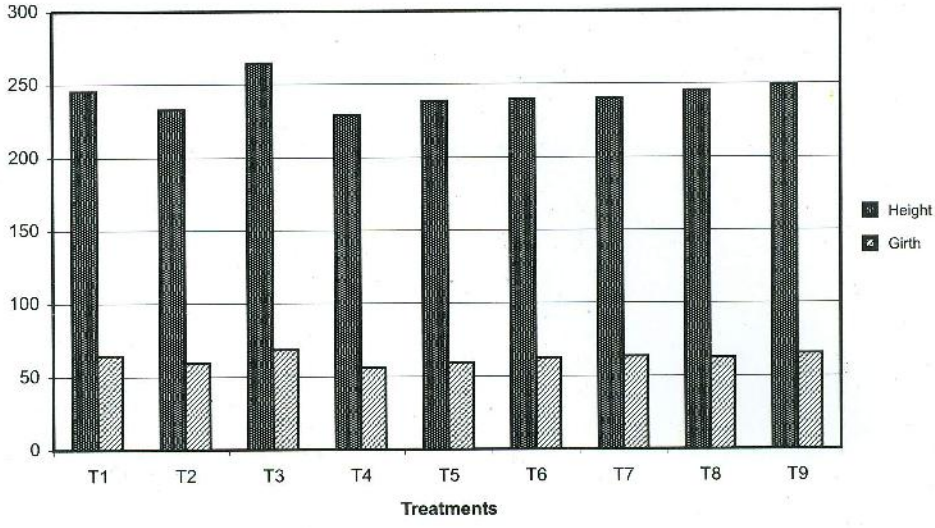
Soluble fertilizers in banana

Application of 50% recommended NPK as soil application at 3,5 and 7 MAP along with 5 sprays of 3% Polyfeed (19:19:19) followed by 5 sprays of 3% Multi K (13:0:45) at 15 days interval **(T3)** recorded vigorous plant growth, advanced the flowering and maturity, more yield and better fruit quality. In Robusta, application of 50% recommended NPK at 3,5 and 7 MAP + 5 sprays of 3% Polyfeed followed by 5 sprays of 3% multi K recorded significantly more plant height (264.6 cm), pseudostem girth (68.5cm), retained more healthy leaves at flowering (14.7) with larger mean leaf area (1.14 m^2) as well as total leaf area (16.76 m^2) and LAI (4.19) and less phyllochron (6.96days). The treatment also recorded early flowering (282.7 days), more bunch weight (20.3kgs), more number of hands (9.43) and fingers per bunch (154.4). Besides, it also recorded more finger weight (125.2g), finger length (20.4cm), fruit TSS (24.1 ° B), reducing sugars (20.42%) but lesser acidity (0.36 %).

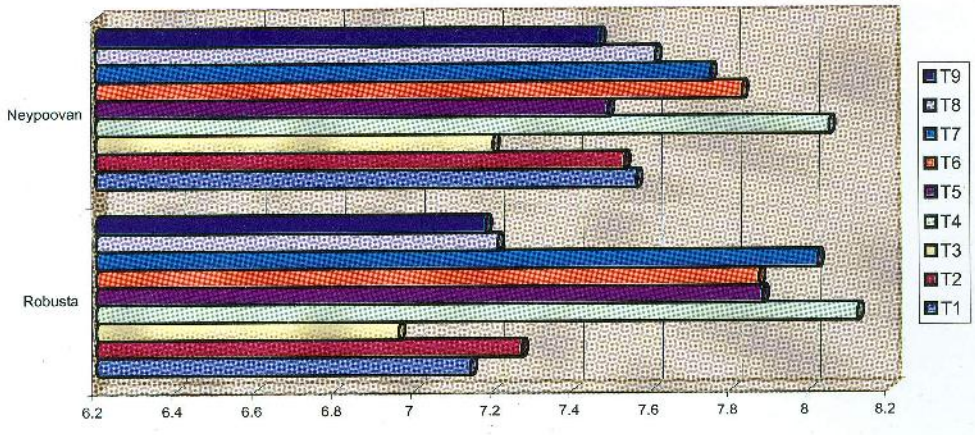
The leaf nutrient analysis also revealed that in Robusta, application of 50% recommended NPK as soil application along with 5 sprays of 3% Polyfeed at the vegetative stage followed by another 5 sprays of 3% Multi K at reproductive stage at 15 days interval (T3) recorded significantly more leaf N (2.86%), K (4.42%), Ca (1.35%) and Mg (0.87%) contents which was on par with T9 i.e, application of 9 sprays of 3% Polyfeed followed by another 10 sprays of 3% Multi K at 15 days interval from 30 -300 days after planting.

Similar treatment (T3) in Neypoovan recorded significantly taller plants (276.8 cm) with more plant girth (64.3cm), more number of healthy leaves at flowering (14.3), larger mean leaf area (2.20 m^2) as well as total leaf area (15.73 m^2), LAI (3.93) with lesser phyllochron (7.20 days). The same treatment also advanced the flowering (284.6 days) as well as maturity (105.8 days), enhanced the bunch weight (12.65 kg) with more number of hands (10.65), fingers per hand (15.80) and total number of fingers per bunch (168.3). Whereas, application of 9 sprays of 3% Polyfeed during vegetative growth phase followed

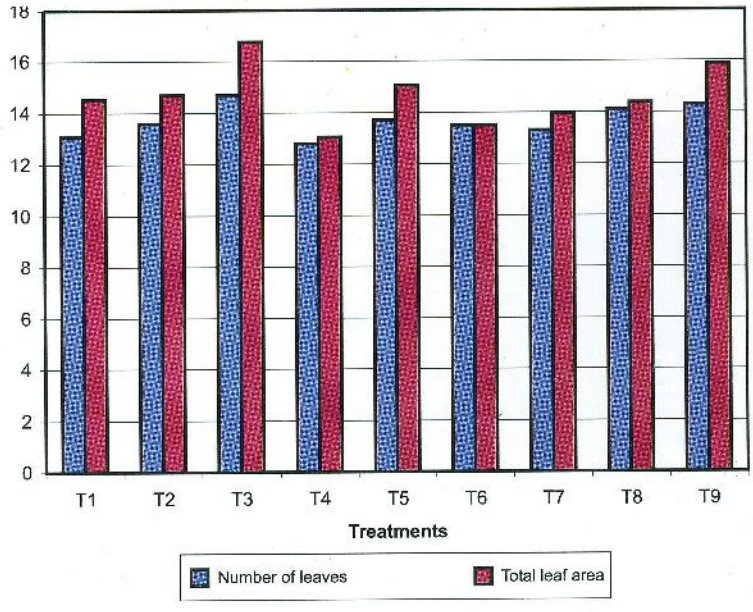
Effect of soluble fertilizers on height (cm) and girth (cm) of Robusta



Effect of soluble fertilizers on phyllochron (days) in Robusta and Ney Poovan



Effect of soluble fertilizers on number of leaves and total leaf area (m^2) in Robusta



by 10 sprays of 3% Multi K during reproductive phase at 15 days interval recorded more finger weight (70.9 g), finger length (12.4 cm), finger girth (10.2cm), TSS (34.6 °B), reducing sugars (21.63%) and less fruit acidity (0.55%).

The leaf nutrient concentrations were also found maximum in the plants treated with 50% recommended. NPK as soil application at 3,5 and 7 MAP +5 sprays of 3% Polyfeed followed by 5 sprays of 3% Multi K at 15 days interval.

Soluble Fertilizers On Nematodes

Soluble fertilizers could check the nematodes in banana within the economic threshold level

The infestation of root lesion nematode, *Pratylenchus coffeae*, root knot nematode, *Meloidogyne incognita* and spiral nematode *Helicotylenchus multicinctus* were recorded in the soil as well as root samples of cultivar Robusta for which soluble fertilizers were applied as foliar application. But, the nematode population was well below the threshold level in both soil as well as root samples. The soil samples collected from Neypoovan banana had root - knot nematode, *M.incognita* whereas root lesion nematode, *P. coffeae* was found in the root samples and the population was well within the economical threshold level.

Micronutrients in Banana under high pH soils

Soil application of Fe @ 5 g Ferrous Sulphate/plant with foliar application of Zn @ 0.5 % Zinc Sulphate and B @ 4 ppm Boric acid under high pH soil recorded highest bunch weight of 13 kg, which is 41.3 per cent more than that of control (without micronutrients), 6.8 per cent more than that with soil application of Fe, Zn and B and 5.2 per cent more than that with foliar application of Fe (as 0.5 % Ferrous Sulphate), Zn and B in II ratoon crop of Karpuravalli.

41.3 per cent more yield was obtained in Karpuravalli banana by applying 5g $FeSO_4$ /plant and spraying 0.5% $ZnSO_4$ and 4 ppm Boric acid.

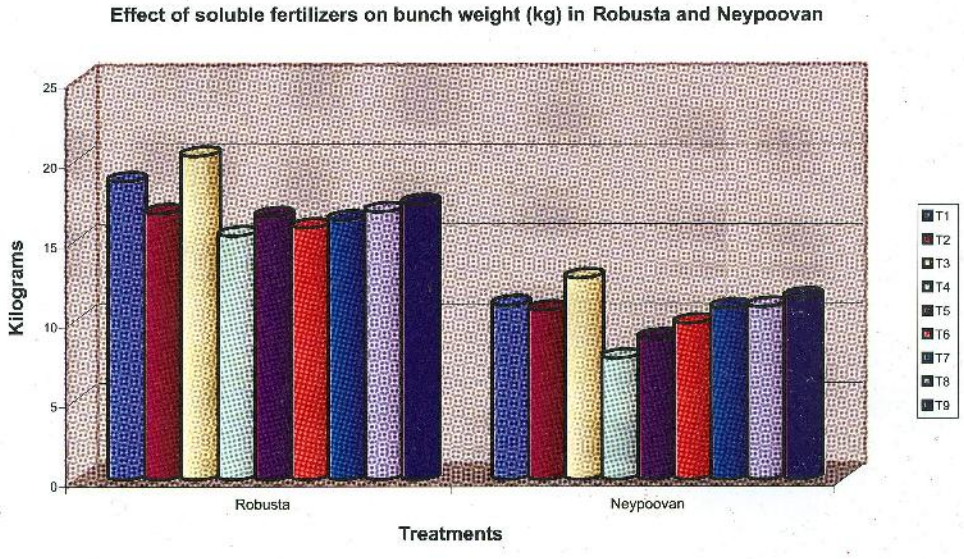
The fruit quality parameters like total soluble solids (TSS), acidity and TSS/acidity ratio were significantly influenced by the application of soil or foliar application of micronutrients. The highest TSS, lowest acidity and the highest TSS/acidity ratio were recorded in soil application of Fe and foliar applications of Zn and B in II ratoon crop of Karpuravalli.

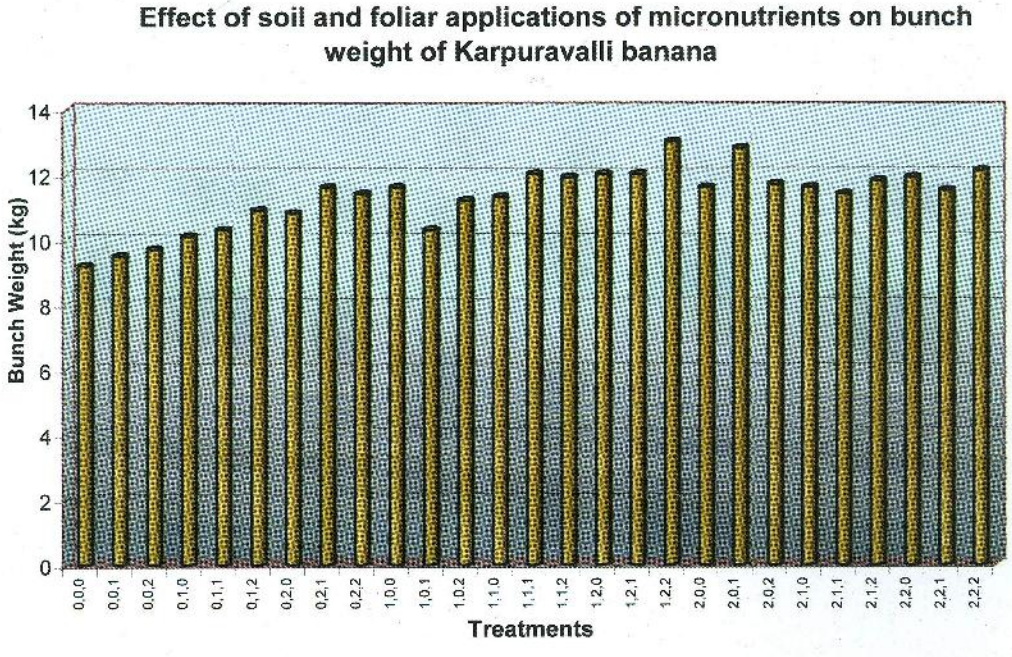
Integrated Nutrient Management

Leaf samples of Rasthali from the field experiment on Integrated Nutrient Management System in Banana recorded nutrient contents as follows N:2.3-2.9%, P:0.1-0.3%, K:2.9-3.4%, Ca:0.6-0.7, Mg:0.2-0.5, Fe:95-120ppm, Cu:3-5ppm, Mn:185-203, and Zn: 12-18ppm. The highest and optimum leaf nutrient concentrations were observed in the treatment 80%recommended dose of NPK + Phosphobacteria + Rice husk ash or Vermicompost. These treatments also recorded the highest bunch weight, which was 29 per cent more than that of 100 % inorganic- (NPK fertilizers only). The performance of Phosphobacteria was superior to Azospirillum and VAM. The performance of Rice Husk Ash was superior to vermicompost and poultry manure in increasing the bunch weight. Application of 10 kg Rice Husk ash + 25 g Phosphobacteria/plant could generate an additional profit of Rs. 29,250/- per hectare and reduced the input cost due to fertilizers by Rs. 10,000/- per hectare in Rasthali banana. Thus, integration of rice husk ash and phosphobacteria in the NPK fertilization in Rasthali could accrue a net profit of Rs. 39,250/- per hectare.

Application of 10 kg Rice husk ash + 25g phosphobacteria per plant gave an additional profit Rs. 29,250 per hectare in Rasthali banana cultivation.

PMEC





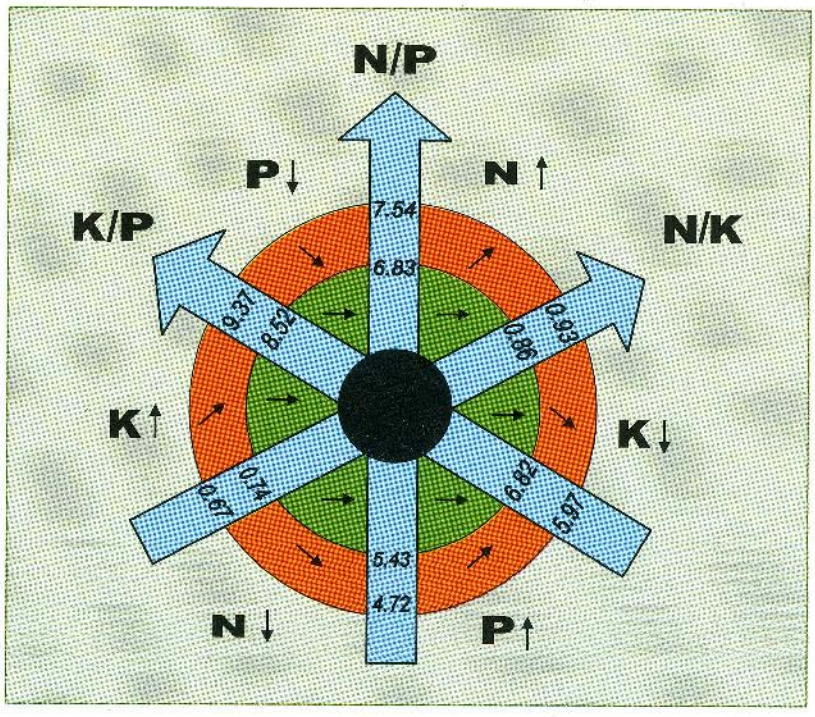
Effect of different organic manures and bio-fertilisers with graded levels of NPK on bunch weight of Rasthali

Sub treatments / Main treatments	Azospirillum			VAM			Phosphobacteria			Mean
	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	60% NPK	80% NPK	100% NPK	
Control	4.6	6.0	8.2	5.6	7.0	9.0	5.4	6.8	8.9	6.8 a
Poultry manure	5.4	6.9	7.9	6.1	7.6	8.2	7.2	8.4	8.7	7.4 ab
Vermicompost	7.1	10	9.0	7.9	9.2	9.2	7.9	11.5	10.5	9.1 bc
Rice husk ash	7.8	9.9	8.6	8.0	9.8	10	8.5	11.5	10.9	9.4 c
Mean	6.3	8.2	8.4	6.9	8.4	9.1	7.3	9.6	9.8	
Mean	7.6 a			8.1 ab			8.9 b			

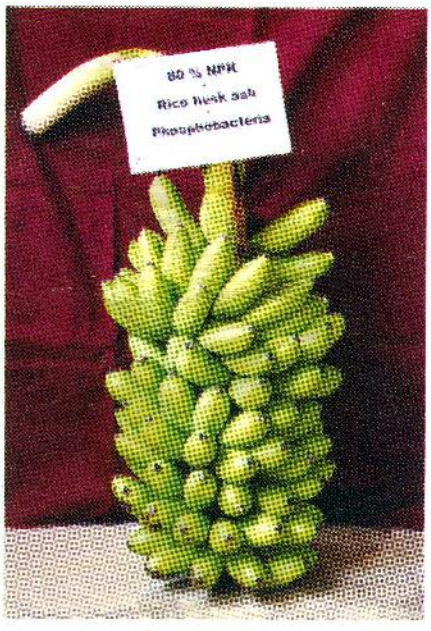
DRIS for monitoring status of N, P and K of Nendran

A chart of Diagnosis and Recommendation Integrated System (DRIS) was constructed for monitoring status of N, P and K in cv. Nendran banana by developing norms of DRIS through an extensive survey for soil and leaf N, P and K in Nendran banana cultivated regions of Tamil Nadu. The DRIS chart was translated into a computer programme, incorporated with mathematical procedures for calculating DRIS indices. The main components of DRIS norms were formed by means (6.13, 0.80 and 7.67) and coefficient of variations (8.59, 5.89 and 8.33) of N/P, N/K and K/P of leaves of high yielding population (n=157).

Fig. DRIS chart for Nendran banana with respect to leaf concentrations of N, P & K



The values for N/P, N/K and K/P at the intersection point are 6.13, 0.80 and 7.67, respectively.



Diagnosis and recommendation integrated system (DRIS) was constructed for Nendran banana in Tamil Nadu

How to quantify requirement of fertilizer in Nendran?

In order to calculate the required quantities of different fertilizers based on the soil initial test values to achieve a fixed target of yield, different fertilizer adjustment equations were developed for Nendran banana. The equations are given below.

$FN = (29.8 \times T) - (0.97 \times SN)$

$FP = (5.45 \times T) - (1.24 \times SP)$

$FK = (57.92 \times T) - (0.92 \times SK)$

Here, FN, FP and FK are nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) requirement (kg/ha) of Nendran banana cultivated in one hectare, respectively, through fertilizers. T is the target (tons/ha) of Nendran banana yield. SN, SP and SK are quantities (kg/ha) of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) already existing in the soil, before application of fertilizer. Once the initial

soil NPK contents are estimated through soil testing and the Nendran banana yield target is fixed, the NPK balance to be applied through fertilizers to achieve the fixed target can be calculated by using these equations. These equations are incorporated into a farmer-friendly computer package written in BASIC and is given below.

```
10   REM Programme for calculating fertilizer requirement to achieve targeted
     yield in Nendran banana – developed by DR. K.J. Jeyabaskaran
20   LET SN = 0
30   LET SP = 0
40   LET SK = 0
50   LET T = 0
60   INPUT "Soil N in kg/ha"; SN
70   INPUT "Soil P2O5 in kg/ha"; SP
80   INPUT "Soil K2O in kg/ha"; SK
90   INPUT "Target fixed – Nendran yield in t/ha";T
100  LET FERN = 29.8*T - 0.97*SN
110  LET FERP = 5.45*T - 1.24*SP
120  LET FERK = 57.92*T - 0.92*SK
130  PRINT
140  PRINT "Fertilizer N required in kg/ha"; FERN
150  PRINT "Urea required in g/plant"; (FERN/2500)*(1000*100/46)
160  PRINT
170  PRINT "Fertilizer P2O5 required in kg/ha"; FERP
180  PRINT "Super phosphate required in g/plant"; (FERP/2500)*(1000*100/
     16)
190  PRINT
200  PRINT "Fertilizer K2O required in kg/ha"; FERK
210  PRINT "Muriate of potash required in g/plant"; (FERK/2500)*(1000*100/
     60)
220  PRINT
230  INPUT "Expected price of Nendran banana in the market, at harvest (Rs./
     kg)"; P
240  INPUT "Cost of Urea (Rs/50 kg)"; CN
250  INPUT "Cost of Super phosphate (Rs/50 kg)"; CP
260  INPUT "Cost of Muriate of potash (Rs/50 kg)"; CK
270  PRINT
280  PRINT "Expected income from Nendran banana sales, if target is achieved
     = Rs."; P*1000*T
290  LET CF = ((FERN/46)*CN + (FERP/16)*CP + (FERK/60)*CK)*2
300  PRINT "Expenditure due to fertilizer cost = Rs."; CF
310  PRINT "Expected profit in one ha.(Gross profit–fertilizer cost) = Rs.";
     (P*1000*T) - CF
320  PRINT
330  PRINT "Note : The expenditure due to other cultivation practices like
     land preparation, weeding, spraying, staking etc. and cost of suckers, pes-
     ticides, herbicides etc. should be deducted from the calculated profit"
340  END
```

To achieve a fixed target yield in Nendran equations were developed for calculating required fertilizers in Nendran and an users friendly basic program has been developed for this purpose.

Physiology and Biochemistry

Source and sink relationship

A month after leaf clipping at flowering stage in Ney Poovan (AB) the photosynthesis recorded higher than control plants.

In the field study a diploid Ney Poovan (AB) was grown under standard recommended practice and at flowering different number (T1-6,T2-8,T3-10, T4-12 and T5- control, no clipping) of leaves were maintained. The clipping was done from the bottom. For all the physiological and biochemical observations 3rd leaf from the top was taken (including flag leaf). At flowering photosynthesis was observed as 23.69 µmol $CO_2.m^{-2}s^{-1}$. One month after leaf clipping the photosynthesis (Pn) was significantly higher (9.6 µmol $CO_2.m^{-2}s^{-1}$) in T1 than control (4.6 6 µmol CO_2. $m^{-2}s^{-1}$). This phenomenon may be due sink demand met by less number of source (6 leaves) as a result the potential of the leaf has been expressed and Pn was higher in T1.

The mobilization of pre-flowering stored product in the rhizome (starch) for fruit development was 26.4% more in T1 than control plants. The pre-flowering stored product has been utilized better manner in the leaf clipped plants. In the senescence studies, the indicator enzymes of senescence, peroxidase (16.8%)and Ascorbic Acid Oxidase (4.6%)activity was lower in T1 than and control implies that there was faster senescence processes taken place in the control plants. The yield of was recorded in T1 (8.6 kg/bunch) on par with control plants (9.2 kg/bunch). The post harvest quality characters were assessed and found that the quality, such as TSS, acidity, total sugars, reducing sugars, starch, pulp peel ratio, moisture content, pigment in peel, texture of the pulp, flavour, taste, color of the fruits were not affected due to leaf clipping. The shelf life of green fruit was rather increased to 90 days in leaf clipped plants compared 65 days in control.

The shelf life of green fruit increased to 90 days in plant clipped compared to control (65 days) and the postharvest quality of the fruit were not affected by leaf clipping.

Rhizome and root development of banana

Root observations were taken in cvs. Neypoovan (AB) and Karpuravalli (ABB) at seventh month under field condition. The number of roots varied from 360-382 roots/plant & 490-502 roots / plant and the thickness varied from 0.3 to 0.6 cm & 0.6 to 1.3 cm in Ney Poovan and Karpuravalli respectively. Diameter and number of the root varies with ploidy level. Ploidy and diameter of the root positively related to the number of roots. In a Pot study, it was observed that 3-month-old plant had total root dry mass recorded higher in Karpuravalli (12.8 g) than in Ney Poovan (10.6g) and Rasthali (10.8g). Most of the blackened secondary and tertiary roots support water absorption passively. It was interesting to note that the cut end roots produce multi fibrous roots around the edges of the cut end. This was observed in both the varieties.

Cut end of the roots produce multi fibrous roots around the edges of the cut end and dead blackened roots support the water uptake passively

Most of the secondary and tertiary roots found dead (black in color)

POST HARVEST TECHNOLOGY

Handling and storage

By combining best post harvest treatments obtained so far (heat shock, modified atmosphere packaging and low temperature storage) at 75 and 90% mature Robusta banana could be stored in marketable condition up to 136 days (131 at low temperature and subsequently for 5 days at room temperature) while the Rasthali banana could be stored for 121 days in green condition followed by 5 days at ambient temperature. With the help of ethrel they ripened normally and had acceptable eating quality.

Robusta and Rasthali bananas could be stored for 136 and 121 days respectively by combining best post harvest treatments like heat shock, modified atmosphere packing and low temperature storage.

Robusta banana hand stored after 136 days

Processing of banana

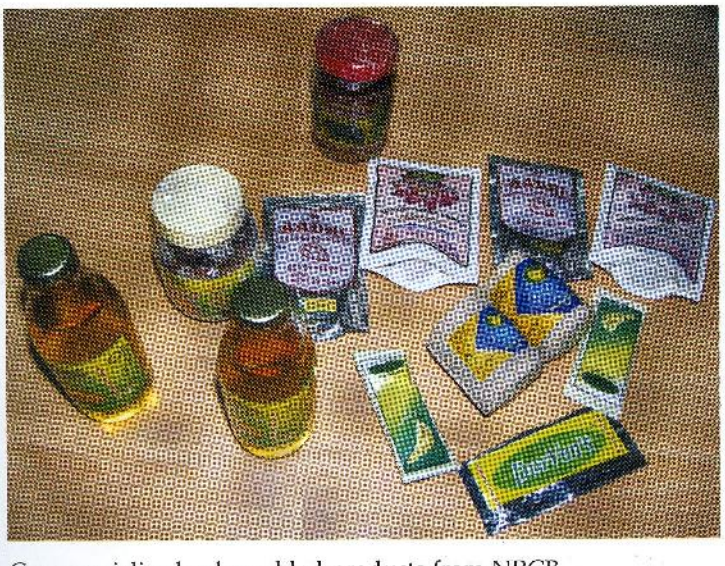
The procedure for production of fermented banana fruit pickle was developed using raw banana. The quality analysis was carried out up to one year. After 12 months of storage, the pickle had 8.80% moisture, 40.81% carbohydrate, 0.91% protein, 35.11% fats, 3.78% ash and 5.10% crude fibre. The organoleptic quality was acceptable with a score of 5.60 on a 9 - point hedonic scale. This product has been commercialized by NRCB.

A process was developed for production of banana flour based biscuits. The banana flour based biscuits had 64% carbohydrates, 0.71% protein, 20.61% fats and 13.3 mg% vitamin C. The organoleptic quality was comparable with commercial maida biscuits available in the market. This product was also commercialized by NRCB.

Processes for preparing Fermented fruit pickle and banana flour have been standardised.

Storage and chilling injury in banana

It was observed that 75 and 90% mature Robusta banana suffered chilling injury after 14-18 days storage at 10 and 12°C. They failed to ripe even after treating with artificial ripening aid (ethrel). Packing the fruits in 400 gauge polybags controlled the injury and they ripened well with ethrel even after 35 days of storage at low temperature. Rasthali banana of 75 and 90% maturity suffered chilling injury after 23 days at 10°C and after 28 days at 12°C. Providing modified atmosphere packaging controlled the chilling injury both at 10 and 12°C. These fruits ripened with normal eating quality when treated with ethrel.



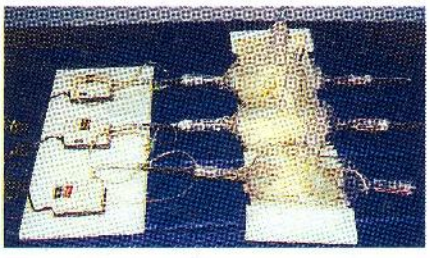
Commercialized value added products from NRCB

CROP PROTECTION

Insect Pest Management

Collection and identification of leaf sheath volatiles from banana

Leaf sheath volatiles from banana cultivars such as Pisang Awak (ABB), Pisang linin (AB), French plantain (AAB), Bluggoe (ABB), Cavendish (AAA) and Wild Balbisiana (BB) was collected using resin adsorbent by air entrainment technique for 72 hrs. The collected volatile was eluted using polar and non-polar solvents. Leaf sheath volatiles of cultivar Pisang Awak was analysed by GC-MS which, indicated different types of alkanes having carbon atom C18 to C70. HPLC analysis of leaf sheath volatiles of Pisang Awak and Wild balbisiana indicated the presence of 6 and 7 different volatile components respectively. Probable components identified by GC-MS from Pisang Awak are 1. Eicosane 2. Octadecane 3. Octacosane 4. Tetratriacontane 5. Hexatriacontane 6. Docosane 7.Heptacosane 8. Nonacosane and 9. Heneicosane.



Air entrainment technique to collect leaf sheath volatiles

- Volatile components from leaf sheath of Pisang Awak and Wild balbisiana have been identified by GC-MS.
- EPN, *Heterorhabditis indica* was evaluated against stem weevil both at lab and field level.
- Entomopathogenic fungi *Beauveria bassiana* was mass multiplied and evaluated against banana aphid.

Stem Weevil Management

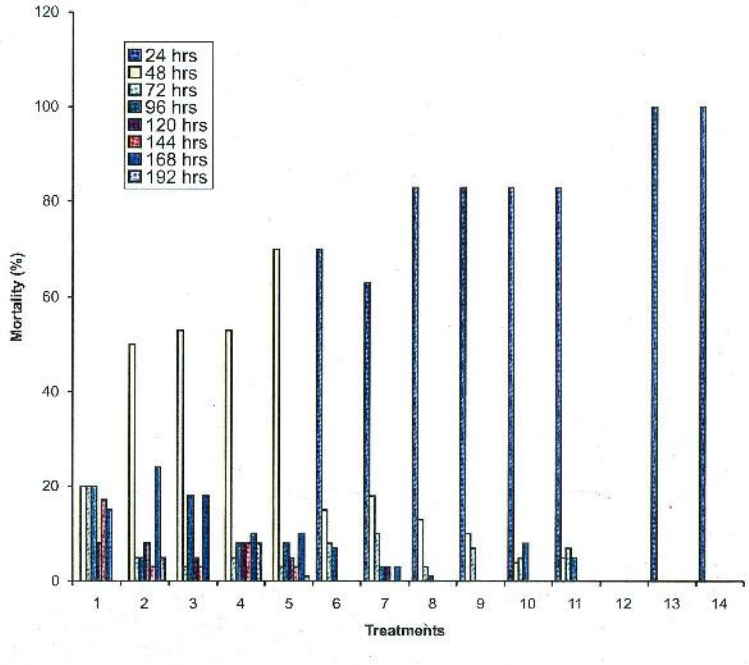
Entomopathogenic nematode

Entomopathogenic nematode, *Heterorhabditis indica* was evaluated (@ 500 IJ's to 10,000 IJ's/ weevil) against banana stem weevil under laboratory conditions. Result indicated that the nematodes @ 500IJ's /weevil gave 83 per cent mortality.

Stem injection of EPN to control banana stem weevil

By using banana injector infective juveniles of *H.indica* were injected into the plant. After 30 days, the injected plant was destroyed and nematodes were extracted. Results indicate that nematodes were able to penetrate inside the plant.

Entomopathogenic nematode, *H. indica* and Entomopathogenic fungus, *Beauveria bassiana* were field evaluated using longitudinal and split pseudostem as a delivery system against banana weevils.



Laboratory evaluation of *H.indica* against stem weevil

The doses for EPN were in the range of 1.0 X 10^6 to 2.0 X 10^6 IJ's/ trap. The doses for EPF were in the range of 2.5 X 10^6 to 7.5 X 10^6. The weevil catch and mortality was recorded from 5th day onwards, to the extent of 25 in EPN and 36 per cent in EPF respectively.

Mass production of *Beauveria bassiana*

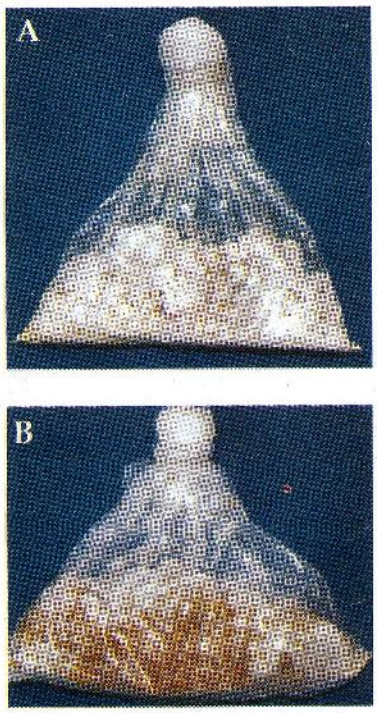
B.bassiana was mass multiplied on different cereals such as Sorghum, Ragi, Cumbu Chaffy grains, Rice and Wheat. The conidial production was estimated and it was 2.5 X 10^7/g, 3.5 X 10^6/g, 4.3 X 10^5/g, 3.0 X 10^8/g, 2.6 X 10^7/g and 1.5 X 10^7 respectively. Maximum production was obtained in Chaffy grains.

Evaluation of *Beauveria bassiana* against banana aphid

The EPF, *B. bassiana* was evaluated against banana aphid, *Pentalonia nigronervosa* under laboratory conditions. The dose ranging from 0.5 X 10^6 - 2.0 X 10^6 conidiospores. Aphid mortality was recorded at 24 hrs after inoculation. Maximum mortality was recorded in the treatment T4 - 2.0 X 10^6 at 48 hrs. After inoculation, a minimum mortality of 17.5 per cent was recorded in T1-0.5 X 10^6.

Management of banana rust thrips

Bunch sleeves impregnated with 0.1 per cent solution of Chlorpyrifos + Paraffin oil + adjuvant evaluated under field conditions against banana thrips, *Chaetanaphothrips signipennis* indicated blemish free fingers with improved finger size and colour.



Mass production of *B.bassiana* on different substracts (A) on chaffy grains (B) on wheat

Nematodes Management

Survey for nematodes

A total of 297 each of soil and root samples collected from different varieties of banana viz., Nendran, Poovan, Ney poovan, Red banana, Sanna chankadali, Robusta, Karpuravalli and Pacha nadan in Northern part of Tamil Nadu, Pondicherry and Kerala revealed that 40.4 per cent of the samples recorded root-lesion nematode, *Pratylenchus coffeae* followed by 26.3 and 21.5 per cent with respect to root-knot and spiral nematodes. The percentage occurrence of burrowing nematode, *Radopholus similis* was 11.5 per cent. All the banana varieties were susceptible to either one or more nematodes.

- Survey samples had root lesion nematode (40.4%), root knot nematode (26.3%) and spiral nematode (21.5%) predominatly.
- VAM found to reduce as *M. incognita* population.

Host parasitic relationship

The pathogenicity of *M.incognita* studied on banana cv. Robusta exhibited 25% reduction in plant growth at the level of 100 nematodes per plant inoculated at three months after planting and thus indicating that 100 nematodes per plant is considered to be minimum threshold level (MTH).

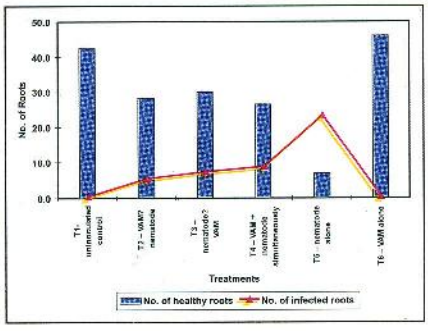
Management of nematodes through biopesticides

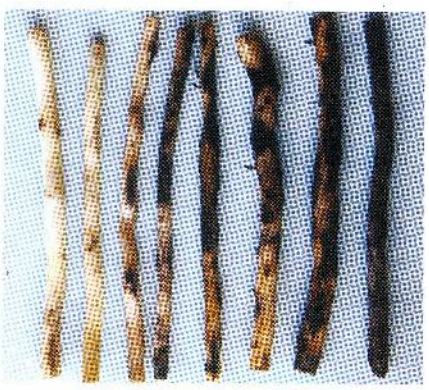
Fresh leaves of eight plants viz., *Acalypha indica, Cassia fistula, C. auriculata, Crotolaria juncea, Calotropis gigantea, Abutilon indicum, Azadirachta indica and Solanum torvum* were tested for its nematicidal activity against the root-lesion and root-knot nematodes. The results revealed that all plant extracts exhibited cent per cent mortality when exposed to 72h. Among them, *Abutilon indicum, Azadirachta indica and Solanum torvum* recorded cent per cent mortality even at 24h.

VAM fungi against root -knot nematode

The individual and interactive effects of VAM (*Glomus fasciculatum and G.mosseae)* and root-knot nematode *M.incognita* studied on banana cv. Robusta revealed that maximum plant growth and

Effect of individual and interaction effects of VAM and *M.incognita* on root characters of banana cultivar Robusta





Lesion nematode infested banana roots. (Healthy to advanced stage)

reduction in nematode population was noticed from the plants inoculated with VAM, whereas minimum plant growth and maximum nematode population, was recorded from the nematode inoculated plants.

Varietal Screening

Among 85 varieties screened, Singhlal, Sakkarachayna, Malai Kali, Manik Champa, Madavazhai, Kartobiumtham and Marabale were resistant to root-lesion nematode. Karthobium tham and *Musa bulbisiana* showed highest Protein and Phenol content whereas susceptible varieties produced healthy root lesions and rotting. Enzymes like Peroxidase, Polyphenol oxidase and PAL also increased significantly and thus exhibiting resistant reaction to *P.coffeae*. Whereas Protein and Phenol content and Enzymes like Peroxidase, Polyphenol oxidase and PAL were noticed lowest in cvs. Poovan and Manohar and thus exhibiting highly susceptible reaction to *P.coffeae*.

Fungal and Bacterial Diseases Management

Identification of effective antagonists against Fusarium wilt pathogen

Trichoderma viride RT isolate overgrowing on Foc

Out of 31 *Trichoderma viride* isolates screened, 12 isolates viz. Tv.7, 8,10,17,18,20,21,22,23,25,30,RT-1 were found to be effective in inhibiting the mycelial growth of *Foc* pathogen. Similarly out of 38 isolates of bacteria screened, three isolates namely *Pseudomonas* spp., *Bacillus* spp. and *Azospirillum* sp. were found more effective. With regard to potentiality of substrate colonization, the *T. viride* isolate RT1 achieved cent per cent coverage in 3 days of incubation. The SDS-PAGE analysis of different effective isolates of *T. viride* showed that approximately 33 kDa protein were expressed well only in the effective *T. viride* isolates compared to least effective *T.viride* isolates such as Tv. 10, 17, and 23.

In a pot culture experiment, the application of antagonistic microbes such as *T.viride* isolates, *Bacillus* spp., *Azospirillum* spp. and *Pseudomonas* spp. have drastically reduced the Fusarium wilt severity besides increasing the plant growth parameters compared to pathogen *Foc* inoculation. The incidence of the disease was not observed in TC plants inoculated with *Azospirillum* sp. and *T.viride* isolate 18 inoculated plants and in both cases, the survival of the plants was 100 per cent.

Foc pathogen

Bio-chemical basis of resistance

The PO activity has significantly increased due to the application of antagonistic microbes followed by challenge inoculation with *Foc* compared to control. The activity of the enzyme reached the peak on 4th day after inoculation and then drastically reduced on 8th day and regained its level on 12th day of sampling. In the case of control the activity was almost same in all the days of sampling. Among different microbes applied, the maximum activity of per-oxidase was observed in the *T.viride*-18, *Azospirillum* sp. *T.viride* -30 and RT-1 applied plants and the increase was four fold compared to pathogen alone inoculated plants.

Effective fungal, bacterial antogonists against FOC, the wilt pathogen were identified through *in vitro* & pot experiments.

Bio agents and botanicals evaluated against Fusarium wilt in cv. Rasthali

The pot culture experiments on the evaluation of different bio agents and botanicals in cv. Rasthali indicated that the application of *T. viride* had maximum reduction in disease severity (Score 1.8) and whose

effect was on par with the chemical treatment propiconazole applied as drenching and injection. The Fusarium wilt score for the control treatment (Foc alone) was 4.8. Application of *Solanum* sp. extract in combination with either *T. viride* or *Bacillus* sp. also drastically reduced the Fusarium wilt disease (Score 2.3 to 2.5)

Management of Sigatoka disease

Spraying of paraffinic oil at 2.5% and 3% in combination with Propiconazole (0.05%) had maximum reduction in disease severity followed by oil 3% along with companion (0.05%). The YLS-0 was also maximum in these treatments compared to control.

Management of crown rot disease

Among different *T. viride* isolates isolated from the fruits surface of different varieties of banana viz., Poovan, Monthan, Rasthali, Karpooravalli and Pachanadan, the maximum inhibition of pathogen (80%) was observed due to both *T.viride* –R and *T.viride*-M. *In vivo* evaluation of the *T. viride* isolates against crown rot pathogen under room temperature condition showed that the maximum reduction of disease severity (66.25%) of crown rot was observed due to *T.virens* isolate which was followed by *T.viride*-Poovan and *T. viride* –RT-1 isolates. In the case of low temperature conditions *T. hamatum* performed better which was followed by *T. viride* –R and *T.viride*-RT-1 (58.40%).

Among 40 native bacterial isolates evaluated against crown rot pathogen only five had significant inhibitory effect on the pathogen and the maximum per cent reduction in mycelial growth of the pathogen was recorded due to *Pseudomonas* sp.-5 followed by *Pseudomonas* –4. *In vivo* evaluation under low temperature condition (21° C) indicated that the maximum reduction of disease (87.5%) was observed in *Pseudomonas* isolate-2 treated fruits followed by *Pseudomonas* -3 treated fruits whereas under high temperature condition the maximum per cent reduction was observed in the *Pseudomonas* –1 (70%) treated fruits followed by *Pseudomonas* sp. – isolate-4 (42.5%).

Among different botanicals tested at different concentrations *in vivo*, cent per cent inhibition was observed at 25 and 50 % concentrations of *A.sativum*, which was followed, by *S.torvum* (91.11% inhibition at 25 % conc. and 93.33% inhibition at 50 % conc) and *S.nigrum*.

In vivo evaluation of all the bioagents and botanicals indicated that *T.viride* isolate S7 and botanical extract, *S.torvum* recorded the maximum reduction of 67.31% and 66.15 % crown rot incidence compared to pathogen alone inoculated fruits.

Anthracnose management

Among 43 bacterial antagonist isolates evaluated, only 10 isolates were found effective in inhibiting the mycelial growth of the pathogen. Of which, maximum inhibition was recorded in the bacterial isolates isolated from the cv. Poovan (73.17%) followed by cv. Monthan (68.29%). These effective bacterial isolates belonged to genera, *Pseudomonas, Bacillus, Azospirillum, and Sporosarcina.*

In vivo testing under room temperature conditions (31° C) showed the maximum per cent reduction of 75.55 was observed in Bac-1C treated fruits followed by Bac-9P treated fruits (58.79). In the case of low temperature condition, the maximum per cent reduction of 75% was observed in the Bac-9P treated fruits followed by Bac-S2 & 8b (43.75%).

Crown rot disease in Robusta

Combination of *Solanum spp.* extract either with *Trichoderma* viride or *Bacillus* sp drastically reduced the wilt in Rasthali.

T.viride isolate S7 reduced the crown rot incidence by 67.3%, whereas 66.5% reduction incidence was observed with application of *S.torvum* extract.

Out of 700 germplasm, 8 found immune against leaf sopt disease in field screening experiment.

Management of *Colletotrichum musae* and *Botryodiplodia theobromae*

The spore germination assay conducted for *Colletotrichum musae* using the lipids bands of *Solanum* sp. indicated that the bands having Rf values 0.60 and 0.67 recorded 91% and 97 % inhibition respectively. In the case of *Solanum* sp. the lipids bands of Hexane extract having Rf value of 0.14 recorded 64% of spore inhibition compared to control.

Evaluation of germplasm accessions

Out of 700 accessions evaluated against leaf spot diseases, eight Viz. Kalibun (AAB)- 0574 & 0133, Dudhsagar (AAB) - 0374, Pisang Rajah (AAB) - 0217, Kalibow (AAB) - 0211, Pisang seribu (AAB) - AAB, Thiruvananthapuram (AAB) - 0125, Klueteprad (ABB) - 0253 were found immune. These varieties can be used as resistance source for developing resistant varieties against Sigatoka leaf spot diseases.

Pisang Lilin, a diploid resistant, donar parent became susceptible to wilt pathogen.

Out of 20 accessions evaluated under pot culture conditions against Fusarium wilt, 11 acessions 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 resistant. Interestingly Pisang lilin hitherto resistant has been found susceptible to wilt disease (score- 2).

Nutrient solublising microbes

Screened different isolates of Phosphate solublising bacteria for their efficiency *in vitro* and found that out of 19 PSB isolates, the isolate PSB 13, recorded maximum release of phosphorus (0.70 ppm) compared to other isolates.

Among all the phosphate solublising bacterial isolates, PSB-19 recorded the maximum increase in plant growth parameters followed by PSB 4,5,7 & 9 compared to control.

PSB-19, an isolate of phosphate solubilising bacteria increased plant growth parameters.

All the effective plant growth promoting microbes were found to produce growth promoting hormones such as IAA and SA *in vitro*. The result of this study indicated that all the isolates tested have produced the growth hormones viz., IAA &SA significantly more compared to control. With regard to IAA production, the maximum was recorded in PSB-2 (280 µg/ml) followed by PSB14 (258 µg/ml) and PSB 1,12 17, (220 µg/ml of culture filtrate) whereas in the case of SA production, the maximum was in PSB-13 (198µg/ml) followed by PSB-12 (190µg/ml).

Molecular charectarisation of phosphobacteria

Seventeen isolates of Phosphobacteria were subjected to SDS – PAGE analysis for the identification of protein responsible for the effectiveness of the isolate in solublising the Phosphorus. The protein-banding pattern showed that the expression of certain proteins which are having a molecular weight of 97.4 and 62 kDa were expressed more in virulent isolates such as PSB5, 7, 8,11 and 12.

Viral diseases

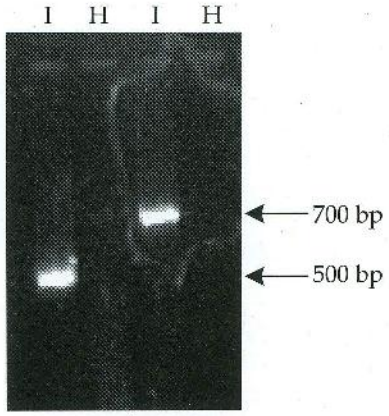
Survey

Survey has been conducted at different locations of Trichy, Tanjore, Pudukottai, Coimbatore, Erode, Lower Palani, Sirumalai and Kolli hills for banana viruses. High incidence of BBTV has been recorded both in plains (Peravoorani and Coimbatore). Incidence of BBTV is increasing in all hill regions of Tamil Nadu. In Darjeeling district of West Bengal, ie Kalimpong and Siliguri area high percentage of BBTV was noticed. BBMV has been recorded for the first time in West Bengal.

BBTV remain a major problem in hill banana cultivation. Bract mosaic recorded for the first time in Siliguri, West Bengal.

Detection

Of late CMV is becoming an important virus disease in TC plants. A RT- PCR technique has been developed for detecting CMV and two-virus specific primers amplified the partial coat protein region of CMV. Using Bract mosaic virus specific primers, the Sugarcane mosaic virus was amplified through RT-PCR. A non-radioactive probe for BBTV to detect a broad range of isolates was developed. The sensitivity of DNA required for the detection of BBTV by NASH by chemiluminescent probes was 0.06885 ng/µl whereas in colorimetric method was 0.6885 ng/µl. NASH with chemiluminescent detection was found to be more precise and sensitive than colorimetric and PCR methods. BBTV was detected from different part of plants from infected cvs. Rasthali and Robusta. The youngest unopened leaf rolled in the pseudostem, the center core region and meristematic regions were positive in all samples. The virus distributions in roots are not uniform and detection is very poor in these samples.



RT-PCR for CMV

RT-PCR based diagnostor technique developed for CMV. NASH with chemiluminescent defection in more sensitive for BBTV, detection

Banana streak virus

One of the germplasm collections belonging to *M.accuminata* clone had severe streaks similar to BSV induced symptom, which has been confirmed to be BSV infection. Germplasm / wild accession received from UP and WB were found to have integral sequences of BSV. Seven sets of BSV primers amplified the product from *Musa balbisiana* and Poovan only. Varied results were obtained with 14 BB clones maintained in germplasm. Ten diploids were screened for resistance to BSV and none was found infected with the virus. One of the diploids tested showed a mild symptom, but it was confirmed to be negative.

Ten diploids clones are resistant to BSV

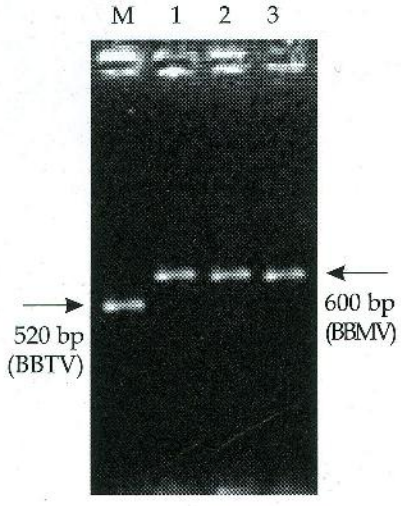
Etiology

Mild mosaic symptomatic leaves of cv. Karpuravalli did not yield amplicon when it was tried with mild mosaic virus specific primers. Poovan plants with Kottai vazhai malady and problem of non-emergence of bunches have been known to contain BSV sequences, confirmed by PCR further study on their association is in progress. Nendran variety having Neer Vazhai malady also tested positive for BSV by PCR. Foorkey disease of large cardamom was found associated with banana bunchy top virus. This has been confirmed by PCR using bunchy top virus specific primers. All the six components of Foorkey were detected using BBTV primers. Heartleaf rotting in Ney Poovan is found to be associated with BSV.


Foorkey disease of large cardamom (The causal virus is related to BBTV)

DNA isolation protocols

Five techniques of DNA isolation were compared for BBTV detection by PCR. The reducing agent 2-mercapto ethanol was compared with Sodium sulphite. The use of LN2 in homogenization was also



Amplification of partial cp gene of BBMV from aphid vectors

Three aphid spp are acquired BBMV after short probes on infected plants.

Virus infected samples can be dried and stored for 30 days without losing detectable virus by PCR.

Vaccum packing of banana fingers increased grean life of banana upto 41 days as compared to 20 days in control.

assessed. Among four methods of DNA isolation used for BSV detection, Gawal and Jaret (1991) and Selvarajan *et al* 2002 were found more suitable.

Transmission

Mealy bugs collected from Guava, Sugarcane and Amla did not acquire banana streak virus from Poovan. This result has been confirmed by PCR. Three aphids species namely *Pentalonia nigronervosa* (Banana aphid), *Aphis craccivora* (Cowpea aphid), *Aphis gossypii* (Cotton aphid) after short feeding on infected plants acquired BBMV. A product of approximately 600 bp was amplified by RT-PCR. Among fifty plants of *N. glutinosa, Chennapodium* and *V.mungo* inoculated with CMV, only Tobacco plants expressed the CMV symptom after three months of inoculation. Transmission of CMV by aphid to *N.glutinosa* has been confirmed. Positive sap and aphid transmission of CMV has been confirmed through DAC-ELISA. Aphids were not able to acquire the virus from BBTV infected detached leaf. In aphid transmission, 29.4 per cent of the plants inoculated with aphids expressed the typical symptoms of BBTV but the other plants remained asymptomatic.

Storage of virus infected samples for PCR test

Storage of banana virus infected leaf samples were tried under different conditions. (viz., 1.wet storage at 4°C, 2. at -86°C, 3. stored at room temperature after oven drying at 55°C, 4. dried using calcium chloride and 5. air dried at room temp. In case of BBTV the samples dried at oven and using Calcium chloride were remain positive up to 30 days. All samples were negative after 45th day of storage except one stored at -86°C. In case of BSV, the samples (dried in oven and dried using Calcium chloride) were positive up to 45th day of storage. The samples stored at 4°C and -86°C were remain positive at 60th day of storage.

Botanical extracts on banana viruses

Among botanicals tried *Crotolaria juncea* and *Pongamia glabra* increased the defense related enzymes after spraying. *Bougainvillia spectabilis* did not increase in infected plants.

ACHIEVEMENTS FROM EXTERNALLY FUNDED PROJECTS

Studies on ripening of banana fruits

The Robusta banana fruits were treated with Ethrel for ripening of banana at 25^0 C. The results indicated that 500 ppm Ethrel treatment ripened the Robusta banana fruits and developed light yellow colour after 24 hours at 25^{0}C. The quality of fruits viz., TSS, acidity and sugars were analysed and there was no change in the quality of fruits however the T.S.S increased to 29^0 Brix as compared 26^0 Brix in control.

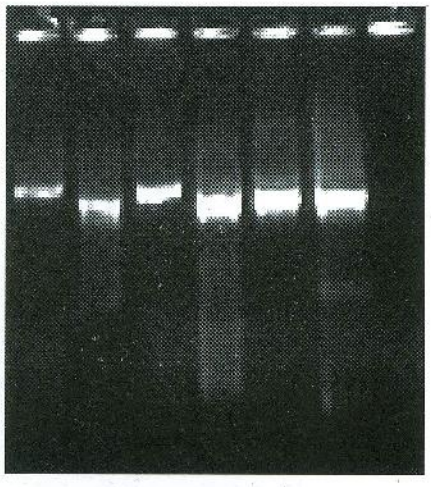
Studies on the packaging of banana

The fingers of Robusta and Rasthali banana were packed in different packing materials and also vacuum packed. Vacuum packing of fingers increased the green life of Robusta and Rasthali bananas upto 41 days as compared to 20 days in control. The vacuum-packed banana fruits recorded the lowest PLW with no microbial spoillage

of fruits upto 41 days. The fruits were artificially ripened using Ethrel 500 ppm at 25°C and all fruits developed light yellow colour with out affecting the edible quality of Robusta fruits. The fruits even after 41 days of storage at 13 .5° C recorded good edible quality and ripened uniformly in Rasthali banana.

Diagnostic kit for banana bunchy top nano virus

The BBTV hill banana isolate was further purified and polyclonal antiserum produced. All the six components of BBTV hill banana isolate were amplified using primers designed from published sequences. Non-radioactive nucleic acid labeled probe was developed for all the DNA components using dig oxygenen. The IC-PCR technique is comparatively more sensitive and could detect virus, which was not possible with PCR or ELISA. Four different methods of storage were tested for BBTV and calcium chloride drying found better for routine transport and testing for BBTV by PCR. 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 before expression of symptoms. The PCR based kit developed in this project is routinely being used for indexing TC plants sent by TC industries from different parts of India. Healthy planting material for a few commercial clones has been developed. The final report on NATP project on diagnostic for BBTV has been submitted and the project got successfully completed on31st Dec 2004.



Amplification of six DNA components of BBTV by PCR

ELISA, PCR and NASH based diagnosic kits developed for BBTV detection under NATP-MM project.

Sigatoka resistant bananas through polyploidization

- Three Plants regenerated from the *in vitro* polyploidised shoot tips (2n=4n) have been planted in the field and they are under evaluation for male and female fertility, ploidy and resistance to Sigatoka leaf spot diseases. Polyploidised plantlets of Cultivar Rose and Kanai Bansi have been multiplied in sufficient numbers for the analyzing their stability under field conditions.
- Leaf samples collected from the polyploidised plantlets of Cultivar Rose and Kanai Bansi were sent to Czech Republic for ploidy analysis using Flow Cytometry and they were found to be mixoploid and triploid respectively confirming the change in ploidy after treatment with colchicine 7.5mM for 24 hours.

Evaluation of global hybrids at farmers field - IMTP - EPMG programme

- Under this project, the selected IMTP accessions namely, FHIA-01, FHIA-03, FHIA-23 (global hybrids) and Saba-landrace / cultivated clone were identified to be more promising and suited to tropical and subtropical regions of India. For this purpose, multilocation trial was under taken for FHIA-01 and Saba in 6 different locations viz., NRCB, Trichy, Koppu, Kattuputhur, Salem, Yercaud, and Gudalore.
- Comparative evaluation trial of FHIA-23 is being conducted Robusta as reference cultivar at three locations, Trichy, Mallimapathu and Melkandarkottai.

3 TECHNOLOGY ASSESSMENT, REFINEMENT AND TRANSFER

College students looking nematodes through microscope on Science Day

- Technology has been developed for the 'Production of virus free tissue cultured banana and plantains and quality standards for tissue culture bananas'.
- The Technical know-how of production of banana biscuits was transferred to M/s. Ansa Herbs and Foods Pvt. Ltd. Trichy during 19-20th January 2005.
- The Technical know-how of production of banana fig, flour, pickles, health drink and baby food was transferred to Mr.G.Murugesh Kumar, Tuticorin during 31st January to 4th Feb. 2005.
- The technical know-how of production of banana fruit and flower pickle was transferred to Mr.Srinivasan, Perambalur and Mr.Saravanan, Tirupattur during 28-29th March 2005.

Training activities

- NRCB organized a training programme on "**Improved Production Technology for Banana**" for the Department officials of state horticulture department, Tamil Nadu, sponsored by National Horticulture Board, New Delhi and State Department of Horticulture, TamilNadu on 28-30th June 2004(Training co-ordinator-Dr.M.M.Mustaffa, Principal Scientist).
- NRCB organized a "Banana growers conference" in collaboration with Mangalore Chemicals and Fertilizers, Bangalore on 6.1.2005 at NRCB, Trichy (Training co-ordinator-Dr.M.M.Mustaffa, Principal Scientist).
- NRCB organized 17 training programmes on value added products to farmers, students, unemployed youth and women during the year under report (Training co-ordinator-Dr.C.K.Narayana Sr.Scientist).

Dr. S. Sathiamoorthy, Director interaction with Banana Entrepreneurs

Participation in exhibition

Participating in exhibition is the most simplest and effective method of disseminating the technology. The NRCB also organized exhibition and displayed important value added products from banana. NRCB participated/organized in exhibition at different places are furnished below.

Scientist explaining about banana cultivation for the farmers of Andra Pradesh

Frontline demonstrations

Frontline demonstrations (FLD) were conducted to demonstrate the production potential of the newly released varieties, high density planting with drip irrigation, management of pests and diseases through bio control agents in a given farming system at different places namely Koppu, Trichy; Gudalur, Theni; Yercaud, Salem; and Melakalkandar kottai, Trichy besides given training on value added products on banana for the benefit of farmers and entrepreneurs. The training and field days were organized for agricultural officers, extension workes and farmers for the dissemination of technologies.

High density planting (HDP) and fertigation demonstrated on farmers field near Somarasampettai (Trichy) in Nendran and Grand Naine. Many farmers in Trichy, Madurai and Coimbatore and in other districts have adopted the HDP and fertigation technology in banana production.

NRCB participated/organised in the following exhibition

Exhibition	Venue	period	Organized by
Awareness on scope of value addition in banana farmers of Pondichery	NRCB	20th & 27th May, 04	NRCB
Exhibition on Value added products at International Congress on Musa	Penang, Malaysia	6th to 9th July ,2004	INIBAP
Exporters seminar	Virudhunagar	11th Sep, 04	SBI
Banana products awareness campaign on Science Day for school students of Trichy district	NRCB	21st Oct, 04	NRCB
International workshop on Banana	Pune	25-26th Nov, 04	FAO, GOI, Dept of Hort, Govt of Maharastra.
Banana products awareness campaign for Self help group	Lalgudi	20th Dec, 2004	NABARD & TDCC
Exhibition and awareness campaign on value added products for SHG	Amaravathi, Trichy	27th Dec, 04	Mahalir Membattu Thittam, Trichy
Seminar on opportunities in banana based industry	NRCB	28th Dec, 04	NRCB & Rajiv Gandhi Youth foundation, Min. of Sports and Youth affairs, GOI
AGRICON 2005	Vallam , Tanjore	12-13th Feb, 05	CII
AGRI-TRADE 2005	Trichy	24-27th Feb, 05	CII
Scientific workers seminar	KVK, Sirugamai	5th March, 05	KVK
Banana seminar	Sirumugai, Coimbatore	11th March, 05	SPIC-ABC, Chennai
Rastriya Bagwani Kisan Mela	IIHR, Bangalore	22-23 March, 05	MOA, GOI

Dr. S.Sathiamoorthy, Director, NRCB adderssing in a seminar on opprtunities in banana based industry, organised by Rajiv Gandhi Youth Foundation, Ministry of Sports and Youth Affairs, GOI and NRCB

Human Resource Development

Training / Meeting / Seminar / Symposium etc. attended

International

- Dr.S.Sathiamoorthy, Director and Dr.B.Padmanaban, Sr.Scientist participated in the International Congress on Musa: Harnessing research to improve livelihoods at Penang, Malaysia from 6-9th July, 2004.
- Dr.S.Uma, Sr. Scientist (Hort.) attended a overseas training on '*Agrobacterium* mediated genetic transformation techniques in Banana' at Katholeik University of Leuven, Leuven, Belgium, for a period of 6 months from May 2004 to November 2004.
- Mrs.M.S.Saraswathi, Scientist (Hort.) attended a overseas training on 'Mutant germplasm characterization using molecular markers' at International Atomic Eenergy Agency (IAEA), Vienna, Austria from 27th September and 22nd October, 2004.
- Dr.M.M.Mustaffa and Dr.R.Selvarajan participated in an "International workshop on Banana" on 25-26, November-2004 at Pune, organized by FAO Rome, Govt. of Maharashtra and Dept of Horticulture, DAC, GOI, New Delhi.

National

- Dr. R.Selvarajan, Sr. Scientist (Pl. Path.) attended a training programme on Digital photo library at NRC for Medicinal and aromatic plants, Anand, Gujarat, from 23 -24 April 2004
- Dr.C.K.Narayana, Sr.Scientist (Hort.) attended a short term training course on "Innovative Food Processing Technologies" at PHT Centre, Dept. of Agricultural & Food Engineering, IIT, Kharagpur from 4th to 15th Oct. 2004
- Dr. R.Selvarajan, Sr. Scientist (Pl. Path.) attended a NATP sponsored training workshop on "Developing winning research proposals" at NAARM, Hyderabad from 26th to 30th Oct. 2004.
- Dr. Uma, Senior Scientist (Hort.) attended Rastriya Bagwani Kisan Mela and presented the paper entitled 'Banana Tissue culture Industry in India - Status, Problems and Prospects' held at Bangalore during 22-24 March, 2005.
- Dr. R.Thangavelu, Sr. Scientist (Pl.Path.)attended 21 days training programme on "Recombinant DNA techniques" at Div. of Biochemistry, IARI, New Delhi from 5th to 25th Jan. 2005
- Dr.I.Ravi Sr.Scientist (Pl.Physiol.) attended 21 days refresher course on "Advanced Biochemical and Molecular Techniques' conducted at CAS Division of Biochemistry, IARI, New Delhi, during 1st to 21st March 2005
- Drs. M.M.Mustaffa, B.Padmanaban, S.D.Pandey, C.K.Narayana, R. Thangavelu, R.Selvarajan, V.Kumar, I. Ravi, attended a National Seminar on Banana Industry - Present Scenario and Future Strategies held at Bidhan Chandra Krishi Viswavidhyalaya, Kalyani, West Bengal from 11-13th June, 2004

4 ORGANISATION AND MANAGEMENT

The National Research Centre for Banana (NRCB) was established on the recommendation of 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 Tiruchirappalli (11.50 N latitude; 74.50 E longitude and 90m above mean sea level). The centre receives an average precipitation of 600-900 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 research. A detailed break up of the posts and names, financial requirement which includes the budget estimate (Plan and Non Plan for the year 2004-05) are furnished.

Organisation Set up

The National Research Centre for Banana (NRCB) is headed by the Director who is the decision making authority of NRCB. The Director is assisted by Research Advisory Committee (RAC), Staff Research Council (SRC) and Institute Management Committee (IMC) besides Research, Co-ordination, Administration and Technical cell. In research, the Director is assisted by Heads of Crop Improvement, Crop Production and Post Harvest Technology and Crop Protection sections. The centre had 15 research projects and each research project is monitered through frequent meetings convened by the Project leader and Head of the concerned sections as well as quarterly report submitted by each scientist against the flow chart prepared at the time of Project Formulation (RPF-I). The research management and co-ordination unit under the Technical cell at the centre maintains the project files, compiles reports and takes follow up action for implementation of the decision taken during the RAC/Annual Staff Research Council meetings. The centre also promotes international collaboration between NRCB and INIBAP, France, besides consultancy services. For a better administration, the centre had three sections viz., Establishment, Stores & Purchase and Cash & Bill under the control of Assistant Administrative Officer (AAO) and the section Audit and Accounts is controlled by Assistant Finance and Accounts Officer (AFAO). The centre had a total area of 38 ha which has been developed by making plots of 50x50 m and road at every 200 m. Four open wells and six borewells with 2.5 lakh ltr. capacity water tank are available for irrigation. As on today, NRCB Library holds about 1060 volumes and 60 technical reports, 50 CD-ROM's and subscribes 35 Indian journals, 10 Foreign journals, besides it has 500 journal back volumes and 40 projects dissertations. NRCB is in the mailing list of INIBAP and IGPRI and all the ICAR institute/SAU's. The centre also had a separate wing for ARIS, Arts and Photography and Transfer of technology. The total sanctioned as well as existing strength of the employees of NRCB is furnished.

Administration

Man Power

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

Details of scientific posts sanctioned / filled / vacant in ICAR as on 31st March, 2005

Name	Designation	Post Sanctioned	Filled as on date	Vacant
Dr.S.Sathiamoorthy	Director	1	1	-
Dr.M.M.Mustaffa	Principal Scientist (Hort.)	1	1	-
Dr.P.Sundararaju	Principal Scientist (Nema.)	1	1	-
Dr.B.Padmanaban	Senior Scientist (Ent.)	1	1	-
Dr.S.D.Pandey	Senior Scientist (Hort.)	1	1	-
Dr.C.K.Narayana	Senior Scientist (Hort.)	1	1	-
Dr.S.Uma	Senior Scientist (Hort.)	1	1	-
Dr.I.Ravi	Senior Scientist (Pl.Phy.)	1	1	-
Dr.R.Thangavelu	Senior Scientist (Pl.Path.)	1	1	-
Dr.R.Selvarajan	Senior Scientist (Pl.Path.)	1	1	-
Dr.V.Kumar	Senior Scientist (Hort.)	1	1	-
Dr.K.J.Jeyabaskaran	Scientist (SS) (Soil Sci.)	1	1	-
Mr.R.Natarajan,	Scientist (Eco.Bot.)	1	1	-
Mrs.M.S.Saraswathi	Scientist (Hort.)	1	1	-
Vacant	Scientist (Biotechnology)	1	-	1
Vacant	Scientist (Food Technology)	1	-	1

Details of Non Gazetted posts sanctioned in ICAR

Name	Designation	Post Sanctioned	Filled as on date	Vacant
Mr.Raghuraman	T-5 Technical officer	1	1	-
Mr.S.Palanichamy	T-5 Technical officer	1	1	-
Mr.P.Durai	T-4 Lab Technician	1	1	-
Mr.P.Ravichamy	T-3 Technical Asst. (Journalism)	1	1	-
Mr.D.Ramachandramoorthy	T-3 Tech.l Asst (Civil Overseer)	1	1	-
Mrs.C.S.Jacqueline	T-3 Tech.Asst. (Computer Prog.)	1	1	-
Mrs.T.Anitha Shree	T-3 Lab Technician	1	1	-
Mr.R.Pitchaimuthu	T-2 Field Technician	1	1	-
Mr.N.Marimuthu	T-2 Field Technician	1	1	-
Mr.V.Selvaraj	T-2 Lab Technician	1	1	-
Mr.T.Sekar	T-2 Lab Technician	1	1	-
Mr.K.Kamaraju	T-2 Lab Technician	1	1	-
Mr.A.Subramanian	T-2 Driver	1	1	-
Mr.P.Mohan	T-2 Tractor Driver	1	1	-
Mr.V.Manoharan	T-2 Driver	1	1	-

Name	Designation	Post Sanctioned	Filled as on date	Vacant
ADMINISTRATION				
Mr.B.Vijayakumar	AAO	1	1	-
Mr.M.Krishanmoorthy	P A to Director	1	1	-
Mr.R.Sridhar	Stenographer Gr.III	1	1	-
Mr.R.Krishnamurthy	Upper Division Clerk	1	1	-
Mrs.S.Durgavathy	Lower Division Clerk	1	1	-
Mr.M.Devarajan	Lower Division Clerk	1	1	-
AUDIT AND ACCOUNTS				
Dr.S.D.Pandey	AFAO (Incharge)	1	-	1
Mr.M.Balu	Assistant	1	1	-
Mr.R.N.S. Kannan	Stenographer Gr.III	1	1	-
SUPPORTING				
Mr.R.Mohanraj	Mali SSG-III	1	1	-
Mr.V.Pandiyan	Mali SSG-III	1	1	-
Mr.V.Thangaraju	Messenger SSG-II	1	1	-
Mr.P.Kamaraj	Mali SSG-II	1	1	-
Mr.V.Ganesan	Mali SSG-I	1	1	-
Mr.C.Kumaran	Mazdoor SSG-I	1	1	-
Mrs.K.Mariammal	Safaiwala SSG-I	1	1	-

Finance and Audit

Head of Account	Budget for 2004-05		Expenditure 2004-05	
	Plan	Non-Plan	Plan	Non-Plan
Estt. Charges	-	82.20	-	90.55
Travelling expenses	2.00	1.10	1.72	1.10
Other charges	148.00	37.20	148.27	29.56
Works	50.00	1.50	50.00	0.78
Total	200.00	122.00	199.99	121.99

Awards

PISANG RAJA AWARD

Dr.S.Sathiamoorthy, Director, NRCB received a prestigious PISANG RAJA award for the best banana researcher in the Asia and Pacific region. This award is presented once in two years for outstanding contribution to banana research and development in this region. Dr.S.Sathiamoorthy has devoted his entire carrier to banana research including collection, conservation and characterization of the diverse *Musa* germplasm in India that resulted to the establishment of largest *Musa* collection in Asia. He has authored and co-authored 236 publications including four books and 5 book chapters. This prestigious award presented to him on 23rd day of November, 2004 during 3rd BAPNET steering committee meeting held in China.

JAWAHARLAL NEHRU AWARD

Dr.R.Thangavelu, Sr.Scientist (Plant pathology) received the Jawaharlal Nehru Award for P.G. Agricultural Research (Crop Protection) 2003 for his doctoral programme entitled "Characterization of *Fusarium oxysporum* Schlecht f.sp. *cubense* (E.F.Smith) Snyd and Hans and molecular approaches for the management of Fusarium

Dr.R.Thangavelu, Sr.Scientist (Plant Pathology) receiving the Jawaharlal Nehru Award

wilt of banana". He received this prestigious award from the Hon'ble Minister for State for Planning on 18th Sept.2004 at a function held at IARI Campus, New Delhi.

TECHNICAL CO-ORDINATION

RAC, Management Committee, SRC, QRT etc., Meetings with significant decisions

Seventh Research Advisory Committee Meeting

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

After detailed discussions on the research progress in 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	Member Secretary
Dr.H.K.Jain Ex-Director-IARI, 40, Surya Niketan, Vikas Marg Estension New Delhi - 110 092	Dr.M.M.Mustaffa Principal Scientist, National Research Centre for Banana, Tiruchirapalli - 620 102

Members

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

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

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

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

Shri. Subash Shamrao Kadam
Nended, Maharastra

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

Institute Management Committee Meeting

Eighth Institute Management Committee Meeting

The eighth IMC meeting was held on 14th March, 2005 under the Chairmanship of Dr.S.Sathiamoorthy, Director NRCB, Tiruchirapalli. Dr.S.Sathiamoorthy welcomed the Management Committee Members and briefed the research achievements of NRCB.Dr.R.Selvarajan, Sr.Scientist (Pl.Path.) presented the status of viral diseases of banana and their management to the IMC members. Mr.B.Vijayakumar, AAO has presented the action taken report on the proceeding of the seventh 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.

Eighth Institute Management Committee meeting chaired by Dr. S. Sathiamoorthy, Director, NRCB

List of IMC Members

Chairman

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

Members

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

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

Dr.M.M.Mustaffa and Dr.P.Sundararaju
Principal Scienitsts, NRC (Banana), Tiruchirappalli

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

Non Official Member

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

Shri. Subash Shamrao Kadam
Nended, Maharastra.

Members Secretary

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

Dr. S. Sathiamoorthy, Director, NRCB explaining about value added products of banana developed at NRCB to the members of IMC

Staff Research Council Meeting

Nineth SRC meeting

The Ninth Staff Research Council meeting was held on 12th May, 2005 in the Committee room under the Chairmanship of Dr.S.Sathiamoorthy, Director, National Research Centre for Banana, Tiruchirapalli. Dr.M.M.Mustaffa, Member Secretary welcomed the Chairman and Members of the SRC. Then the progress of the various on-going projects and technical programmes were presented by the respective project leaders and discussed. The work done under the NATP and adhoc projects were presented by the respective Principal Investigators and reviewed the physical and financial research accomplishments.

5 PARTNERSHIP AND LINKAGES

Educations and Training

As a research guidance, scientists of NRCB guided students from Bharathidasan University for their M.Sc. /M.Phil./M.Tech. Dissertation work. During the period under report the following scientist have guided M.Sc./M.Phil. /M.Tech. students. The number of students guided by the respective scientists is given below

Dr.P.Sundararaju - 4 M.Sc. students

Dr.B.Padmanaban - 2 M.Sc. students

Dr.R.Thangavelu - 7 M.Sc. and 3 M.Phil. scholors

Dr.R.Selvarajan - 4 M.Sc. and 1 M.Phil. scholors

Dr.C.K.Narayanan - 1 M.Tech. student

Dr.V.Kumar - 2 M.Sc. students

Trainees attending practicals in the NATP - winter school on conventional and molecular diagnostic techniques for virus detection" at Virology lab

Summer / Winter School and short courses

Dr.R.Selvarajan, Sr.Scientist (Pl.Path.) conducted a training (winter school) on "conventional and molecular diagnostic techniques for virus detection" at Virology lab, NRCB from 24th Sept to 7th Oct 2004 for researchers from SAU, Technical personnel from TC industries and to a progressive farmer. This training (winter school) was sponsored by NATP (mission mode), New Delhi. Totally 14 persons from 5 states participated in the training programme. Ten resource persons from ICAR, SAU and Quarantine department delivered lectures. In this training hands on expertise was given on visual diagnosis of banana viruses, detection techniques such as ELISA, DIBA, PCR and RT-PCR, NASH or DOT BLOT Hybridisation using non radioactive virus specific probes to the participants.

Resource generation / consultancy

Contract services are provided on virus testing of Tc plants, testing of soil and banana products on commercial basis at NRCB. Training on value added products are offered on cost basis to the interested clients. Tissue culture plants from TC industries are indexed with technology developed in virology lab on commercial basis.

A Turn key basis project entitled "Establishment of virus testing facility for producing virus free banana plants in Andhra Pradesh" will be executed for Biotechnology centre, Dept of Horticulture, Govt. of AP as per consultancy service and an agreement has been made between the NRCB (ICAR) and Dept of Horticulture, Govt of Andhra Pradesh for implementing the project.

Special assignments outside the organization

Dr.R.Selvarajan, Sr.Scientist (Pl.Pathology.) served as a National consultant with virology specialization for a FAO project implemented in India.

6 PUBLICATION AND INFORMATION

National Researh Centre for Banana (NRCB) brings out a number of publications viz., folders, Technical bulletin, brouchers, books, News letters and Annual reports which are matching with the international standards in three languages like English, Tamil and Hindi for the benefit of progressive farmers, entrepreneurs, scientists, students, extension workers and policy makers.

During the year 2004-05, NRCB brought out six publications which includes two books, two technical bulletins and two folders besides research papers published in reputed journals. In addition NRCB brings out the newsletter twice in a year. Scientists from NRCB also participated in various symposia/seminar and presented more than 60 research papers in different disciplines of which 25 research papers were presented in the Interantional Congress on *Musa*: Harensing researh to improve livelihoods held on 6-9 July 2004 at Penang, Malaysia.

Papers Published in refreed Journals

1. S.Uma, S.Sudha, M.S.Saraswathi, M.Manikavasagam, R.Selvarajan, P.Durai, S.Sathiamoorthy and S.A.Siva. 2004. Analysis of genetic diversity and phylogenetic relationship among indigenous and exotic Silk (AAB) group of bananas using RAPD markers. *J. Hort. Sci. & Biotech.* 79(4) : 523-527.
2. S.Uma, S.Sathiamoorthy, M.S.Saraswathi, P.Durai, Hari Om Sharma and Anuradha Agrawal. 2005. Evaluation and Utilisation of Introduced *Musa* Germplasm in India. *Indian J. of Plant Genetic Resources* 18(1):79-81.
3. 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 Agri. J.* 50 : 418-420.
4. Jeyabaskaran, K.J., S.D. Pandey and G. Gomadhi. 2005. Substitution of potassium-rich cement kiln flue dust and distillery effluent for potassium fertilizers in banana cv. Ney Poovan. *J.Potassium Research* 21:
5. Thangavelu, R., Sundararaju, P and Sathiamoorthy, S. 2004. Management of antracnose disease of banana caused by Collectrichum musae using plant extracts.*Journal of Horticultural Science and Biotechnology*.79 (5). 664-668.
6. Thangavelu, R., Palaniswami, A. and Velazhahan, R. 2004. Mass multiplication of *Trichoderma harzianum* using biodegradable banana waste for the control of Fusarium wilt of banana. *Agriculture, Ecosystems & Environment*. 103(1): 259-263.
7. Mustaffa, M.M., B. Tanuja Priya and V. Krishnamoorthy. 2005.Standardisation of carrier material as ethylene absorbent on shelf life of Rasthali banana. *J. Food Sci. & Tech.* 42(1): 46-48.
8. 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.

Books

a. S.Uma, R.Selvarajan, B.S.Chundawat and Jose C. Samuel, 2004. Micropropagation in Banana and Plantain. Ministry of Agriculture, Dept. of Agriculture & Co-operation, New Delhi and FAO, Rome. Pp.71

b. Padmanaban, B. and S.Sathiamoorthy 2005. Vazhaiyai Thakkum Poochikalum kattupaduthum muraikalum (Book in Tamil) p 65.

NRCB Library

NRCB library holds about 960 books and 60 technical reports, 50 CD-ROM's, and subscribes for 35 Indian journals, 10 foreign journals, besides it has 500 journal back volumes, 40 projects and dissertations. The facility offered by the library includes computerized calatogues, reprographic services, bibliographical services and information service.

The information search is fully automated using Nirmals software. Online Public Access cataloguing service is provided in LAN mode using CD Mirror server and Pentium IV computers.

The library provides ISI Web knowledge online search facility for Science Citation Index, Agricola CD's and Musadoc. The library also maintains a digital photo library comprising of photos related to banana cultivation, pest and disease management, post harvest technology and priced publications.

VSAT Facility at NRCB

NRCB is now linked with nationwide computer networking of National Informatics Centre (NIC) of planning commission, Government of India. This will facilitate exchange of information and data within ICAR units located at different parts of the country and also amongst other network users, in a faster way, with minimum cost. The website of the centre is www.nrcb-india.org.

Extension and Public Relations Unit

The extension and public relation unit plays a key role in dissemination of the technology developed on banana at the centre with special reference to the cultivation aspects as well as on Value Added Products. Most of the technology transfered to banana farmers through extension activities. The centre has organised kisan melas (2), field days (13), Front line demonstrations (2), Radio talks (20), Television programmes (3), exhibitions (35) and News Paper coverage (25). Besides 600 school students and 10,000 farmers visited NRCB for enriching their knowledge on banana cultivation aspects and banana value added products.

ANNEXURE - I

List of approved on going projects

I Crop Improvement

1. Management of genetic resources of banana

   Project Leader : **S.Uma**
   Project Associates : S.Sathiamoorthy, R.Natarajan*, M.S.Saraswathi*

2. Crop improvement of banana through conventional breeding

   Project Leader : **S.Sathiamoorthy**
   Project Associates : S.Uma, R.Natarajan*, M.S.Saraswathi*

3. Crop improvement of banana through non-conventional breeding

   Project Leader : **S.Uma**
   Project Associates : M.S.Saraswathi*, S. Sathiamoorthy.

   * on study leave

II.Crop production and Postharvest technology

4. Standardisation of agrotechniques for banana production and productivity

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

5. Integrated nutrient management in banana

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

6. Studies on micronutrients in banana

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

7. Standardization of technology for organic banana production

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

8. Standardization of nutritional requirements of banana using soluble fertilizers

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

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

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

10. Studies on handling, storage and processing of banana

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

11. Standardization of storage conditions for banana

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

III. Crop Protection

12. Insect pest management in banana

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

13. Studies on banana nematodes and their management

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

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

    Project Leader : **R.Thangavelu**

15. Studies on viral diseases of banana and their management

    Project Leader : **R.Selvarajan**

List of on going externally funded projects

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

   P.I. : **S. Uma**
   Co. P.I. : S. Sathiamoorthy, M.S. Saraswathi

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

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

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

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

4. Development of nematode resistance in *Musa* lines - Funding source VVOB, Belgium

   P.I. : **T. N. Balamohan**
   Co. P.I. : S. Sathiamoorthy and P. Sundararaju

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

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

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

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

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

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

ANNEXURE - II

Meterological Data of NRCB, Trichy

Month/Year	Temperature in °C		Relative Humidity		Total Rainfall
	Min	Max	Min	Max	(mm)
April 04	26.9	40.2	26.5	81.1	1.7
May 04	25.6	35.5	45.2	85.2	20.2
June 04	25.6	36.9	35.3	74.4	30.8
July 04	27.9	36.1	37.9	78.7	79.5
August 04	26.8	37.7	32.1	70.3	4.8
September 04	24.3	34.2	48.0	88.8	294.9
October 04	23.9	31.2	57.1	92.5	115.5
November 04	21.8	29.7	63.0	94.8	56.5
December 04	22.4	30.9	49.3	92.3	0.0
January 05	21.4	30.0	40.7	94.8	0.0
February 05	21.9	33.7	28.3	90.6	0.0
March 05	25.4	37.3	24.5	88.6	5.0

7 कार्यकारी सारांश

सिहांवलोकन

केला भारतवर्ष का प्रमुख फल है एवं कुल फल उत्पादन में इसका ३१.७ प्रतिशत योगदान है। इसे विभिन्न उत्पादन पद्यतियों द्वारा देश के विभिन्न कृषि जलवायु क्षेत्रों में उगाया जाता है। खाद्य सुरक्षा, पोषण एवं व्यापार में केले की महत्ता को ध्यान में रखते हुए भारतीय कृषि अनुसंधान परिषद द्वारा राष्ट्रीय केला अनुसंधान केन्द्र की स्थापना के लिए एक कार्यदल गठित किया गया था। यह केन्द्र केला उत्पादन से जुड़ी समस्यायों के निदान के लिए मौलिक, व्यवहारिक एवं रणनीतिक जीवीय तथा अजीवीय पहलुओं पर शोधरत है। गतवर्ष के दौरान केन्द्र द्वारा हासिल की गयी प्रमुख अनुसंधान उपलब्धियां इस प्रकार है-

शस्य सुधार

आसाम, मेघालय एवं अरूणांचल प्रदेश से केले के कुल ४६ जनन द्रव्यों का संग्रहण किया गया, इनमें से एकुमिनाटा (८), बल्वेसियाना (२), इन्सेते (१), रोडोक्लेमस प्रजाति (६) अन्य प्रजातियां (१०) तथा अवर्गीकृत प्रजातियां (१५) थीं। प्राथमिक एवं द्वितीयक संग्रहण द्वारा कुल ४२ अर्धजंगली एवं विदेशी प्रजातियों का संग्रह किया गया। पूर्वोत्तर क्षेत्रों से एकत्र किये गये जनन द्रव्यों में से मुसास्वर्णफल श्रेष्ठ पाया गया तथा इसका, इनीवैप इपगिरी के वर्णक्रम के अनुसार वर्गीकरण किया गया। एकत्र किये गये विदेशी एवं जंगली जनन द्रव्यों में आई.वी. १०४ तथा पिसांगरेजांग अधिक उपयोगी साबित हुई। आर.ए.पी.डी. द्वारा विश्लेषण के बाद पूर्वोत्तर क्षेत्रों से एकत्र जनन द्रव्यों को ३ वर्गो से संबंधित पाया गया।

अगाली (केरल) में जनन द्रव्य बैंक की स्थापना की गयी एवं यहां पर पूर्व-संकरण खण्डों में एकत्रित जनन द्रव्यों को सभाल कर रखा गया। एकत्रित जनन द्रव्यों को सूत्रक्रमि एवं सिगाटोगा (पर्ण धब्बा बीमारी) के प्रति जांचा-परखा गया तथा सेन्नाचेनकदली, पिसांग रोज, लैराक, चेन्दाक, आई. टी.सी. ०१६८ तथा येनगम्बी के.एम. ५ पर पर्ण धब्बा रोग का कोई प्रभाव नहीं पड़ा। सूत्रक्रमि के प्रति छंटनी के दौरान विदेशी जनन द्रव्य एफ.एच. आई.ए. २३, आई.टी.सी. १४३७, आई.टी.सी. एम.वी. १६८, पिसांग मस एवं पिसांग बर्लिन तथा स्थानीय जनन द्रव्य मनथन प्रतिरोधी पायी गयीं। चेक गणराज्य की प्रयोगशाला (अणु जीवद्रव्य आनुवांशिकी) तथा केला अनुसंधान केन्द्र के सम्मलित प्रयास से ३६ जनन द्रव्यों का प्लाइडी स्तर ज्ञात किया गया। २२ भारतीय केले की प्रजातियों के लिए भ्रूण आनुवांशिकीय कोशिका निलंबन पद्धित विकसित करने के लिए प्रयास किये जा रहे हैं।

शस्य उत्पादन

केले की जैविक खेती अजैविक खेती की तुलना में श्रेष्ठ पायी गयी। रोपाई के बाद प्रति पौधा २.५ किग्रा. कम्पोस्ट, १ किग्रा. केंचुआ खाद,१ किग्रा. नीम की खली एवं २.५ किग्रा. पोल्ट्री खाद देना लाभकारी सिद्ध हुआ। जैविक केले की उपज अजैविक विधि के समान प्राप्त हुई, जबकि फल गुणवत्ता एवं लाभकारी शूक्ष्म जीवों का स्तर जैविक केले में उच्च (४० प्रतिशत) पाया गया। सवा, रसथली एवं रोवस्टा प्रजातियों के लिए सघन रोपण पद्धति का मानकीकरण किया गया तथा टपक सिंचाई को दूसरी विधियों की तुलना में जल एवं उर्वरकों की बचत के लिए श्रेष्ठ पाया गया। सवा प्रजाति से टपक सिंचाई के साथ मनथन से अधिक उपज प्राप्त हुई।

उच्च पी.एच. मान वाली मश्दाओं में प्रति पौधा ५ किग्रा. जिंक सल्फेट तथा ४ पी.पी.एम. बोरिक अम्ल के पर्णीय छिड़काव से पूरबल्ली केले में ४१. ३ प्रतिशत अधिक उपज प्राप्त हुई तथा फलों की

गुणवत्ता उत्तम पायी गयी। फास्फोवैक्टीरिया (२५ ग्राम) तथा १० किग्रा. चावल की भूसी की राख प्रति पौधा देने से प्रति हेक्टेयर २६२५० रूपये की अतिरिक्त आय रसथली प्रजाति से प्राप्त गयी। तमिलनाडु में केले की खेती के सर्वेक्षण के पश्चात ड्रिस पद्धति को विकसित किया गया। फूल आने के पूर्व पत्तियों की छटाई (क्लिपिंग) लाभकारी सिद्ध हुई।

शस्योत्तर तकनीक

तुड़ाई के बाद रोबस्टा एवं रसथली प्रजातियों के फलों को ताप-उपचार एवं परिवर्तित वातावरण पैकिंग के द्वारा १२१-१३६ दिन तक कम तापक्रम पर भण्ड़ारित किया जा सका तथा निम्न ताप (१०-१२° सेल्शियस) पर भी फलों में शीत-आघात का असर नहीं हुआ। फलों को पकाने में इथ्रेल का प्रयोग लाभकारी साबित हुआ।

शस्य सुरक्षा

सूत्रक्रमि *हेटोरोहैवडिटिस इंडिका* तथा फफूंदी *ब्यूवेरिया वैसियाना* केला के तना बेधक कीट को नियंत्रित करने में सक्षम पाये गये। केले की घार को क्लोरपाइरीफांस तथा पैराफिन तेल से संतश्प्त कपड़े के थैलों से ढकने पर थ्रिप्स का असर नहीं हुआ तथा उत्कृष्ठ रंग व आकार के फल प्राप्त हुए। केरल, तमिलनाडु एवं पाण्डुचेरी में सर्वेक्षण से पाया गया कि केले की अधिकांश प्रजातियां जड़-छेदक सूत्रक्रमि के प्रति सहनशील है। वानस्पतिक कीटनाशकों (नीम, मकोय एवं एवुटलान) तथा वैम के प्रयोग से सूत्रक्रमि की संख्या को नियंत्रित किया गया। पनामा विल्ट को नियंत्रित करने में *ट्राइकोडरमा विरडी, स्यूडोमोनास, वैसिलस* तथा *एजोसपाइरिल्लम* का प्रयोग लाभकारी साबित हुआ। पैराफिन तेल व प्रोपीकोनाजोल का मिश्रण सिगाटोगा की रोकथाम में कारगर पाया गया। कोष्ठ मोजैक विषाणु को पहली बार सिलीगुड़ी (पश्चिमी बंगाल) में चिन्हित किया गया, जबकि तमिलनाडु में पहले से ही इसका प्रकोप विद्यमान है। अधिकांश डिप्लोइड प्रजातियां प्रकोष्ठ विषाणु के प्रति प्रतिरोधी पायी गयीं।

तकनीकी हस्तानतरण

केला अनुसंधान केन्द्र द्वारा विकसित तकनीक को किसानों एवं उद्यमियों तक पहुंचाने के लिए विषाणु, सूत्रक्रमि, उकठा तथा पर्णधब्बा रोग की पहचान व उनके रोकथाम पर प्रशिक्षण कार्यक्रम आयोजित किये गये। लघु किसानों एवं महिलाओं को केले से अचार, रस व रेशे तैयार करने पर भी प्रशिक्षित किया गया।

मानव संसाधन का विकास

केन्द्र के वैज्ञानिकों एवं तकनीकी कर्मचारियों की दक्षता बढ़ाने के लिए उन्हें लघु एवं मध्यम अवधि के प्रशिक्षण प्राप्त करने के लिए देश एवं विदेश में भेजा गया।