NRCB

वर्षिक प्रतिवेदन

Annual Report

2002 - 2003

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

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वर्षिक प्रतिवेदन
ANNUAL REPORT
2002 - 2003

With Best Compliments

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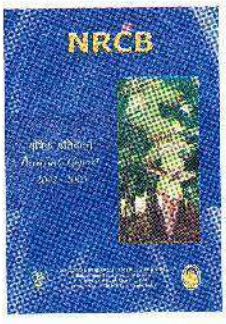

Immature bunch of Cv. Robusta

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View of the Laboratory cum
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PREFACE

It is my pleasure to present the Annual Report 2002-03 of the National Research Centre for Banana, Tiruchirapalli. As the Centre is stepping into its second decade of establishment and in the beginning of the X five year plan period, the Centre has initiated many innovative programs for the improvement of banana industry which would go a long way in benefiting the small growers and entrepreneurs in the country.

The Centre has made notable achievements in exploration of bananas and collected four unique accessions from N.E.region. Molecular characterization and updating of the MGIS data base has been in progress. A beginning has been made in the standardization of technology for organic bananas and modified high density planting with fertigation technology has been widely adapted by the farming community.

Major emphasis was given for the bio-control of major pests, nematodes, pathogens and viruses. Technology for the management banana weevil using entomo-pathogenic fungi and nematodes is in progress. Plant extract from *Solanum torum* has been found effective in the control of FOC and anthracnose disease in fruits. PCR technique was highly effective for the detection of important virus diseases in banana.

Based on the recommendations of Research Advisory committee and Quinquennial Review Team, the entire research projects were reoriented with interdisciplinary approaches. As a part of the extension activity, the Centre has honoured 10 progressive banana farmers for their contribution to banana industry. Various laurels were bought to the centre by the scientists.

Free and paid training programs on value addition in banana were conducted for the rural women and entrepreneurs for taking up these ventures commercially.

I compliment Dr.M.M.Mustaffa and members of the Editorial committee for compilation and editing of the Annual Report and express my appreciation to all the staff members for their co-operation.

Tiruchirapalli
March, 2004.

S. SATHIAMOORTHY
Director

1 EXECUTIVE SUMMARY

Germplasm Management

Two explorations were undertaken during this period to Andaman Islands, Assam and Arunachal Pradesh and collected wild and cultivated accessions (38) including 4 unique accessions viz., *Musa nagensium, M. itinerans, M. aurantiaca* and an unidentified accession with green male bud. In addition, 208 accessions have been collected from NBPGR regional station, Thrissur and conserved in the NRCB field gene bank. Database has been updated for 48 accessions in MGIS.

Molecular (19) and morphotaxonomic characterization (15) of Andaman island accessions have been completed using RAPD markers. Protocol has been standardized for surface sterilzation and *in-vitro* germination of mature zygotic embryos.

Production

Application of organic manures such as distillery sledge, vermicompost, neem cake and poultry manure recorded maximum vegetative and bunch parameters in Rasthali and Karpuravalli banana. Studies on different fertigation levels under high density planting in Robusta, Rasthali and Saba cultivars showed that paired row system (5200 plants /ha) recorded better plant growth as compared to other densities in all fertigation levels. Maximum plant height and pseudostem girth were recorded in phosphobacteria application and more number of leaves were produced in vermicompost + Azospirillum applied plants. In Karpuravalli banana, soil application of Fe, foliar applications of Zn and B produced the highest bunch weight, which was 56.7 per cent more than control under high pH soil condition.

Postharvest

GA 100ppm treated Ney Poovan fruits stored in ZECC had the highest green life (6days) and yellow life (5days). The control fruits stored at room temperature (RT) had the highest PLW, total sugars and ascorbic acid. The organoleptic score was the highest in fruit packed in poly bags with ventilation and stored in ZECC than those stored at RT. Virupakshi banana fruits treated with Ethrel 500 ppm and sealed in poly bags failed to ripen normally even after 7 days while those without poly bags ripened within 3 days when stored at room temperature after treating with Ethrel.

Protection

Five new minor pests were reported in banana. Developed a rapid screening technique for *Musa* germplasm evaluation against banana stem weevil. Pseudostem trapping technique has been developed for banana weevil management. Plant products were isolated and identified few extracts for the management of banana weevils. *Musa* germplasm was screened against banana stem weevil and identified accessions moderately resistant to banana stem weevil. Isolated and identified entomo-pathogenic fungi and entomo-pathogenic nematodes for the management of banana weevils.

Banana wastes such as petiole and pseudostem were successfully used for mass production of nematode egg parasitic fungi, *Paecilomyces lilacinus* and *Trichoderma harzianum*. Two application of bio-control agent, *T.viride* @ 20 g/plant was found effective in controlling nematodes (*P.coffeae* and *M.incognita*) as well as reduced the incidence of Panama wilt disease in cvs. Rasthali and Virupakshi. The yield significantly increased by 30% when intercropped with *Tagetes* spp. as compared to untreated control. Econeem and Nimbicidine have shown maximum efficacy in reducing the nematode population with increased plant growth and was on par with the nematicide Carbofuran. A bio-control agent, *Verticillium chlamydosporium* successfully controlled the second stage juveniles and eggs of *M. incognita* under *in-vitro* conditions. The root-knot nematode, *M. incognita* was recorded for the first time in an ornamental banana, *Ensete superbum*.

An effective antagonistic bacteria (1b) from the banana fruit surface has been identified for the control of post-harvest crown rot disease caused by *Lasiodiplodia theobromae* and was on par with the fungicide. Botanical extract *Solanum torvum* spray at 50% concentration on banana fruits after the harvest effectively controlled the anthracnose disease. Mass production of *Trichoderma viride* was achieved in rice chaffy grains added with 5% jaggery solution. 100% coverage of the substrate was observed in 6 days. The cfu/g of substrate was $1.2X10^{9}$ at 2nd month of storage of substrate. The fungicide Mancozeb (flowable) was effective in arresting the growth of newly identified

pathogen (Basidiomycetes). Application of PGPM and plant extract *Solanum torvum* increased the plant growth parameters of FOC inoculated plants by 20% more than the control in the pot culture studies. Spraying of Paraffinic oil 5% + half the dose of fungicides such as Propiconazole, Carbendazim and Mancozeb controlled Sigatoka disease effectively and increased the yield up to 20 per cent over control. In the process of isolation of principle compound from *Solanum torvum*, ethyl actate, fractions showed high anti-fungal activity against *Colletotrichum musae* and *FOC*.

Dot blot technique has been standardized for detection of BBTV. BSV could be detected in mealy bugs by PCR technique using BSV primers specific to Mysore group of Banana. The BSV genome has been isolated from purified viral preparation. The diploids viz., Matti, Venkadali, Sanna Chenkadali and Kunnan were free from BSV viral genome. The virus has been detected in a diploid, which was not expressing symptom of the virus. BBTV has been detected in Hill banana samples. RT-PCR technique has been developed for detection of BBMV. Endophytes were isolated from healthy plants but were not found in virus-infected plants. BSV has been detected in samples affected with a malady called Vikkal in Poovan The nine segments of amplicons of banana vir genome have been purified for sequencing. D blot technique has been used to screen BSV i Mysore group bananas. Only three were foun positive for BSV and BSV integrants has bee detected in AB collections of germplasm

Transfer of Technology

On-farm advise, farmers meeting and lectur were given to popularise clean disease fr planting material, identification of disease suckers, improved production technologies f tissue culture banana, drip irrigation, modifie high density planting and for reducing cost cultivation, improved protection technologi for control of new pests and diseases. addition, training was imparted to sm farmers and women entrepreneurs processing and value added produ including fibres.

Human Resource Development

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

2 INTRODUCTION

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

Salient Research Achievements in the past

I. BANANA GENETIC MANGEMENT AND IMPROVEMENT

The research Centre has the mandate to collect the available indigenous and exotic germplasm in *Musa* genome for genetic enhancement, utilization and conservation. In this connection, a total of 1045 indigenous and exotic accessions of *Musa* are pooled at this Centre. A database has been developed for 600 *Musa* accessions based on INIBAP/IPGRI descriptor. The evaluation of the accessions to various biotic and abiotic stresses are in progress. The germplasm was screened for salt tolerance using Tetrazolium and found that Saba, Burro Cemsa, Pisang Ceylon, Bluggoe, Pisang Awak, Monthan, Robusta and Rasthali were found to be resistant. Among the germplasm accessions evaluated for pseudostem weevil, Bhimkol, Athiakol, Elavazhai, Saapkal, Dudh Sagar, Pisang Lilin and Pisang Jare Buaya were found to be field tolerant. Evaluation of IMTP (International Musa Testing Programme) accessions from INIBAP, France, for their resistance to Sigatoka leaf spot diseases have resulted in identification of six accessions tolerant to Sigatoka leaf spot diseases.

Protocols have been standardised for *in-vitro* conservation of different genomes of the selected germplasm. The embryo culture protocol has been standardised for ABB cultivars. Standardised regeneration of meristematic tissues of Silk (AAB) group by optimising the BAP concentration for proliferation of viable shoots. Under *Musa* Germplasm Information System (MGIS), passport data for 809 accessions have been done while complete evaluation and characterisation have been updated for 100 accessions.

II. BANANA PRODUCTION

Various experiments have been carried out to increase the production and productivity of banana under wetland system of cultivation. Application of 25% substitution as organic manures favoured better plant growth, reduced crop duration, increased bunch weight and TSS in eight banana varieties. Inorganic application of 100% nitrogen extended the crop duration. Maintenance of banana field up to 6 months without weed enhanced the vegetative growth, produced better bunches with reduced crop duration. The loss due to weed is estimated to be 33%. Application of Glyphosate @3.5 Kg a.i. per ha controlled the weeds up to 6 months and increased the bunch weight. Planting of suckers during February for Rasthali, Poovan and Nendran varieties and planting of Karpuravalli during December gave maximum bunch weight than other seasons of planting.

Salt tolerance in banana was due to high Na selectivity in leaves and roots, high average leaf area, low Na concentration in the roots and low compartmentation of Na in the leaves. Application of 15kg FYM + Gypsum 2kg + 360g K increased the yield and quality in cv. Nendran and Rasthali bananas in salt affected sodic soils. Application of cement factory flue dust @0.5Kg per plant could save 60% of potassium in Karpuravalli banana. The critical level was found to be 710 ppm K and 480 ppm Na and K/Na 1.46 the banana soil and for banana leaf K 2.82%, Na 0.47% and K/Na ratio 5.7%. The leaf Na concentration increased from lamina base to top and from margin towards midrib and the reverse trend was observed for leaf K. K/Na ratio was >1 in leaf and <1 in sodic injured leaf.

Application of 15kg poultry manure with 160g N, 40g P and 240g K (80% of the recommended dose) through inorganic fertilisers increased yield. Application of 25% N as FYM + 50% N as neem cake + 25% N as Urea was found to be optimum for improving the soil physical properties with increased bunch weight.

III. CROP PROTECTION

Electron microscopic studies of pseudostem weevil indicated substantial layers of variously shaped sensillae in the antenna tip and segment, proboscis and elytra, which were used as sensory receptors. BSW showed a high degree of host preference for Nendran variety. Disc on stump and longitudinal split traps @ 100 traps per ha were optimum for weevil trapping. Commercially available sex pheromone on leaf eating caterpillars indicated maximum male moth catch during 14-17 standard week. Wide spread occurrence of burrowing nematode, root lesion nematode, root knot nematode and spiral nematode were recorded in all banana growing regions of India. Cyst nematode was recorded for the first time in Robusta banana in Tamil Nadu. Neem cake application along with 50g Carbofuran in 2 splits considerably reduced the root lesion nematode in susceptible Nendran banana. Neem extracts caused 74% mortality of root lesion nematode when exposed for 20 hours. Banana waste i.e. petiole and pseudostem could be successfully utilised for mass multiplication of nematode egg parasitic fungi, *Paecilomyces lilacinus* and *Trichoderma harzianum*. Two applications of *Trichoderma viride* @ 20g per plant was effective in controlling the nematodes and Panama wilt in Rasthali and Virupakshi varieties.

Widespread occurrence of Banana Bract Mosaic Virus (BBMV) and Banana Streak Virus (BSV) was found in the entire banana growing regions of India. Electron microscopy and serological analysis have confirmed their identity. 'Kokkan' disease of unknown etiology seriously affecting the plantains in Kerala has now been identified due to BBMV. The yield loss due to BBMV and BSV has been ranging from 48 to 70%. DIBA, DAC-ELISA tests have been standardised for BBMV and BSV. BSV expression in Poovan is highly influenced by the temperature.

Fusarium wilt (Foc) of banana still continues to be serious in cvs. Silk, Red banana, Virupakshi, Karpuravalli and cooking bananas. *Trichoderma viride* and *Pseudomonas fluorescence* were found to inhibit wilt pathogen in dual culture. Cultivar Poovan, the known wilt resistant clone, is now being found to be susceptible to wilt in certain areas. Occurrence of new race is suspected.

Occurrences of Black Sigatoka and Septo leaf spots have been recorded, isolated a pure-cultured for the first time in India. The are found to be more aggressive in many of t commercial cultivars, caused severe defoliati and loss of yield and quality. Propicanazole Hexacanazole @0.1% was found to be effecti in the control of Sigatoka and Septoria leaf sp diseases. Pitting disease caused by *Pyricula grisea* has been reported for the first time India.

IV. CROP PHYSIOLOGY AND BIOCHEMISTRY

Higher number of leaves and leaf area indu early flowering. The dehanding of the first to three hands did not have any effect on fi filling of the subsequent female flow indicating that fruit filling is not dependant photosynthates alone. The evaluation germplasm accessions of AB, BB, AAB and A genomes for growth parameters revealed t the 'B' genome contributes for more vigor growth, tolerance to drought and h temperature and starchiness to fruits, while genome offers quality traits like flavour taste.

V. POST HARVEST TECHNOLOGY

The post harvest loss of banana were 8-9 farmers level, 20-25% at wholesalers level 15% at retailers level. The process technology for jam, fruit bar, papad, bisc wine, alcohol, fig, health drink, baby food spiced pickle were developed using diffe banana varieties. Osmotic dehydra technique improved the quality and storage of banana fig.

75% matured Karpuravalli and Poo varieties showed higher shelf life of 12 days respectively under ambient condit Pre-harvest spray of K_2SO_4 0.5-1% and ur 2% in Poovan and GA 20-25ppm in Ney Poo variety applied between 30-60 days flowering significantly increased the b weight. Soilrite with $KMnO_4$ enhanced storage life of Karpuravalli banana upt days at 14°C. Sealed packaging of banana i gauge polyethylene packs stored at extended the storage life up to 30 da Poovan and 19 days in Karpuravalli f Propylene glycol 100ppm and citric 200ppm were effective in reducing the per value and acidic value in Nendran ba chips.

VI. TRANSFER OF TECHNOLOGY

On-farm advise, farmers meeting, lectures were given to popularise clean disease free planting material, identification of diseased suckers, improved production technologies for reducing cost of cultivation, improved protection technologies for control of new pests and diseases. In addition, training was imparted to the small farmers and women entrepreneurs in processing and value added products including fibres.

VII. HUMAN RESOURCE DEVELOPMENT

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

MANDATE

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

BUDGET

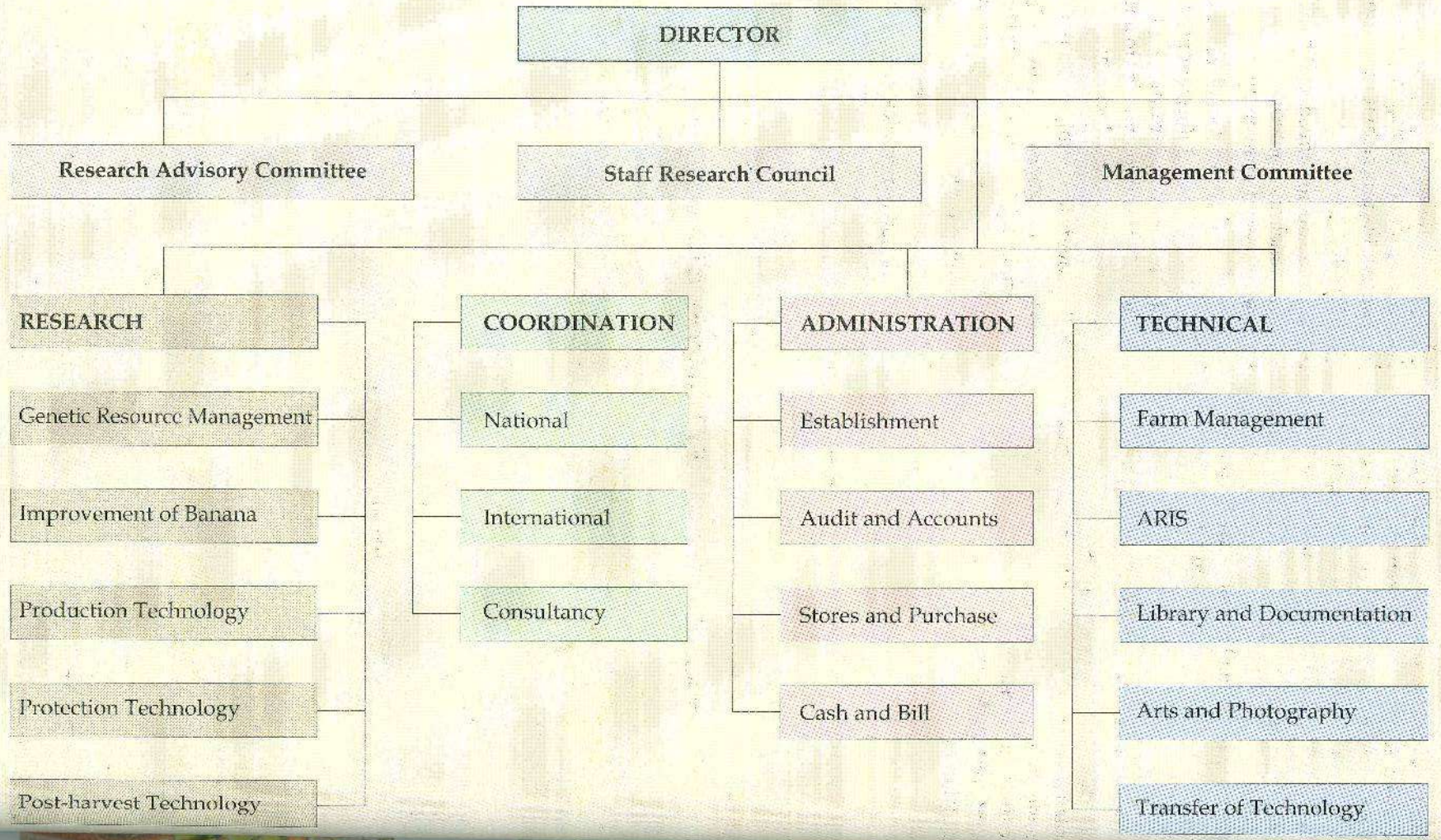
Budget and Expenditure for 2002-2003 (Rupees in lakhs)

Head of Account	Budget for 2002-2003		Expenditure 2002-2003	
	Plan	Non-Plan	Plan	Non-Plan
Estt. Charges	-Nil-	67.00	-----	65.27
Travelling expense	1.00	0.85	0.68	00.85
Other charges	88.00	18.90	87.12	12.52
Works	11.00	0.25	7.6	0.24
Total	100.00	87.00	95.40	78.88

MANPOWER

Grade	Sanctioned	In position	Vacant
Scientific	16	14	2
Technical	15	15	–
Administration	9	9	–
Supporting	7	7	–
Total	47	45	2

ORGANOGRAM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Research Advisory Committee
Staff Research Council
Management Committee
RESEARCH
Genetic Resource Management
Improvement of Banana
Production Technology
Protection Technology
Post-harvest Technology
COORDINATION
National
International
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ADMINISTRATION
Establishment
Audit and Accounts
Stores and Purchase
Cash and Bill
TECHNICAL
Farm Management
ARIS
Library and Documentation
Arts and Photography
Transfer of Technology

I. CROP IMPROVEMENT

1. Management of Genetic Resources of Banana

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

Exploration in Tamil Nadu, Andhra Pradesh, Orissa and N.E. states

Explorations were undertaken in southern and western parts of Tamil Nadu, Andhra Pradesh, Orissa and Maharashtra states and collected 88 wild and cultivated accessions. Andaman Islands and North Eastern states of India covering Assam and Arunachal Pradesh were also explored extensively during this period. (Table 1 and Fig. 2)

The southern and middle Andaman areas were covered and collected 23 wild accessions and cultivated types. In Assam, 4 accessions and in Arunachal Pradesh, 38 accessions of both wild and cultivated, were collected including 4 unique accessions namely, *Musa nagensium*, *M.itinerans* and *M.aurantiaca*. Three

Fig. 1 *Musa sp.* (Taxonomic status unknown)

M.aurantiaca

M.velutina (mutant/hybrid)

Variability for *Musa sp.*

unidentified accessions have been collected whose taxonomic status is yet to be ascertained (Fig. 1).

Two new natural intersectional diploids (*Musa* and *Rhodochlamys*) have been identified with intermediary traits of these two sections. A new natural mutant of *M.velutina* and an intermediary hybrid have also been identified which exhibit location specific distribution. Thirty seven exotic accessions have also been added to the germplasm from ITC, Belgium.

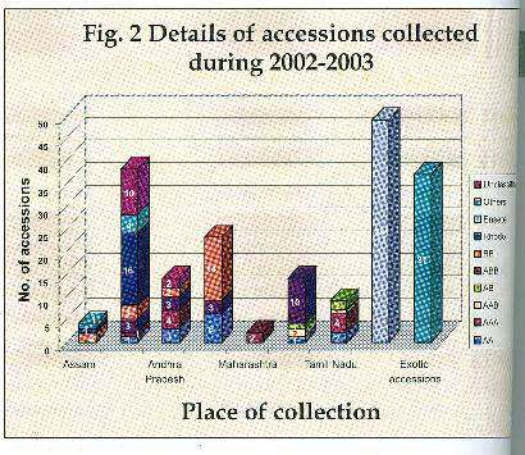


Fig. 2 Details of accessions collected during 2002-2003

Table 1. Accessions collected during 2002-03

Sl. No.	Place of Collection	Accessions
1.	Andaman Islands	*M. acuminata-1*, *M. acuminata-2*, *M. balbisiana* Mangutan-I, *M. balbisiana* New Wandoor, *M. balbisiana* Dhayakela, *M. balbisiana* Hasmathabad, *M.balbisiana* Ranchibasti, *M. balbisiana* Chouldhari-I, *M. balbisiana* Chouldhari-II, *M. Acuminata*, Chouldhari-I, Cheenakela Chouldhari, *M. acuminata* Mt. Harriat-I, *M. balbisiana* Mt. Harriat-I, *M. balbisiana* Mt. Harriat-II, *M. acuminata* Rutland-I, *M. balbisiana* Mangutan-II, *M. balbisiana* Mangutan-III, *M. balbisiana* Chouldhari camp site-I, Junglee cheena, *M. balbisiana* Sippighat, *M. acuminata*, Nicobari Kela, *M. balbisiana*
2.	Assam	Moutupuri kol, Bhimkol, *M. laterita*, Bhat Manohar
3.	Arunachal Pradesh	*M. velutina*, Khappi wild, Sessa wild-I, Sessa wild-II, *M. itinerans*, Tippy wild *balbisiana*, Rhodochlamys hybrid Durga temple, *M. acuminata*, *M. rosacea*, *M. balbisiana*, *M. aurantiaca*, Khuppi cultivar, Thella chakkarakeli, Green Monthan, Pamluk wild, *M. aurantiaca* ziro-II, Raga Monthan, *M. aurantiaca*, Khurmi, *M. aurantiaca*, *M. rosacea*, Adhi Kopak, Black Bhimkol, *M. velutina-I*, *M. velutina* hybrid-III, Pakte, Kodum wild, Dokpu, Kolu, Dokl Dokyo
4.	Andhra Pradesh	Sunkarametta wild-1, Sunkarametta wild-II, Sunkarametta wild-III, *M. balbisiana* wild-I, Thella Chakkarakeli, Pacha Arati Poyo, Uthiran, Srisailam collection, Kovvur Bontha, *M. balbisiana*, Siamala, Agniswar, Moutman
5.	Orissa	MR 01/020, RM 01/047, RM 01/048, RM 01/055, RM01/056, RM 01/ 076, RM 01/ 077, RM 04/ 048/DP-133, RM 01/048/DP-13 RM 03/ 084, KCM-01,KCM-02, KCM-03, *M. Ornata*
6.	Maharashtra	Cavendish (2 clones)
7.	Tamil Nadu	Kadali, Kondai Kadali, Chingan, Samba Kadali, *M. balbisiana* Dwarf Cavendish (3), Robusta

Sl. No.	States	Accessions
8.	NBPGR Regional Station, Hyderabad.	GS-09 to GS-34, GS-43 to GS-65
9.	Exotic collection	Njombe-N2, PC-12-05, PA-03-22, PV-03-44, SH-3436-9, SH-3436-6, Pisang Mas Ayer, Pisang Lilin, *M.ac.ssp.burmannicoides* (Calcutta-4), *M.ac.ssp.microcarpa* type Borneo, *M.acuminata.* ssp. *Zebrina*, TMB x 5295-1, Lep Chang Kut, Cachaco, *Musa peekeli* ssp. peekeli, *Musa maclayi* ssp. ailuluai, Pa (Mysore) no.3 x Pisang Cici Alas, *M.ac.ssp.banksii* x *M., schizocarpa*, Green Red *M.ac.ssp.Banksii* x *M. schizocarpa*, TMB x 1378 (BITA), SH-3640, CRBP 39, FHIA-02, Williams, TMB 3 x 15108-6, TMB 2 x 9128-3, Pisang Ceylan, 2390-2, FHIA-01, FHIA-03, FHIA-18(2), TMP 2 x 1297-3

Conservation

Germplasm collected during the exploration is being conserved at Gudalore, Tamil Nadu where similar environment exits and also at NRCB field genebank.

Characterisation

Morphotaxonomic characterisation

Hundred accessions were characterised morphotaxonomically adopting *Musa* descriptor and included in the NRCB genebank database. Genomic classification for 120 varieties has been completed.

Based on the morphotaxonomic characterization, 7 distinct groups were identified among the pure *balbisiana* clones.

Cluster	Accessions
Cluster 1	Borkal Baista , Bhimkol , Manguthamng
Cluster 2	Sasra Bale, Bhimkol 3, Athiakol 1, Bhimkol 2
Cluster 3	Elavazhai 2, Athiakol 2, Elavazhai 1, Athiakol 3
Cluster 4	Nendrapadathi, Manohar
Cluster 5	Bacharia Malbhog
Cluster 6	*Musa balbisiana*
Cluster 7	Attikol

Molecular Characterisation

Two hundred samples consisting of 16 wild *balbisiana*, 23 Pome and 25 Silk group accessions were subjected for RAPD marker analysis to study the genetic diversity and phylogenetic relationship.

Cluster Analysis using morphological traits

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

Standardization of primers for *Musa balbisiana* accessions

The selected diploid cultivars were tested with 80 random primers. Only 4 primers (OPA-11, OPB-04, OPC-04 & OPD-03) produced more than 5 polymorphic bands. Primer OPA-11 produced 5 monomorphic bands (580 bp bp, 1251 bp, 1419 bp and 1863 bp) a polymorphic bands(397 bp, 468 bp, 665 b bp, 792 bp, 890 bp, 943 bp, 1102 bp, 11 1658 bp and 2263 bp) (Fig.3).

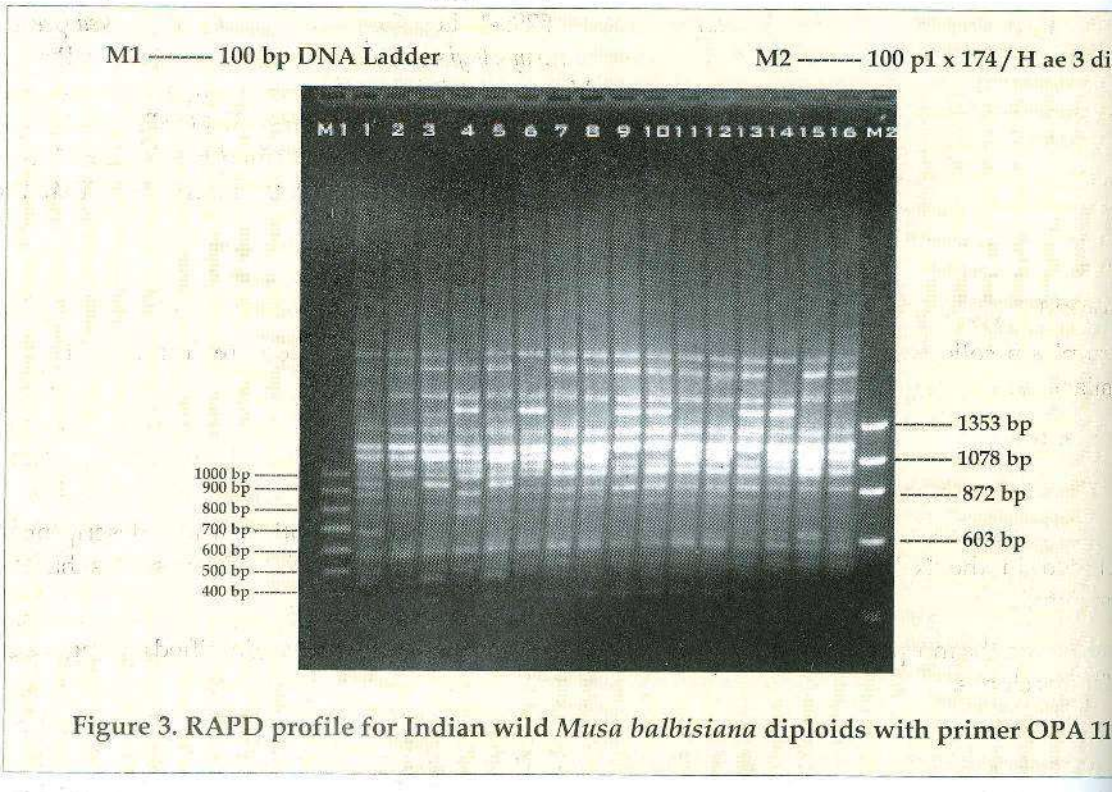


Figure 3. RAPD profile for Indian wild *Musa balbisiana* diploids with primer OPA 11

Primer OPB-04 produced 5 monomorphic bands (687 bp, 848 bp, 1325 bp, 1863 bp and 2863 bp) and 6 polymorphic bands. The OPD-03 primer generated one monomorphic band (483 bp) and 7 polymorphic bands. One monomorphic (883 bp) and 7 polymorphic bands were generated with OPC-04 primer (387 bp, 483 bp, 551 bp, 785 bp, 1008 bp, 1239 bp and 1713 bp).

RAPD Data Analysis

PCR bands from individual plants were scored as either present (1) or absent (O). Analysis of similarity matrix with the NTSYS program (Rohlf, 1990), using the unweighted pair-group method with arithmetic averages (UPGMA) to determine the values of genetic distance. Borkal Baista (BORB), Attikol (ATIK) and Bacharia Malbhog (BAMOL) were distinct. Nendrapadathi (NENP) and Manohar (MANO) expressed maximum similarity in morphotaxonomic characterization and a RAPD with OPA-11 and OPB-04 pri (Fig. 3a). But OPC-04 and OPD-03 fail concur results. The accession *Musa balbisi* distinct in morphotaxonomy but R analysis clustered it with two acces Bhimkol 2 (BIMK2) and Bhimkol 3 (BIMK3

Sasrabale (SASBL), Bhimkol 2 (BIMK2 Bhimkol 3 (BIMK3), Attikol (ATIK) was f to be synonymous based on morphotaxon characterization and RAPD analysis. Ath 2 (ATI2) and Athiakol 3 (ATI3), Elavaz (ELAV2) and Elavazhai 3 (ELAV3), were synonymous in RAPD analysis. Clusterin Athiakol (ATI) and Elavazhai (EL accessions showed different cluste pattern in different primers. The R characterization and morphotaxono characterization are similar in most of the but fail in some specific clusters.

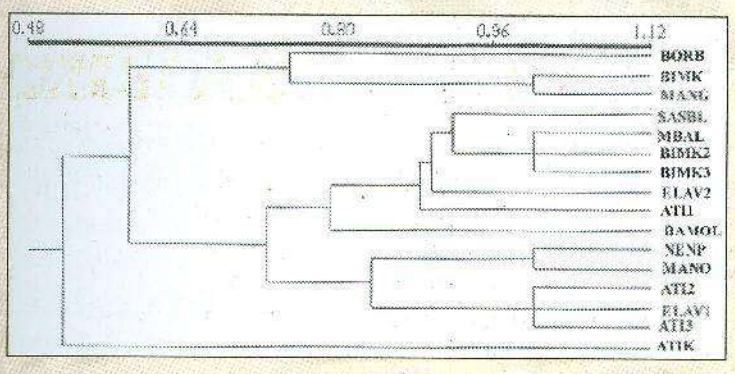


Figure 3a. UPGMA Dendeogram of genetic relationships among Indian wild *Musa balbisiana* diploids based on RAPD analysis

Standardisation of Primers for Pome and Silk groups accessions

Among 80 primers tested, OPA-11, OPB - 04, OPC - 04 and OPD - 03 expressed monomorphic and polymorphic bands in Silk and Pome group. The Silk group tested with OPA - 11primer produced all 9 monomorphic bands (437bp, 655 bp, 948 bp, 1171bp, 1257bp, 1637bp, 1851bp, 2286bp and 2541bp). OPB -04 primer generated 6 polymorphic bands (530bp, 573 bp, 671bp, 746 bp, 1087bp and 1319bp). Primer OPC - 04 generated 8 polymorphic bands (352bp, 424bp, 544bp, 628bp, 704bp, 805bp, 820bp and 3569bp) and 3 monomorphic bands (760bp, 948bp and 1058bp) while 4 polymorphic bands (413bp, 502bp, 661bp and1840bp) were generated with OPD - 03 primer (Fig. 4).

The Pome group accessions tested with OPA 11 produced 7 monomorphic (408bp, 504bp, 688bp, 985bp, 1231bp, 2022bp and 2896bp) and 4 polymorphic bands. With OPB - 04 3 monomorphic (368bp, 545bp and 743bp) and 6 polymorphic bands (368bp, 911bp, 987bp, 1045bp, 1213bp and 473bp) were generated. OPC - 04 primer produced 7 polymorphic bands (360, 413,454,531,824,842 and 1436bp). Three monomorphic bands (276,972 and 1132bp), 11 polymorphic bands (339bp, 401bp, 448bp, 493bp, 500bp, 669bp, 768bp, 1387bp, 1841bp, 2000bp and 2122bp) were generated with OPD - 03 primer.

Cluster analysis with RAPD markers in Silk group (AAB)

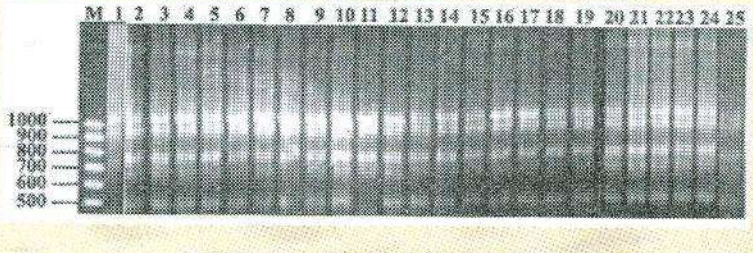
With primers OPB -04 and OPC -04, the clustering pattern obtained in Silk group is presented below:

Cluster members of Silk (AAB) group accessions with OPB - 04 primer

Groups	Members
Cluster 1	Saapkal, Sakkar Chayna, Malbhog, Dudhsagar, Rasthali, Hybrid Sawai, Sakkal Nagpur, Malbhog 2, Amrithapani 1, Honda, Digjowa, Nanjangud Rasbale
Cluster 2	Mutheli, Digjowa 2
Cluster 3	Soniyal, Malbhog 3, Nanjangud Rasbale 2, Pisang Raju Bulu, Madhuranga, Ayirankai Rasthali, Kozhikode, Sabri, Ambeli, Tera Kanchi, Amrithapani 2

Cluster members of Silk (AAB) group members with OPC - 04 primer

Groups	Members
Cluster 1	Saapkal, Sakkar Chayna, Malbhog, Dudhsagar, Rasthali, Hybrid Sawai, Sakkal, Nagpur, Malbhog 2, Amrithapani 1, Honda, Digjowa, Nanjangud Rasbale
Cluster 2	Mutheli
Cluster 3	Digjowa 2, Soniyal, Malbhog 3, Sabri, Madhuranga, Ayirankai Rasthali, Pisang Raju Bulu, Ambeli, Tere Kanchi, Amrithapani 2, Kozhikode, Nanjangud Rasbale 2



M1 -------- 100 bp DNA Ladder

Figure 4. RAPD profile for Silk group accessions with primer OPD 03

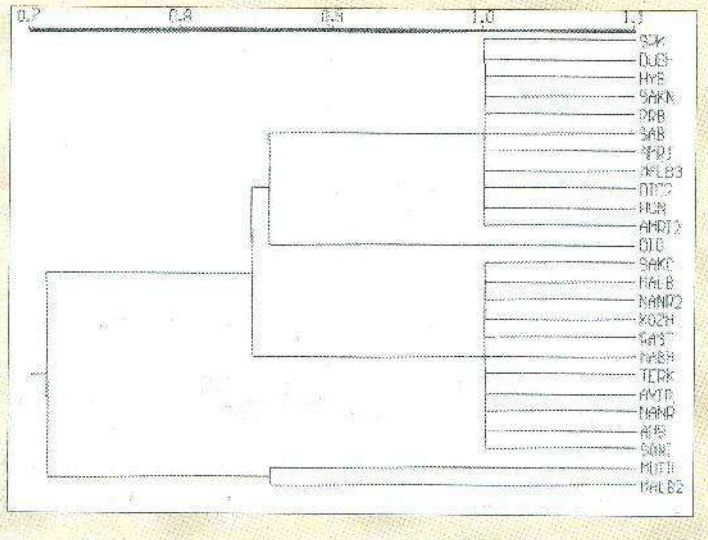


Figure 5. UPGMA Dandiogram of genetic relationships among Silk group accessions based on RAPD analysis

Evaluation

Evaluation of promising selections under multilocational trials

The performance of the three promising selections viz., NRCB Sel. 01, NRCB Sel. 02 (FHIA-01) and NRCB Sel. 03 (Saba) were tested at seven different locations viz., NRCB Podavur, Koppu, Salem, Gudalore, Yercaud, Kattuputhur of Tamil Nadu and Nagichera of North-Eastern region.

The performance of NRCB Sel. 01 was significantly different for growth and bunch parameters in all the seven locations tested. The no. of leaves at shooting, time taken for shooting and crop duration were non-significant (Table 2). Though the performance of NRCB Sel.01 was equally good in all the locations tested, the bunch weight was maximum in Koppu (36.53) followed by NRCB farm (36.08).

The performance of NRCB Sel. 02 (FHIA-01) was significantly different in all the locations for all the parameters studied which indicated that the performance of FHIA-01 is location specific. Though the crop duration was minimum at NRCB farm Podavur (350.68) while it was maximum at Yercaud (396.61). The highest yield (25.43 kgs) was obtained at Yercaud (Table 3). The performance of FHIA-01 was better at higher elevations as compared to lower elevations.

The performance of NRCB Sel. 03 (Saba) was significantly different in all the locations for all the parameters studied. The crop duration was maximum (394.69) at Gudalore and recorded the maximum bunch (29.50 kg) weight. Sel. 03 could be recommended for higher elevations equivalent to Gudalore conditions (Table 4).

Table 2. Multilocational performance of NRCB Sel. 01 (ABB)

Sl.No.	Characters	NRCB (TN)	Koppu (TN)	Salem (TN)	Gudalore (TN)	Yercaud (TN)	Kattuputhur (TN)	Nagichera (Tripura)	CD at 1%	CV
1.	Plant height (cm)	388.03	436.79	412.93	417.95	402.30	402.15	395.78	10.01	1.70
2.	Pseudostem girth(cm)	84.30	87.56	67.05	68.05	87.03	86.55	83.20	4.07	3.52
3.	Petiole length (cm)	79.95	76.98	64.90	66.65	79.80	80.30	67.08	4.30	4.05
4.	No. of leaves at shooting	16.53	17.05	16.38	16.45	16.60	16.63	16.65	NS	1.74
5.	No. of leaves at harvest	10.10	10.84	12.13	13.45	10.15	9.77	13.40	0.63	3.89
6.	Leaf area (sq cm)	12659.23	13237.95	11610.50	13324.90	13544.65	14947.40	13061.47	NS	5.76
7.	Time taken for shooting (days)	352.78	345.55	345.90	354.83	356.43	347.68	344.70	NS	2.10
8.	Time taken for bunch maturity (days)	125.55	123.23	117.00	118.38	127.47	123.53	118.78	NS	2.93
9.	Bunch weight (kg)	36.08	36.53	33.70	34.60	33.75	34.90	30.50	1.96	3.97
10.	No. of hands/bunch	17.05	16.97	15.45	16.63	16.95	16.30	16.90	NS	2.99
11.	No. of fingers/hand	16.40	16.55	15.83	16.30	15.15	15.53	16.92	NS	3.02
12.	Total no. of fingers per bunch	273.80	282.97	263.00	273.28	267.30	264.45	278.00	NS	3.92

Table 3. Multilocational performance of NRCB Sel. 02 (FHIA-01 AAAB)

Table 3. Multilocational performance of NRCB Sel. 02 (FHIA-01 AAAB)

Sl.No.	Characters	NRCB (TN)	Koppu (TN)	Salem (TN)	Gudalore (TN)	Yercaud (TN)	Kattuputhur (TN)	Nagichera (Tripura)	CD at 1%	CV
1.	Plant height (cm)	219.78	243.20	233.15	249.60	260.18	257.70	256.35	8.12	2.29
2.	Pseudostem girth (cm)	81.63	83.68	81.38	84.88	80.65	80.63	79.98	NS	3.05
3.	Petiole length (cm)	48.98	48.95	48.00	48.07	47.33	47.68	46.05	NS	2.30
4.	No. of leaves at shooting	15.13	15.95	16.32	16.22	16.13	16.45	15.75	NS	5.15
5.	No. of leaves at harvest	8.02	8.53	10.13	9.30	10.30	9.50	9.88	0.54	4.02
6.	Leaf area (sq cm)	10386.47	10942.35	9841.00	10707.05	10549.50	10135.00	10107.00	NS	2.89
7.	Time taken for shooting (days)	228.68	237.58	241.08	248.15	261.28	261.88	262.30	8.88	2.48
8.	Time taken for bunch maturity (days)	122.00	128.88	130.75	135.28	135.33	134.95	136.38	3.81	2.01
9.	Bunch weight (kg)	19.95	22.55	22.90	24.72	25.43	24.15	22.73	1.60	4.80
10.	No. of hands / bunch	10.60	11.08	10.38	10.13	10.05	9.63	9.38	0.47	3.23
11.	No. of fingers / hand	15.30	13.88	13.58	14.63	15.05	15.05	14.63	NS	4.12
12.	Total no. of fingers per bunch	161.97	151.85	137.75	149.13	149.88	146.65	146.35	NS	4.32
13.	Crop duration (days)	350.68	366.46	371.83	383.43	396.61	396.83	398.68	12.31	2.27

Table 4. Multilocational performance of NRCB Sel. 03 (Saba ABB)

Sl.No.	Characters	NRCB (TN)	Koppu (TN)	Salem (TN)	Gudalore (TN)	Yercaud (TN)	Kattuputhur (TN)	Nagichera (Tripura)	CD at 1%	CV
1.	Plant height (cm)	334.40	343.40	355.55	351.90	361.62	337.42	337.10	NS	2.22
2.	Pseudostem girth (cm)	84.50	83.32	80.65	81.02	79.65	85.20	83.30	NS	2.29
3.	Petiole length (cm)	65.25	61.82	65.12	69.15	69.47	69.40	69.12	NS	3.49
4.	No. of leaves at shooting	15.87	16.32	16.65	17.35	17.55	16.57	17.10	NS	2.97
5.	No. of leaves at harvest	7.67	7.37	8.57	10.82	11.40	9.60	10.70	0.70	5.19
6.	Leaf area (sq cm)	15641.73	15663.95	14694.35	14034.18	13607.73	13381.43	13784.75	NS	5.21
7.	Time taken for shooting (days)	263.12	265.00	269.82	284.27	286.00	251.15	261.32	10.07	2.60
8.	Time taken for bunch maturity (days)	103.85	105.62	107.22	110.42	111.42	104.87	110.15	NS	3.80
9.	Bunch weight (kg)	23.77	27.85	27.52	29.50	27.42	24.27	23.02	NS	8.12
10.	No. of hands / bunch	10.37	10.35	10.27	11.02	11.10	10.65	10.90	NS	3.46
11.	No. of fingers / hand	13.07	12.32	12.67	13.27	14.20	14.45	13.90	0.68	3.54
12.	Total no. of fingers per bunch	129.67	126.65	131.80	149.55	157.60	147.55	151.20	5.77	2.82

Identification of resistant donor to Banana weevils (B.Padmanaban)

(i) Screening of *Musa* germplasm against banana corm weevil.

Forty seven *Musa* germplasm accessions belonging to diploids (6 accessions), triploids (37) and tetraploids (4) were evaluated for preliminary screening against corm weevil. Under laboratory conditions, adopting leaf sheath evaluation technique found that, none of the accessions were immune to banana corm weevil. Feeding damage ranged from 6.69 to 13.85; 1.48 to 20.13 and 4.04 to 14.82 per cent for diploids, triploids and tetraploids respectively. BCW egg laying and development of eggs into grubs and mortality of weevils was noticed in susceptible accessions while no egg laying was noticed in resistant accessions.

(ii) Screening of *Musa* germplasm against banana stem weevil.

Fifty eight *Musa* germplasm accessions belonging to different genomic groups viz., AB (9), BB (8), AAB (2), ABB (36) and ABBB (3) were screened against banana stem weevil adopting leaf sheath technique under laboratory conditions. Feeding percentage was recorded to an extent of 18.25 to 34.94, 15.76 to 65.73 and 25.56 to 41.11 per cent among diploids, triploids and tetraploids respectively.

(iii) Screening of diploids against major nematodes (P.Sundraraju)

Eleven diploids were screened against major nematodes under field conditions as well as in pots under net house conditions. The results indicated that 10 diploids were found to be free from major nematodes viz., *R. similis* and *H. multicinctus* while for *P. coffeae*, Pisang, Mas, Pisang Berlin, *Musa ornata* and Cultivar Rose were free from incidence. Similar trend was observed in the case of *M. incognita* having infested with 5 diploid banana.

Germplasm Exchange

Fifteen wild and cultivated accessions collected from North-Eastern states under the INIBAP scheme have been deposited with NBPGR, New Delhi for *in-vitro* conservation and onward submission to ITC Belgium.

Two ITC accessions viz., FHIA-01 as suckers and ITC-1265 as cultures were supplied to Growmore Biotech Ltd., Hosur for mass multiplication.

2. Crop Improvement Through Conventional Breeding

(S.Sathiamoorthy, S.Uma and R.Natarajan)

Development of synthetic hybrids through conventional breeding

To develop synthetic diploid, ten diploid male parents with resistance to nematodes, Sigatoka leaf spot and *Fusarium* wilt, were planted in the field.

Exotic accessions	Indigenous accessions
Cultivar Rose	Anaikomban
Pisang Berlin	Kanaibansi
Pisang Lilin	Matti
Pisang Mas	Namarai
	Sannachenkadali
	Tongat

A total of 650 crosses have been made with different combinations among AA diploids. The hybridised bunches are yet to be harvested.

Seeds obtained by crossing *Rhodochlamys* (H5) with *Musa acuminata* (Pisang Jajee) and reciprocal were sown and the seedlings are being evaluated.

3. Crop Improvement Through Non-Conventional Approaches

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

Open pollinated fruits of Pisang Jajee (AA) and Athiakol (BB) were harvested at matured stage. The seeds were extracted and were stored in refrigerator. Initially the seeds were surface sterilised using sodium hypochlorite (5%) for 5 minutes followed by mercuric chloride (0.1%) for 2 minutes and sterile water rinsings in between. Seeds were split opened longitudinally to isolate the whitish mushroom shaped embryos. Embryos were then transferred to Colchicine solutions of different concentrations viz., 5mM, 7.5mM and 10mM and kept in Orbital shaker at 100 rpm for 12 hrs. Cultured on three different media viz., Murashige and Skoog (MS) (1962), Modified MS Medium (MMS) and Knudson C medium (1952).

In Pisang Jajee, hastened development was observed at 10mM concentration in MS and MMS and 5mM in Knudson C medium while others delayed development. But in case of Athiakol, Colchicine treatment suppressed the growth and development of embryos in all the three media tried.

Cell suspension culture

Various explants viz., callus, leaf explants from *in-vitro* propagated plants, young leaf whorls around meristems, scalps of activ multiplying shoot bud and male flower bud Matti, Sanna Chenkadali and Anaikomban (diploids) were tried to standardise a prot for development of cell suspensions in bana

Different concentrations of MS medi with different growth regulator concentrati have been used to establish banana suspension cultures

Table 5. Role of growth regulators on cell suspension culture.

Growth regulators (mg/l)	Time taken to establish cell suspension in Matti (days)		Time taken to establish cell suspension in Sanna Chenkadali (days)		Time taken to establis cell suspension in Anaikomban (days)	
	Callus cultures	Leaf explant	Callus cultures	Leaf explant	Callus cultures	Leaf expla
Picloram						
1.0	119.4	133.6	107.2	129.0	109.2	117.8
2.0	137.0	147.4	118.6	140.0	121.6	131.0
3.0	Nil	Nil	Nil	Nil	Nil	Nil
2,4-D						
1.0	102.8	121.6	96.8	112.8	88.0	99.2
2.0	121.0	139.6	107.2	128.2	97.8	113.6
3.0	Nil	Nil	Nil	Nil	Nil	Nil
2,4, 5-T						
1.0	107.6	121.6	101.4	120.8	101.0	106.8
2.0	129.0	134.8	111.8	133.6	110.6	120.4
3.0	Nil	Nil	Nil	Nil	Nil	Nil

Values represent the average of 5 experiments with 20 explants

Among the different concentrations of MS medium (full strength, half strength and ¼ strength), half strength MS medium was found suitable for cell suspension culture. The full strength MS medium killed the cells after inoculation. Among the different growth regulator concentrations, 2,4-D (1.0 mg/l) took lesser time for the establishment of cell suspension culture in both initiation materials (Table 5). Higher concentrations of all the three auxins were found harmful for the establishment of cell suspensions. Phe exudation hampered the establishment o suspension culture and it has been succes eliminated by frequent subculturing addition of ascorbic acid (10mg / l). Ad of Polyvinyl pyrolidone (PVP) had no eff controlling the exudation of phe compounds. The establishment o suspension from scalps of actively div buds and male flower buds are in progress

II. CROP PRODUCTION

1. Production Technology

1.1 Standardization of Technology for Organic Banana Production

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

In Rasthali and Karpuravalli bananas, among organic fertilization, application of 2.5kg compost + 1kg vermicompost + 1kg neem cake + 2.5kg poultry manure plant^{-1} at 3rd, 5th and 7th month after planting significantly increased the growth parameters during reproductive stage (Fig. 6). It also significantly increased the bunch weight, number of hands, total number of fingers, finger length and girth. However application of inorganic fertilizer significantly increased the plant height, girth, number of leaves and leaf area as compared to organic fertilizers.

Organically produced fruits recorded significantly better quality as compared to inorganic fertilizers applied fruits. Quality parameters like T.S.S, acidity, total sugars and starch were maximum in 2.5kg compost + 1kg vermicompost + 1kg neem cake + 2.5kg poultry manure plant^{-1} at 3rd, 5th and 7th month after planting followed by neem cake 2kg plant^{-1} in cultivars Rasthali and Karpuravalli respectively (Table 6).

Table 6. Effect of organic manures on fruit quality parameters of Rasthali and Karpuravalli banana

Treatments	Rasthali				Karpuravalli			
	Acidity (%)	T.S.S (°B)	Total sugars (%)	Starch (%)	Acidity (%)	T.S.S (°B)	Total sugars (%)	Starch (%)
T1	0.53	26.40	21.90	5.50	0.55	27.60	22.50	5.50
T2	0.55	26.80	22.20	5.40	0.54	27.20	22.27	5.70
T3	0.57	26.20	24.10	4.60	0.55	27.40	21.60	6.00
T4	0.53	26.80	22.20	5.20	0.55	27.73	22.50	5.23
T5	0.58	27.40	24.10	4.30	0.58	28.67	23.53	4.60
T6	0.57	27.20	23.80	4.80	0.57	28.20	23.13	4.90
T7	0.58	28.40	24.20	3.80	0.60	29.60	24.20	3.80
T8	0.59	29.40	25.33	3.20	0.61	32.20	26.30	3.40
T9 (inorg)	0.52	26.20	22.23	5.90	0.52	27.07	21.33	5.80
C.D (5%)	0.01	0.19	0.15	0.13	0.01	0.23	0.57	0.14

Fig. 6a Effect of organic manures on height and girth of Karpuravalli and Rasthali banana

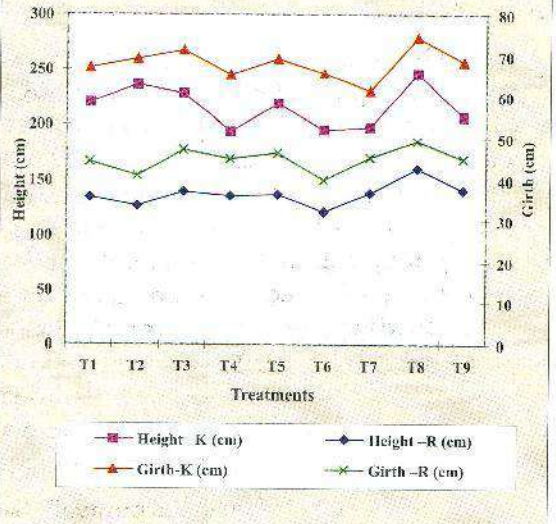


Fig. 6b Effect of organic manures on tot no. of leaves and leaf area of Karpurava and Rasthali banana

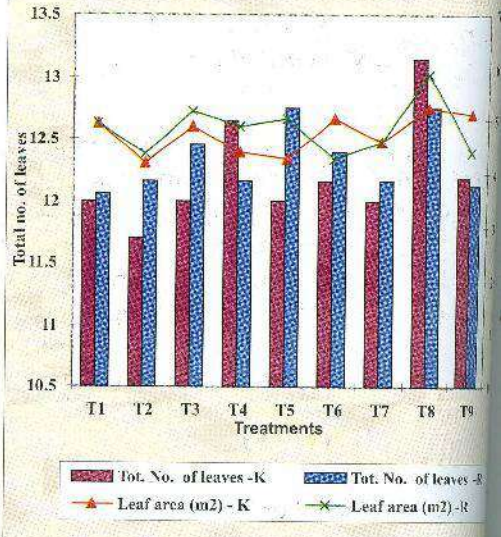


Fig. 6c Effect of organic manures on bunch weight and no. of hands in Karpuravalli and Rasthali banana

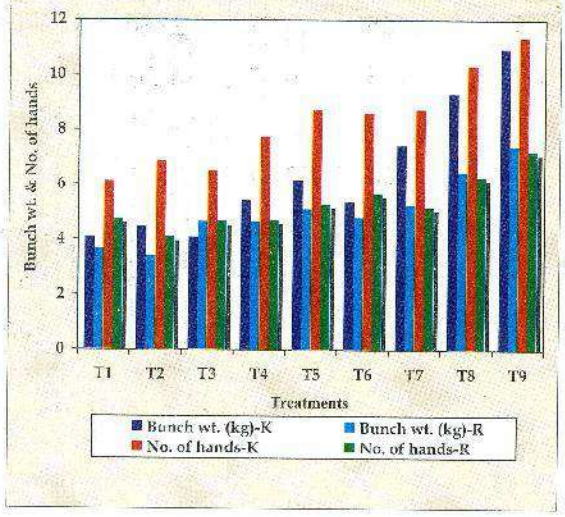
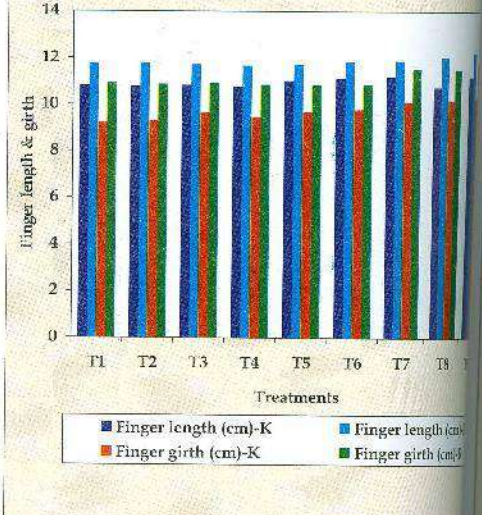


Fig. 6d Effect of organic manures on fing length and girth of Karpuravalli a Rasthali banana



Effect of organic farming on plant parasitic nematodes (P.Sundararaju)

Soil and root samples collected indicated the presence of four important nematode species viz., *Pratylenchus coffeae, Meloidogyne incognita, Helicotylenchus multicinctus* and *Heterodera oryzicola*. All the four nematodes were significantly lower in plants which received distillery sludge @ 2.5 kg + vermicompost @ 1 kg + neem cake @ 1 kg + poultry manure @ 2.5 kg at 3, 5, 7 MAP as compared to the control plants. The root-lesion and root-gall indices were higher in control plants registering 4.0 and 3.7 respectively.

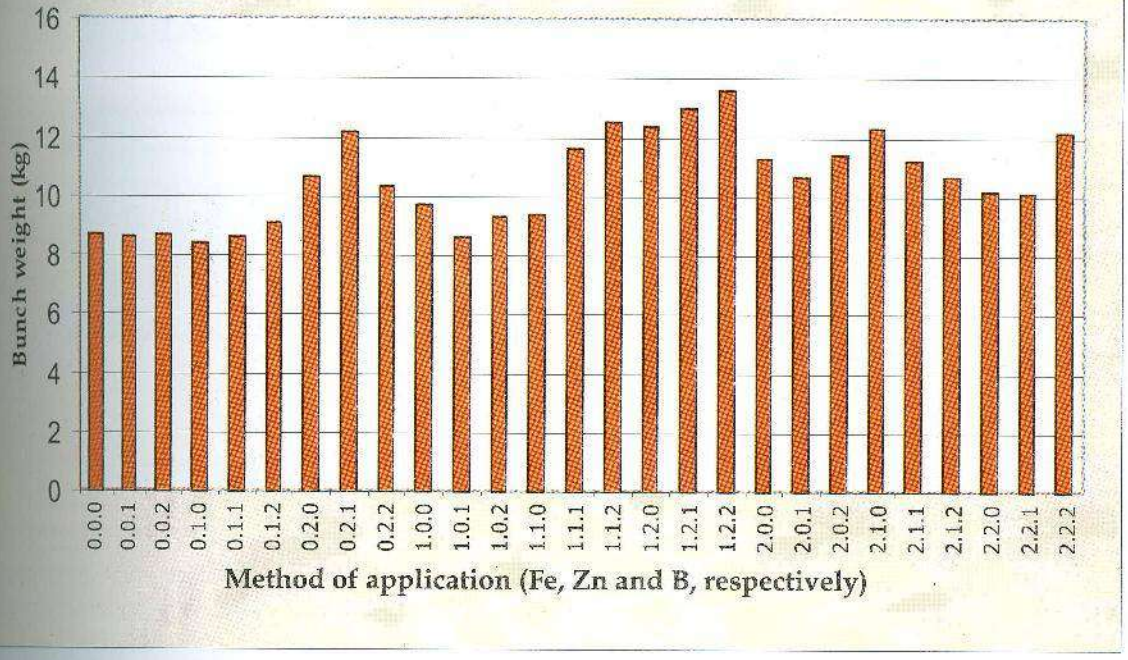
1.2. Studies on Micronutrients in Banana

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

Soil and foliar application of micronutrients in banana under high pH soil.

The effect of application of Fe on plant height, pseudostem girth, total number of leaves, number of fingers per bunch and number of hands per bunch banana was in the order of soil application (1) > foliar application (2) > control (0) (no micronutrients) in Karpuravalli. The effect of application of Zn and B on the above parameters of Karpuravalli banana was in the order of foliar application > soil application > control (no micronutrients). Soil application of Fe with foliar application of Zn and B recorded the highest bunch weight, which was 56 per cent more over control (without micronutrients) (Fig. 7).

Fig. 7. Effect of micronutrient application methods on bunch weight of Karpuravalli



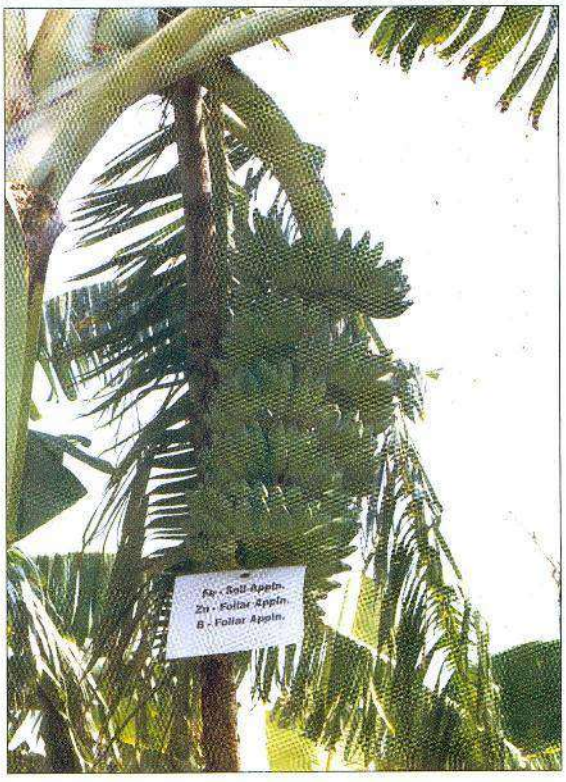


Fig. 7a Karpuravalli banana applied with micro-nutrients

1.3. Studies on Integrated Nutrient Management System i n Banan

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

Effect of cement kiln flue dust (CKFD) as amendment and source of potassium Karpuravalli (ratoon)

The highest bunch weight was observed at recommended K + 0.5 kg CKFD/ pl in Karpuravalli (Fig.7a). The CKFD 0.5 kg/plant recorded the highest followed by 0 kg and 1 kg CKFD/plant. titrable acidity decreased with increasing of CKFD. The PBC-K at 0 kg, 0.5 kg and CKFD/plant were 28.15, 29.00, and 3 cmol/kg.$(M/l)^{-0.5}$, respectively.

1.4. Standardization of Nutritional Requirements of Banana using Soluble Fertilizers

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

The experiment was laid out in two culti viz, Robusta (AAA) and NeyPoovan (AB) nine treatments and three replications. treatments were imposed initial gro observations were being recorded and experiment in progress.

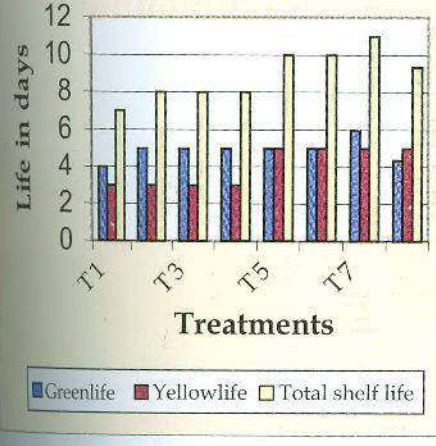
2. Postharvest Technology

2.1. Studies on Handling, Storage and Processing of Banana

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

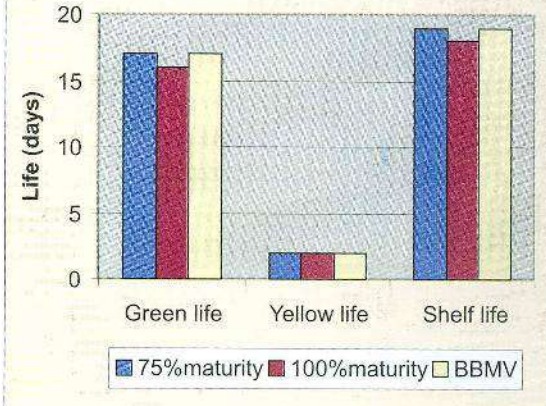
Ney Poovan fruits at full maturity were harvested and the effect of different post harvest treatments were studied at room temperature (RT) and Zero Energy Cool Chamber (ZECC). GA 100 ppm treated fruits stored at ZECC had the highest green life (6 days) and yellow life (5 days) (Fig.8). The PLW (%) was highest (35.41%) in RT control, while lowest in ZECC. Fruits stored in ZECC were more acidic than those stored at RT. The TSS and total sugars increased and were maximum at the end of storage. The starch decreased towards the end of shelf life. The control fruits had significantly higher levels of ascorbic acid through out the storage period. The organoleptic score showed that fruits packed in poly bags had higher quality than rest of the treatments in both RT and ZECC conditions.

Fig. 8. Effect of postharvest treatments and storage conditions on green life, yellow life and shelf life of Neypoovan banana



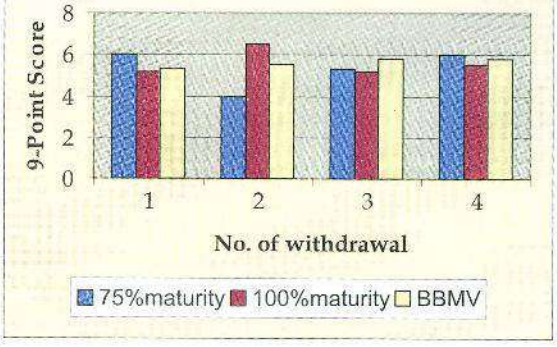
Three-forth, fully mature and BBMV affected Poovan bunches were harvested from farmers field in Thottiyam. The fruits were dehanded, dipped in 500 ppm Bavistin for 10 min, packed in CFB boxes with polyethylene lining and stored at 13.5°C and RT. The TSS and acidity were highest in 100% mature fruits (Fig. 9). The total sugars and TSS were more in BBMV affected fruits at harvest but its increase during storage was slow as compared to other treatments. The BBMV affected fruits had the highest TSS and starch contents. The acidity was the highest at 75% maturity and the lowest in BBMV affected fruits. As the period of storage at low temperature prolonged, the post cold storage life of the fruits at RT reduced. After 19 days of storage at 13.5°C, all the treatments exhibited chilling injury symptoms.

Fig. 9. Effect of maturity and BBMV infection on shelf life of Poovan banana



The effect of maturity and BBMV infection on quality changes of Poovan banana during storage at room temperature (RT) was studied. 75, 100% matured and BBMV affected fruits were stored at RT and the quality changes showed a different trend. The TSS, acidity and total sugars of BBMV affected fruits were higher than non-affected fruits of 75 or 100% maturity. The starch was the highest (25.2%) in BBMV affected fruits initially but it declined at the end of storage life while the decrease was maximum in BBMV infected fruits. The mean

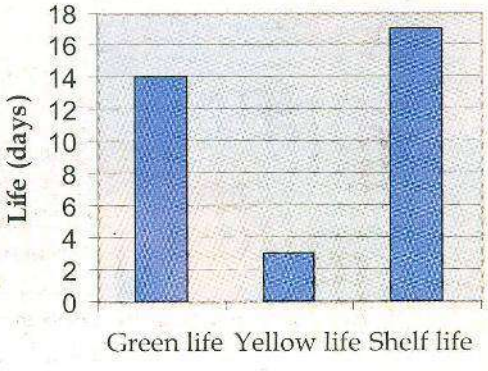
Fig. 10 Effect of Maturity and BBMV infection on overall acceptability of Poovan banana



values of organoleptic score for colour, flavour and texture were maximum in mature or BBMV affected fruits. The ripening behaviour indicated that the ripening was faster in 100% mature fruits followed by BBMV affected and 75% mature fruits (Fig. 10).

Tellachakrakeli banana were harvested at full maturity and the fruits were dipped in 500 ppm Bavistin and stored at 13.5°C. The results showed that the TSS, acidity, total su increased gradually and maximum cont were recorded at 10th day of storage. The st content decreased after 10 days of storag low temperature (Fig. 11). Fruits ripened a after 5 and 10 days of storage sho acceptable colour, flavour and texture. green life was 10 days at 13.5°C followed b yellow life of 3 days at RT.

Fig. 11. Effect of transportation on green life, yellow life and shelf life of Tellachakrakeli banana



A private entrepreneur exporte consignment of Poovan banana to UK f Thirukkattupalli. One sample of the same simultaneously stored at NRCB under conditions of storage viz. RT and 13.5°C observe their shelf life and quality changes. results showed that under RT, 5.67% of fr ripened within 9 days while 100% ripened in days while at 13.5°C, only 22.5% fruits ripen on 9th day and 32.3% fruits ripened on 13th d and 100% fruits ripened only on 18th day storage at low temperature. On 18th d chilling injury symptoms were noticed in fru stored at 13.5°C. Fruits had an yellow life o days under both conditions. There was significant variation in the organoleptic score fruits stored at RT or 13.5°C after ripening.

3. Crop Protection

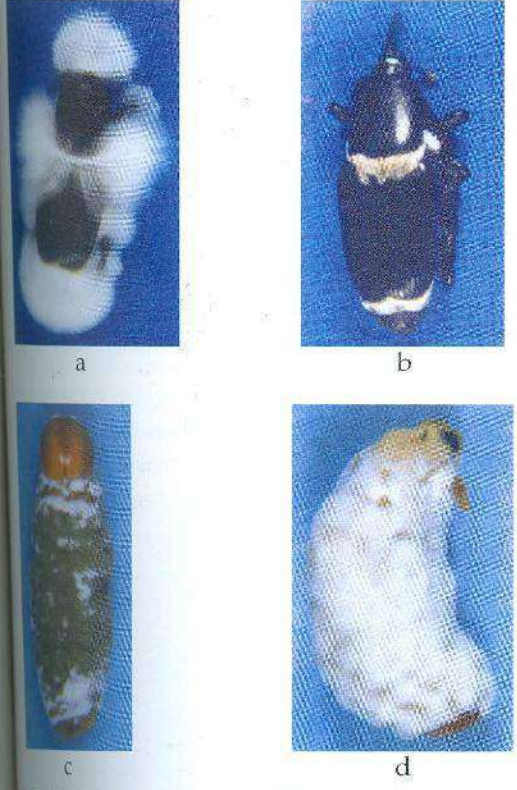
3.1. Insect Pest Management

(B.Padmanaban and P.Sundararaju)

Search for natural enemies and new insect pests of banana

Entomopathogenic fungi viz., white muscardine, *Beauveria bassiana* (Balsamo) Vuillemin (Std) (ITCC No. 5365.02), *Beauveria brongniartii* (Sacc.) Petch (ITCC No.5366.02) and green muscardine, *Metarhizium anisopliae* (Metschnikoff) Sorokin (ITCC No. 5328.02) were isolated from banana stem weevil, *Odoiporus longicollis* and the soil samples collected from endemic areas of Tamil Nadu and Karnataka (Fig. 12).

Banana fruit scarring moth, *Adoxophyes privatana* (Walker) (Tortricidae: Lepidoptera), a new pest of banana was identified from Tamil Nadu, India. This is commonly known as "Bell moth", infesting the cultivars such as Virupakshi (AAB) and Mysore (AAB). The larva feeds on the peel and affects the cosmetic value of fruit.



a b c d

Fig. 12. Banana stem weevil and grub infected with entomopathogenic fungi: (a) *B. brongniartii* (b) *B. bassiana* (c) *M. anisopliae* on grub (d) *B. bassiana* on grub

Chemical control methods for the management of banana weevils

Swabbing of Chlorpyrifos 0.06% over the pseudostem at fifth month after planting was effective against stem weevil. Sucker treatment with Monocrotophos prior to planting and soil application of Carbofuran 40g/plant at 5th month after planting was effective against corm weevil damage.

Evaluation of banana pseudostem trapping

A maximum of 6.0 and a minimum of 1.0 weevil/trap/week was recorded in the field. Trap catch was high during 3rd to 6th and 41st and 45th standard weeks. 95% of the weevils trapped were corm weevils.

Identification of suitable management method for Banana fruit scarring beetle

A survey was undertaken in the endemic areas of Nadia and 24-N Parganas districts of West Bengal for control of fruit scarring beetle, *Nodostoma subcostatum*. Banana fruit scarring beetles were collected to determine sex ratio and ratio of colour morphs. Volatiles of banana fruit scarring beetle, body washes and leaf washings were collected in organic solvents for GC-MS analysis.

Evaluation of plant products against *O. longicollis* under laboratory conditions.

Root extract of *Acoras calamus* (2%), leaves of *Vitex negundo* (2%) and nuts of *Terminalia chebula* (2%) caused 100% mortality of banana stem weevil in 24hrs, 96hrs and 96hrs respectively.

Evaluation of aggregation pheromone of banana corm weevil

Aggregation pheromone (Cosmolure) was studied under field conditions. Maximum population of 26 weevils/ two traps/week was recorded during 2nd standard week of 2002 and declined during 9th week (15 weevils/trap/week) and subsequently reduced to 2.5 weevils/trap/week during 52nd standard week. Four peaks were recorded during 2,7,31 and 36th standard weeks in Mahadevpura, Karnataka while a single major peak during 23rd standard week was observed in Sirumalai. Female weevil catch was higher than the males.

Entomopathogenic Nematodes
(B.Padmanaban and P.Sundararaju)

Among the eight isolates (Ad, Mrl, Mdr, In, Pr, Si, Na and Ks) evaluated against banana stem weevil, minimum (12.5%) and maximum (50%) morality was recorded on second day after inoculation (DAI). In Na, maximum mortality of 100% was attained on 6th DAI followed by Tm and In on 9th DAI. Mortality was recorded from 6th and 7th DAI in the treatments Pr and Si. The nematode isolates collected from weevil endemic areas revealed the presence of symbiotic bacteria.

TTP isolate was evaluated against adult and grub of BSW, under laboratory conditions @25-150 infective juveniles/grub or adult weevil. In the adult, mortality was recorded from 3rd, 4th and 5th day in the treatments with 125-150 IJ's and 25IJ's /weevil respectively, whereas, the grub mortality was recorded from 1st, 2nd, 3rd and 4th day in the treatments with 125-150, 100, 75 and 25-50 IJ's / grub respectively.

Entomopathogenic Fungi: Laboratory bioassay to assess the pathogenicity of entomopathogenic fungi to BSW

(B. Padmanaban and R. Thangavelu)

A laboratory bioassay was developed to measure the pathogenicity of fungi, *Beauveria bassiana, B. brongniartii* and *Metarhizium anisopliae* to stem weevil. The fungi assessed against grubs/adults were both conidial suspension and toxins at 25°C and 100% RH.

The white muscardine fungus, *B. bassiana* was more effective than the other two fungi *B. brongniartii* and *M. anisopliae*. In the crawling method, *B. bassiana* and *B. brongniartii* registered the maximum mortality of 73.3 to 76.6 per cent, whereas, only 46.6 per cent mortality was recorded on *M. anisopliae*. In the conidial suspension treatment, maximum mortality of 83.3 per cent was recorded in B. *brongniartii* followed by *Metarhizium anisopliae* and *B. bassiana*, 41.6 and 37.5 per cent respectively. In the toxin treated leaf sheaths *B. bassiana* and *M. anisopliae* registered mortality to an extent of 37.5 and 45.8 per cent respectively whereas, *B. brongniartii* indicated only 16.6 per cent mortality on 4th day after inoculation.

Laboratory Evaluation of EPF against Banana Corm Weevil

(B. Padmanaban and R. Thangavelu)

The isolated fungi such as *Beauveria bassiana, B. brongniartii* and *M. anisopliae* was evaluated adopting Crawling and insect dip methods. In the crawling method, *Beauveria bassiana* recorded maximum mortality of 62.0% whereas *B. brongniartii* upto 100% and *M. anisopliae* 30%.

Conidiospores and toxins of *Beauveria bassiana* and conidia of *M. anisopliae* were evaluated by dipping insect in the solution for 10 seconds. *Beauveria bassiana* (Condiopores) indicated mortality from day one, whereas, *Beauveria bassiana* (Toxin) indicated mortality from seventh day onwards.

3.2. Studies on Banana Nematodes and their Management

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

The penetration potential and development stages of root-lesion nematode, *Pratylenchus coffeae* in banana were studied in two susceptible cultivars viz., Nendran (AAB) and Poovan (AAB).

The percentage penetration of both *P. coffeae* and *M. incognita* was faster in cv. Nendran than in Poovan. The time taken by the root-lesion nematode for its penetration into the roots of banana was 48 hrs. in cv. Nendran while it was 72 hrs. in cv. Poovan. Root-knot nematode, took 48 hrs. for its effective penetration into the roots of Nendran (Fig. 13). The different developmental stages of nematodes were also observed in roots indicating faster growth and the multiplication of nematodes was more favoured in cv. Nendran than in Poovan.

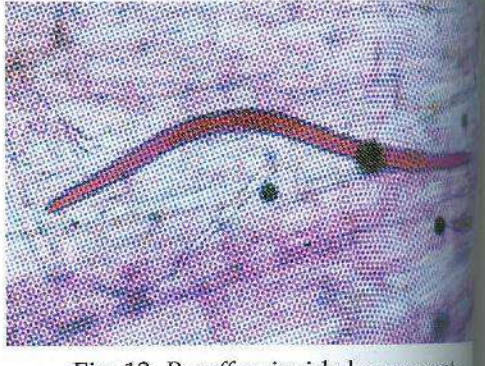


Fig. 13. *P. coffeae* inside banana root

Biochemical parameters like tannic acid (phenol), sugars, amylase, cellulose, protein and chlorophyll were analysed in 28 banana accessions. The activities were high in Gros Michel and low in FHIA 23 while the remaining were on par with each other.

A new nematicide, Cadusafos 10 G applied @ 5 g and 10 g in two applications resulted in significant reduction in the nematode population and increased plant growth followed by Carbofuran and Econeem. The cost benefit ratio was cheaper in Cadusafos 10 G as compared to Carbofuran 3G and other treatments.

Significant reduction in root-lesion nematode population with significantly increased yield was noticed in the Nendran banana field where *Tagetes* sp. was grown as an intercrop (Fig. 14) followed by Monocrotophos 0.05% dip treatment. Maximum nematode population was recorded in untreated control plants in a farmer's field.

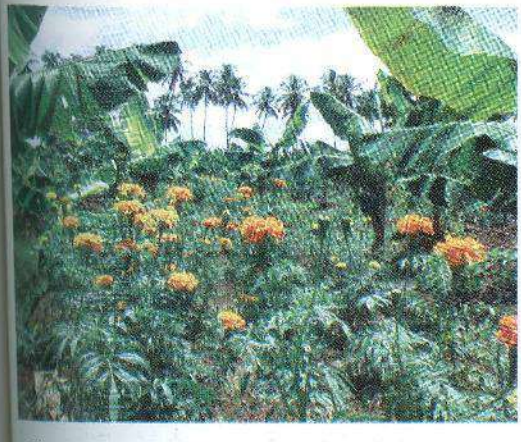


Fig. 14. *Tagetes* intercropped with banana

Management of banana nematodes by using bio-control agents in banana

- The endophytic fungus isolated from 12 accessions was identified as *Fusarium* spp. and its bioefficacy on *P. coffeae* and *M. incognita* was tested under *in-vitro* conditions. The nematicidal effects of endophytic fungi on *P. coffeae* and *M. incognita* juveniles increased with increasing exposure period to the culture filtrates.

- Different bio-control agents namely *Paecilomyces lilacinus*, *Verticillium lecanii*, *Pseudomonas fluorescens* and *Bacillus subtilis* were tested in Rasthali. They were very effective in reducing the nematode population and increased the plant growth as compared to Carbofuran and neem cake. Number of roots, root mass and healthy roots were maximum in all the bio-control agents tested plants. However *Pseudomonas fluorescens* was the best among all bio-control agents tested. Carbofuran treatment was on par with other bio-control agents but the use of bio-control agents were economical and ecofriendly as compared to chemical nematicides application.

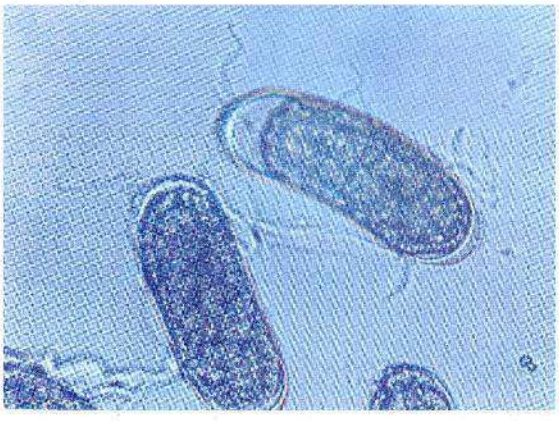


Fig. 15. *P.lilacinus* parasitized eggs of root-knot nematode

- Reported for the first time a natural nematode egg parasitic fungus, *Paecilomyces lilacinus* on root-knot nematode, *Meloidogyne incognita* infecting ornamented banana, *Ensete glaucam* (*Fig.* 15).

3.3. Studies on Fungal and Bacterial Diseases of Banana and their Management

(R.Thangavelu)

Studies on wilt disease of banana

Report of a new disease in banana

A new disease with wilt like symptoms was observed in Rasthali banana in a farmer's field at Thirukattupalli of Thanjavur district, Tamil Nadu. The symptoms observed were longitudinal splitting of pseudostem, yellowing of leaves and brown patches of rotting in the corm. The rolting of psudo stem sheath was observed due to the growth of fungus mycelium. The incidence of the disease was 30 per cent. The fungus was isolated and Koch's postulate has been proved under pot culture condition. The fungus was identified as

a member of the family Tricholamataceae of Basidiomycetes by DNA sequencing.

Screening of botanicals and antagonistic organisms against *Fusarium* pathogen under lab condition

Among 50 botanicals screened initially against FOC under *in-vitro* conditions. Three botanicals were found to be effective in inhibiting the mycelial growth of the fungus. Maximum per cent inhibition of mycelial growth (87.7%) over control was recorded by *Solanum* sp. at 50 % concentration.

Among different fungal (*Trichoderma* spp.) and bacterial (*Pseudomonas* spp. and *Bacillus* spp.) antagonists, the fungal antagonist *Trichoderma* isolate 2 recorded 60 per cent reduction in FOC growth over control.

Studies on the management of Sigatoka leaf spot diseases

Petroleum oil and plant extracts as foliar spray for the management of Sigatoka disease in Nendran (AAB) and Robusta (AAA) cultivars indicated spraying of oil alone and in combinations with half the dose of fungicides effectively reduced the Sigatoka leaf spot incidence at vegetative, shooting and harvest phases. The per cent reduction over control ranged from 55.93 to 96.86 per cent in cv. Nendran and 60.85 to 85.90 per cent in cv.Robusta. Generally good control of the disease and higher value of YLS-0 were achieved by mixing and spraying the Oil 5% with the half the dose of any one of the fungicides tested such as Propiconazole, Carbendazim, Carbendazim + Mancozeb.

Field experiments on the evaluation of bio-control agents and botanicals on the incidence of Sigatoka disease.

The effect of different bio-agents such as *Trichoderma viride*, *Pseudomonas fluorescens* and *Bacillus* sp. and botanicals such as *Solanum* sp, *Jatropha* sp. and *Emblica* sp. on the incidence of Sigatoka leaf spot disease in cv. Robusta was studied. The bio-agents (10^9 cfu or cells/ml) and botanicals extract (50% conc.) were sprayed 4 times at 6 months after planting at 25 days interval resulted significant reduction in disease severity as compared to control. Spraying with *Trichoderma viride* recorded maximum reduction in disease severity followed by *Pseudomonas fluorescens* and botanicals such as *Solanum* sp., *Emblica* sp. and *Jatropha* sp.

Isolation and screening of native antagonists against *Erwinia* spp. isolate under *in-vitro*.

The *Erwinia* spp. causing rhizome rot was isolated and its pathogenisity was proved under pot culture condition. In addition, the bacterial isolate was confirmed by Electron microscopy and bio chemical studies.

Rhizosphere soils from both infested and non-infested area were collected and by serial dilution, bacteria were isolated. By dual culture plate technique two effective bacterial antagonists were identified which restricted the development of *Erwinia* pathogen under *in-vitro* condition.

Evaluation of antagonists and botanicals against crown rot under *in- vivo* condition.

Botanical *Solanum* sp. and two strains of *Pseudomonas fluorescens* and *Trichoderma viride* were found effective against crown rot pathogen under *in-vitro* and *in-vivo* conditions.

Besides, first time cigar end rot disease was observed in Ney Poovan variety and the pathogens involved were isolated (Fig.16).

Fig. 16. Cigar end rot disease in Ney Poovan banana

3.4. Studies on Viral Diseases and their Management

(R. Selvarajan)

Survey

BBMV incidence in Trichy district was 21.8% and 24.6% in cultivars Nendran and Robusta respectively. There was a slight decrease in incidence as compared to previous year. BBMV incidences was observed in Sirumalai hills in Karpuravalli and Virupakshi. Secondary spread of BBTV was noticed in tissue culture banana plants supplied by Tamil Nadu Government under Hill banana rejuvenation scheme. Maximum 73 percent BBTV incidence was recorded in one of the villages in lower Palani hills. In Kolli hills, dual infection of BBTV and BSV in Poovan and Hill banana was noticed and was confirmed by PCR technique. Occurrence of banana streak has been recorded in few accessions maintained at Kovvur, AP and the incidence of BBMV in Amritpani banana in West Godhavari district has also been confirmed by RT-PCR.

Production of BBTV antiserum

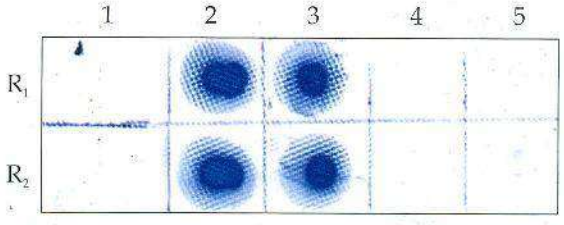
The virus was purified by differential centrifugation and density gradient centrifugation, resulting in partially purified preparation. The purified preparation was stored at -20°C in small volumes required for each injection and White hens were immunized with the virus. Test bleed was taken after a week from last injection and its titre was tested in ELISA and DIBA. The titre of the antiserum was 1:1000 in DAC-ELISA. The DIBA technique was found better than ELISA. The insoluble blue color was developed only in positive samples (Fig. 17).

Detection of BBTV isolates by PCR technique.

BBTV infected samples were collected and samples received from different states of India were used for detection. The primers designed for amplification of BBTV DNA component 3 were used to detect the virus from the samples. The primer set has amplified the viral genome component 3 in all the samples but not in healthy plants (Fig. 18).

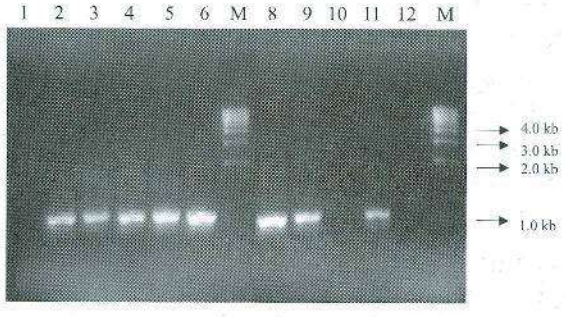
Detection of BBTV in aphid by PCR.

Banana aphids (*Pentalonia nigronervosa*) collected from healthy plants were transferred to infected plants and allowed to feed for three five hours. The total DNA was isolated from aphids after feeding. The cp gene primers were used to amplify the virus from the DNA isolated from the aphids. Amplicons was present only in inoculam fed aphids but not in aphids on healthy plants. The DNA isolated from the aphids was run in the agarose gel and two extra bands were detected only from the aphids which acquired the virus, but not in healthy aphids.



1. Buffer control 2. BBTV infected var.Kothia 3. BBTV infected var. Virupakshi 4. Healthy (Kothia) 5. Healthy (Virupakshi)

Fig. 17 Detection of BBTV by Dot Immuno Binding Assay (DIBA) using chicken antiserum



1: Healthy Robusta (TN) 2:Namarai (Kolli hills,TN); 3:Virupakshi (Sirumalai,TN); 4:Robusta (TN); 5:Monthan (Orissa); 6:Alpon(Bihar) 8: *Musa ornata* (TN); 9:Amritpani (Kovvur, AP); 10: Healthy,Grand Nain (Maharastra); 11:Infected, Grand Nain (Maharastra); 12:Healthy,Virupakshi; M:Markers 1 kb ladder

Fig. 18 Detection of BBTV component 3 in samples received from different parts of India

Dot blot technique for detection of BBTV

In order to develop non-radioactive probes for BBTV, the NA probe was synthesized using DIG-High prime labeling kit of Roche Diagnostics. Amplification of DNA 3 component of BBTV was done from the clones of an isolate. The probe was made only from the amplicons from the cloned product. For dot-blot technique, the DNA isolated from infected and healthy samples were immobilized onto positively charged nylon membrane using blotting apparatus. After immobilization the membranes were baked at 80°C for 2 hr. Membranes were pre-hybridized and hybridized as per standard protocol. After blocking and antiserum reactions the membranes were exposed to luminescent film

and developed. Only the infected samples were positive (Fig.19). This technique is more sensitive than PCR and DAC-ELISA.

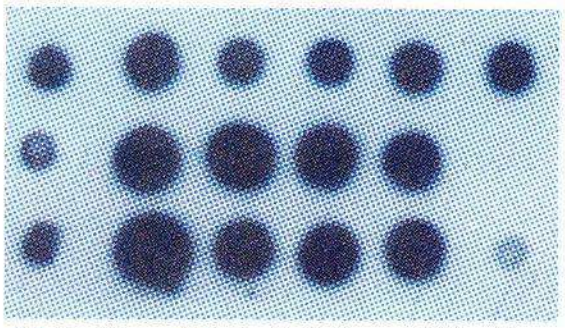


Fig. 19 Dot-blot technique for defection of BBTV

Detection of BSV by PCR

The banana streak virus was detected by PCR in varieties such as Poovan, Nendran, Monthan, and Karpooravalli. Among clones having B genomes tested, 5 were positive and three were negative. One tetraploid and a diploid were positive. Three clones had BSV integrants. Out of five hybrids tested, 4 were positive while symptomless FHIA-01 and Saba were negative.

Duplex PCR

Two DNA viruses viz., BBTV (single stranded DNA) and Banana Streak (double stranded DNA) virus belonging to Para retrovirus were detected by duplex PCR technique. For BSV, the primers have been designed to amplify 500 bp product and for BBTV, the primers were designed for DNA component 3 approximately 1 kb, with equal annealing temperature for the virus. Poovan infected with both the viruses was positive in duplex test.

Production of virus free plants through meristem tip culture

Meristems dissected from plants positive for BBMV in DIBA were used. The meristematic dome along with one or two-leaf primordia were dissected in Robusta and Nendran bananas and were transferred to tubes containing modified MS medium. The mortality of meristem was more and the experiment is in progress.

Isolation and characterization of endophytes conferring resistance against viruses

Plants having high vigor and no apparent viral symptoms were selected for isolation of endophytes. Fungal species such as *Fusarium* spp., *Aspergillus* spp and *Penicillium* spp were isolated as endophytes. The predominant endophytic fungus was *Fusarium* spp. Endophytic bacteria were isolated and pure cultured from internal corm tissues. It was identified as *Pseudomonas fluorescens* based on fluorescence emitting, oxidase, citrate utilization and catalase test. Antiserum was raised against bacterial endophytes in chicken. The antiserum detected the heat-killed cells and live cells of bacteria in ELISA and DIBA. The antiserum titre was 1:1000 in ELISA. The IgY was also isolated from egg yolks and purified by ammonium sulphate precipitation method and it gave positive reaction to *Pseudomonas fluorescens*. The presence of endophytes in different parts has been tested in ELISA. The effect of these endophytes is being tested against viruses.

Changes in Macro and Micronutrients in Virus Infected Banana Plants

(R. Selvarajan and K. J. Jeyabaskaran)

Bunchy top virus infected Virupakshi, bract mosaic infected cultivars viz., Nendran, Robusta, and Ney Poovan and banana streak badna virus infected Poovan were analysed along with healthy samples for macro and micronutrients. The sample was collected from the third leaf of 6-7 months old plants. There was two fold increase in K content in BBTV and BBMV infected Virupakshi, Nendran and Robusta respectively while an opposite trend was noticed in BBMV infected Ney Poovan cultivar. There was no significant difference for N and P in all the cultivars. Mg content was significantly lower in virus-infected plants. In respect to Ca, there was no difference but it was significantly less in BBMV affected cultivars while it was more in BSV affected Poovan. There were no changes in micronutrients such as Fe, Cu, Mn and Zn in virus-affected plants.

NATP Projects

Sustainable Management of Plant Biodiversity

(S.Uma and S.Sathiamoorthy))

A survey was conducted in Andhra Pradesh and Orissa states which resulted in the collection of 28 accessions namely *Rhodochlamys* section (1), *Musa balbisiana* wild (1), *Musa ornata* (1) and local cultivars of bispecific origin (25). From the NBPGR Regional station, Cuttack, collected 17 accessions.

From Andaman Islands, 23 accessions were collected covering the areas Jirkatang forest, Mangutan, New Wandoor, Hasmathabad, Ranchibasti, Chouldhari forest areas, Mount Harriat, Rut Island, Ogragunj, Sippighat and CARI. From western ghats of Karnataka, 7 accessions were collected. Characterization of 100 accessions under pre NATP and 50 accessions under post NATP have been completed.

So far, 209 accessions have been deposited with NFTCR at NBPGR, New Delhi for *in-vitro* conservation along with passport data.

Integrated New Production System for Bananas for Export and Domestic Needs"

(S.D.Pandey and S. Sathiamoorthy)

Under wetland system of cultivation modified high density planting with Robusta cultivar showed that planting 3 suckers/hill with 75% N and K fertigation (150:30:225g NPK/plant/year) (Fig. 20a) and paired row system with 100% N and K fertigation (200g N, 30g P and 300g K) recorded maximum plant growth. Flowering was 2 weeks earlier in paired row system (Fig. 20b) as compared to 3 suckers/hill (Table 7). Significant differences in bunch weight were observed among fertigation levels. 100% N and K fertigation recorded the highest bunch weight (18.60 kg) however the planting system has no influence. In 50% N and fertigation, bunch development and filling of fingers were poor.

Bunch covering resulted in uniform and attractive light green colour of fruits as compared to uncovered bunches (Fig. 20c). Blemishes were also less in covered bunches.

Observations on Sigatoka leaf spot incidence indicated that 3 suckers/hill recorded the least incidence while the maximum was in conventional planting system. However, nematode population was high in 3 suckers/hill followed by 2 suckers/hill and was the least in paired row system.

a) 3 Suckers / hill

c) Bunch covering

b) Paired Row System

d) Packaging for export

Fig. 20

Both density and fertigation levels had no influence on 'green life' and 'yellow life' of fruits. However, physiological loss in weight of fruits was lowest in 50% N and K fertigation under paired row system. The T.S.S. and total sugars were the highest in T5 treatment (100% N and K in 3 suckers/hill) at unripe and ripe stages. The overall organoleptic acceptability was best in lower fertigation levels within paired row system and 75% N and K fertigation level in 3 suckers/hill.

The paired row system of planting at a spacing of 1.2 x 1.2 x 2.0 m (5,200 plants/ha) with 100% N and K fertigation (200:30:300g NPK/plant/year) was highly economical with a high cost - benefit ratio of 2.02 followed by 3 suckers/hill with 75% N and K fertigation (1.74).

Table 7. Effect of density and fertigation on flowering, harvesting and bunch weight of Robusta banana

Fertigation \Density	Days to flowering			
	F_1	F_2	F_3	Mean
D_1	351.35	341.18	331.95	341.49
D_2	360.83	354.80	348.51	354.71
Mean	356.09	347.99	340.23	
CD	D : 2.26	F: 2.77		D x F: 3.92
Fertigation \Density	**Days to harvest**			
	F_1	F_2	F_3	Mean
D_1	102.11	100.41	96.52	99.68
D_2	104.05	104.85	101.65	103.52
Mean	103.08	102.63	99.08	
CD	D : 1.59	F : 1.95		D x F: 2.75
Fertigation\ Density	**Bunch weight**			
	F_1	F_2	F_3	Mean
D_1	11.97	15.74	18.60	15.44
D_2	14.36	16.49	17.06	15.97
Mean	13.16	16.11	17.83	
CD	D : NS	F : 0.32		D x F: 0.46

D 1 - Paired row System
D 2 - 3 Suckers / hill

F 1 - 50% N and K fertigation
F 2 - 75%
F 3 - 100%

Reduction in Post Harvest Losses of Fruits and Vegetables

(M.M.Mustaffa)

- In cultivars Nendran and Robusta, fruits with a portion of peduncle as cushion in polybag significantly increased the green life up to 13 days over other treatments. Vegetable oil (0.5%) treated fruits extend the shelf life by 13 days with highest peel chlorophyll, minimum physiological loss in weight (28.5%) with high pulp peel ratio (2.73).
- Under zero energy cool chamber conditions (ZECC), the green life was 15 days which was 25% more as compared to 12 days in control.
- Propiconazole 0.1% treated fruits under ZECC conditions recorded a green life of 10 days with 5 days as yellow life with a total shelf life of 15 days in Karpuravalli while in Rasthali, it was 9,3 and 12 days respectively.
- The shelf life of Putriscine 12 mM treated Rasthali fruits was 31 days as against control (19 days) under cold storage condition (13.5° C). The increase was 61% over control.
- Use of ethylene scrubbers using coir pith as carrier extended the shelf life of Rasthali banana by 22 days under ZECC storage as against 12 days without ethylene scrubber and the increase was 80% over control.
- Foam sheet packaging of bananas (1.5mm thickness) under ZECC conditions recorded

18 days and 15 days storage as against 13 and 11 days under control without any packaging in Rasthali and Karpuravalli bananas, respectively.

Robusta, Rasthali and Karpuravalli banana bunches packed with foam sheets recorded 1-5% mechanical damage during transport with a reduction in transport losses by 25% as compared to control. Banana hands packed in carton boxes showed less transport and impact losses (1-5%) as compared to control in Rasthali and Karpuravalli bananas.

The bio-control agents and anti-oxidants reduced the microbial losses due to anthracnose disease caused by *Colletotrichum musae*. The bio control agent *Trichoderma viride* (8%) extended the shelf life without spoilage up to 22 days as against 12 days in control. This technology could be useful for the export industry for the control of post harvest diseases and marketing of organic bananas.

Utilisation of Cement Kiln Flue Dust (CKFD) and Distillery Effluent (DE) as Potassium Source in Banana Production

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

In Ney Poovan, application of CKFD and DE with 60 per cent recommended K (as KCl) recorded the highest bunch weight (Fig. 21) which was 25 per cent higher than that of control. Application of CKFD + DE produced 35 % more yield with saving of 40 % K fertilizer and generated Rs. 31,450/ha as additional profit.

In Karpuravalli, application of DE with 80 % of recommended K as KCl increased bunch weight (33 % more) over control. Integration of CKFD and DE produced an additional profit of Rs. 27,500 to 31,750 per hectare.

A maximum PBC-K of 87.5 cmol kg-1.(M/l)-1 was observed in the treatment CKFD + DE with 100 % recommended K, at 11 MAP. Application of both CKFD and DE at the above rates in the soil maintained highest potential buffering capacities of soil for K (PBC-K), throughout the crop growth period as compared to CKFD alone, DE alone and control.

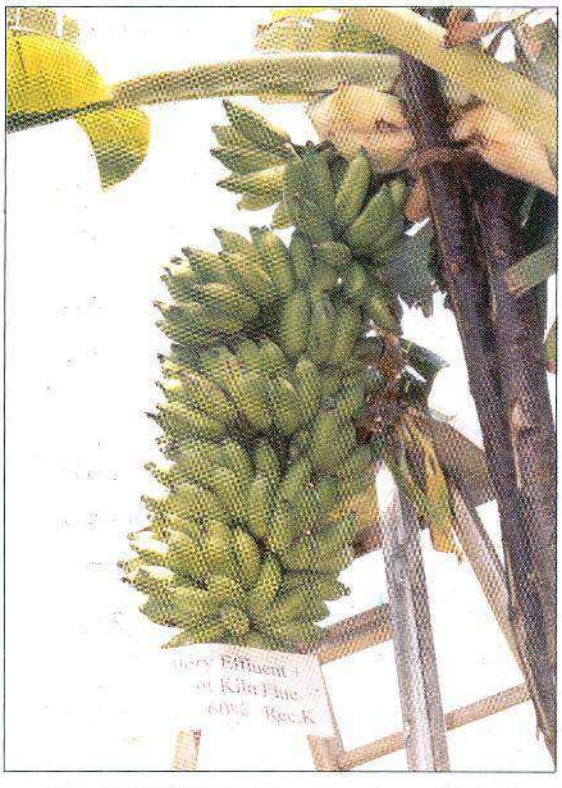


Fig. 21 CKFD + DE on bunch weight of NeyPoovan banana

"Standardization of Processes for Product Development, Value Addition and Waste Utilization in Banana And Plantains"

(C.K.Narayana and S.Sathiamoorthy)

a. Study on the change in physico-chemical composition of wine during its preparation and aging

Poovan and Robusta wine was prepared by inoculating the clarified, sterile juice with wine yeast and incubated at 24-26°C. The changes in its composition during primary fermentation and aging up to six months were studied. In Poovan wine TSS reduced from 24 to 10.8° Brix and in Robusta wine from 23 to 9.53° Brix in first 5 days of fermentation and there was not much reduction in the TSS in both wines subsequently. The acidity increased in Poovan and Robusta during primary fermentation. During aging it reduced initially and subsequently increased in Poovan, while in Robusta it decreased continuously upto six months of aging. The total sugars also reduced after 5 days of initial fermentation and further decreased till six months. The rate of

fermentation was faster in Robusta than Poovan. The alcohol content on 5th day of fermentation was 12.53% and 12.97% in Poovan and Robusta respectively. The organoleptic score for colour was better in Robusta wine after 6 months of storage. The clarity, taste and body showed a decline during storage up to six months.

b. Study on the physico - chemical composition of powder from different varieties of banana

Banana powder from seven commercial varieties were prepared as per the procedure developed and were analyzed for their physico-chemical composition including minerals and the results are presented.

Table 8. Chemical composition of banana powder

Variety	P/P Ratio	Moisture (%)	Acidity (%)	Total sugar (%)	Starch (%)	Ash (%)
Nendran	1.735	3.533	0.476	1.566	74.51	2.88
Rasthali	2.941	3.662	0.508	1.622	71.55	2.89
Pachanadan	1.262	3.789	0.853	2.571	73.33	2.87
Karpuravalli	1.857	2.839	0.466	4.176	73.37	2.29
Ney Poovan	2.181	4.469	0.779	2.899	70.60	2.28
Robusta	1.353	3.968	0.562	1.763	68.03	2.88

Table 9. Mineral composition of different varieties of banana powder

Variety	Minerals									
	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Na (%)	Fe ppm	Cu ppm	Mn ppm	Zn ppm
Nendran	0.30	0.09	1.3	0.4	0.24	0.30	182	5	22	267
Rasthali	0.31	0.10	1.4	0.8	0.48	0.20	248	Nil	16	260
Pachanadan	0.32	0.10	1.3	1.2	1.21	0.20	336	3	17	422
Karpuravalli	0.58	0.09	1.1	0.8	0.24	0.20	138	Nil	12	255
NeyPoovan	0.35	0.06	1.3	0.8	0.48	0.20	250	Nil	26	236
Robusta	0.35	0.10	1.7	0.4	0.24	0.20	263	Nil	14	289
Monthan	0.40	0.10	1.1	0.8	0.24	0.20	326	Nil	13	338

c. Study on the effect of dilution of clarified banana juice on quality changes of Karpuravalli nectar during storage

The clarified Karpuravalli banana juice was diluted with 70,60 and 50% water before making the nectar. The TSS, total sugars and acidity of nectar increased significantly with increase in the level of clarified juice content. The values of acidity increased, while total sugars decreased during storage up to 12 months. The pH was 4.17 in 30% juice and 4.41 in 50% juice level. The clarity of nectar was more in nectars with 30% juice level than 40 and 50%. The clarity decreased with increase in the storage period. The organoleptic evaluation showed that the colour, flavour, consistency and taste scores were better in 30% juice level than others.

Isolation and Identification of Pheromones of Banana Stem Weevil, Odoiporus Longicollis (Coleoptera : Curculionidae)

(J.S.Yadav, B. Padmanaban, A.R.Prasad, P.Sundararaju and B.Krishnakumari)

Isolated and identified the pheromone of banana stem weevil, *Odoiporus longicollis* as sex-pheromone. Gas Chromatography and Electro Antennogram Detector (GC-EAD) studies indicated that the pheromone comprises of few components. Dispensers were developed and the synthesized pheromone components were evaluated under field conditions using funnel traps. Results indicated that the weevils were attracted to the synthesized pheromone lure.

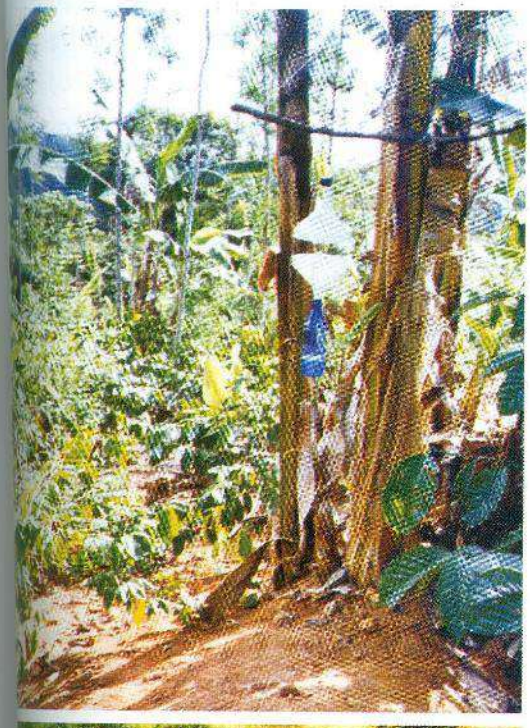


Fig. 22

Development of Diagnostic Kit for BBTV Infecting Bananas and Plantains in India

(T.Selvarajan)

PCR based detection of the BBTV for indexing banana plants has been developed. Oligonucleotide primers were designed based on published sequence of the open reading frame (ORF) of DNA 3, which encodes viral coat protein of approximately 20 kDa. A protocol has been standardized for detection of BBTV based on PCR. This technique was more precise, highly efficient than direct antigen coating ELISA. Fifty Hill banana samples collected from the farmer's field of lower Palani hills supplied by Tamil Nadu Government under Hill banana rejuvenation scheme were tested by this technique. None of the samples amplified the 526 bp PCR product which confirmed their freeness from BBTV.

I.C.A.R. Adhoc Projects

Physico - Chemical and Structural Characteristics of Banana Pseudostem Fibre

(S. Uma and V. Kumar)

The fibre yield was found to be higher (0.8303 and 0.4121 %) in machine extracted than by hand extraction (0.4537 and 0.3148 %) in commercial cultivars and wild *balbisiana* groups. Moreover, the hand extracted fibre was more brighter with better quality than machine extracted fibre.

Among the different bleaching agents tried ethylene diamine tetra acetic acid (EDTA), hydrogen peroxide, sodium carbonate and chlorinated lime, chlorinated lime at 0.75% produced better quality and lustrous fibres than other bleaching agents. The treatment was found better irrespective of the varieties tried.

The fibre yield, cellulose, lignin, moisture and brightness were analysed in different genomes under both machine and hand extraction methods.

Fibre yield	-	0.114 to 1.191%
Cellulose	-	47.82 to 67.64%
Lignin	-	8.00 to 14.00%
Moisture content	-	3.19 to 7.35%
Brightness	-	60.81 to 86.26%

"Pre and Postharvest Technologies for Export Quality Rasthali and Neypoovan Bananas"

(C.K.Narayana)

a. Effect of bunch covering on yield and yield parameters of NeyPoovan banana

Immediately after emergence of last hand, the bunches of NeyPoovan banana were

covered with 100 gauge polyethylene sleeves (1.25 m X 0.8 m) having 2%, 4% , 6% ventilation and control. The transluecent white coloured bunch covers with 6% ventilation was optimum for obtaining the highest yield. Finger parameters and harvest index were significantly higher in 6% ventilation as compared to other treatments.

b. Effect of bunch covering and post-harvest treatments on physiological and biochemical changes Ney Poovan banana during storage at 13.5°C

Fully matured (100 days after flowering) bunches of Ney Poovan banana covered with bunch sleeves were harvested and different post harvest treatments were imposed after dehanding. The results indicated that the PLW (%) was lowest in 6% vented polysleeves while control had the highest PLW (16.00%) after 21 day of storage. The pulp to peel ratio, moisture content, TSS, total sugars and acidity were lowest in 6%-vented polysleeves while the starch content was the highest. The colour score of the fruits in 6%-vented polysleeves were higher than other treatments during storage up to 35 days. The ripening (%) was lowest during storage in 6%-vented polysleeves. The green life was 35 days in all treatments except control while yellow life was highest (4 days) in 6% vented polysleeves. Control had lowest shelf life (22 days).

c. Effect of pre-harvest nutrient spray and post harvest treatments on physiological and biochemical changes of NeyPoovan banana during storage at 13.5° C

Pre-harvest nutrient sprayed bunches were harvested at 75% maturity (90 days from the date of flowering). After harvesting, bunches were dehanded, and different postharvest treatments were imposed as below.

The following were the treatment combinations:

1. Control (T1)
2. Control + Hot water + KMnO4
3. 1% K_2SO_4 - 6 weeks after flowering + Hot water + $KMnO_4$ (T2)
4. 1% K_2SO_4 - 10 weeks after flowering + Hot water + $KMnO_4$ (T3)
5. 2% K_2SO_4 - 6 weeks after flowering + Hot water + $KMnO_4$ (T4)
6. 2% K_2SO_4 - 10 weeks after flowering + Hot water + $KMnO_4$ (T5)
7. 1% Urea - 6 weeks after flowering + Hot water + $KMnO_4$ (T6)
8. 1% Urea - 10 weeks after flowering + Hot water + $KMnO_4$ (T7)
9. 2% Urea - 6 weeks after flowering + Hot water + $KMnO_4$ (T8)
10. 2% Urea - 10 weeks after flowering + Hot water + $KMnO_4$ (T9)
11. 1% Borax - 6 weeks after flowering + Hot water + $KMnO_4$ (T10)
12. 1% Borax - 10 weeks after flowering + Hot water + $KMnO_4$ (T11)
13. 2% Borax - 6 weeks after flowering + Hot water + $KMnO_4$ (T12)
14. 2% Borax - 10 weeks after flowering + Hot water + KMnO4 (T13)

The results showed that T3, T5, T6, T7, T8, T10 and T13 had 42 days of green life at 13.5°C. After shifting to RT the treatment T4, T11 & T13 had 3 days of yellow life while others had 1-2 days of yellow life. The total shelf life was the highest (45 days) in T13. On 42nd day the PLW, pulp to peel ratio, moisture, TSS, pH, total sugars and acidity the were lowest in T5 while starch was the highest. The organoleptic quality score showed that the quality was the best in T5 . Therefore, it was concluded that T5 treatment (2% K_2SO_4, 10 WAF) was the best treatment for obtaining better postharvest storage life and quality in NeyPoovan banana.

Developing Sigatoka Leaf Spot Resistant Bananas Through Polyploidy Breeding

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

Exploration was conducted in Tamil Nadu and Kerala and collected six diploid cultivars of AA and AB genome.

Source of explant for better callus induction was evaluated. Of the four explants tried for callus initiation, leaf scalps and male flower buds were found to be the best.

The growth regulator combination of BAP and Picloram was suitable for callus induction. The combination of BAP and Picloram produced friable callus.

Demonstration of *In-vitro* Propagation of Banana for Higher Productivity

(S.Uma and R.S.Selvarajan)

- Survey for high yielding virus free mother plants of commercial cultivars has been under taken in Tamil Nadu, Kerala and Karnataka.
- Mother plants with desirable traits were identified, virus indexed and brought to the NRCB field mother block.
- Protocols have been developed for mass multiplication of commercial varieties belonging to the group AAA and AAB.
- Plants of cv. Grand Naine have been multiplied and supplied to BRS, Kannara, Kerela for their performance.
- Trails have been carried out at NRCB Trichy and Banana Research Station, Kannara, Kerala for evaluating the performance of conventional suckers over virus indexed tissue culture planting materials of banana and results indicated the superior performance of virus indexed tissue cultured bananas over conventional suckers.
- *In-vitro* multiplied virus indexed plants have better yield potential.
- Use of healthy planting material prevents the spread of virus diseases.
- Reduces the disease spread into non-conventional areas of banana.

Table 10 Evaluation of indexed, conventional and virus affected Bananas cv. Karpuravalli

Trait	Virus indexed tissue culture	Conventional suckers	Virus affected plants	Statistical significance
Duration (days)	393.68	421.73	430.61	**
Yield (Kg)	45.26	26.31	21.47	**
No. of hands	11.23	11.62	9.87	**
No. of fingers/hand	14.73	13.68	12.92	**
Bunch height (cm)	123.6	80.63	72.75	**
Internodal spacing	10.83	6.75	5.66	**
Fruit length (cm)	14.36	10.23	9.18	**

Table 11. Evaluation of indexed, conventional and virus affected Bananas cv. Grand Naine

Trait	Virus indexed tissue culture	Conventional suckers	Virus affected plants	Statistical significance
Duration (days)	343.60	362.75	379.30	**
Yield (Kg)	38.20	22.20	18.60	**
No. of hands	12.32	9.24	7.68	**
No. of fingers/hand	16.12	14.42	14.14	**
Bunch height (cm)	66.20	49.35	40.20	**
Fruit length (cm)	21.68	17.54	16.01	**

Collection, Characterisation of Bananas and Plantains in North eastern India (INIBAP, France)

(S.Uma and R.Selvarajan)

- Totally 4 explorations were undertaken in North-Eastern states of India covering Assam, Arunachal Pradesh, Meghalaya, Tripura, Mizoram, Manipur and Nagaland.
- Totally 119 accessions have been collected both wild and cultivated including new species. During the course of establishment 29 accessions have been lost.
- Four new species were identified in India viz., *Musa rosacea, Musa sanguinea, Musa aurantiaca* and *Musa ornata.*
- *Ensete glaucum* dwarf (Sai Su) has been identified in India for the first time.
- NRCB has identified and reported for the first time the occurrence of a natural tetraploid (Bhat Manohar) of ABBB genomic status. This has been identified from the forest of Assam and Arunachal Pradesh.
- 54 accessions has been characterized for 117 traits morphologically and updated in database.
- 42 accessions have been evaluated for 6 important traits such as crop duration, pseudostem height and yield attributes like number of hands, number of fruits/hand, fruit weight(g). Evaluated against biotic, abiotic stresses and fertility status.
- Using Musa Germplasm Information System (MGIS), passport data for 875 accessions and complete characterization data for 290 accessions along with 55 photographs have been updated in the global database network.

62 accessions have been sent to NBPGR, New Delhi for *in-vitro* multiplication and onward submission to ITC, Belgium.

1. Technologies for various value added products from banana were transferred to 14 potential entrepreneurs through training.

Fig. 23

2. Detection of BBTV using polyclonal antiserum by DAC-ELISA technique has been developed. Multiplex or Duplex PCR for detection of dual infection and Dot blot assay using non-radioactive (NA) probes has been developed for detection of DNA viruses of banana.

Participation in Exhibition/Farmer's Meet

1. Farmer's Meet

Front line Demonstration was organized by NRCB in collaboration with Additional Director of Horticulture, Govt. of Tamil Nadu, on 2nd April 2002 at Karur. Dr.S.Sathiamoorthy, Director, NRCB participated and explained the various activities of NRCB to farmers (Fig. 24).

Fig. 24

2. 250 farmers from Karaikal sponsored by the Additional Directorate of Agriculture and National Horticulture Board for Technology Development, and Transfer for Promotion of Horticulture Government of Pondicherry visited NRCB on 18th July 2002 (Fig. 25).

Fig. 25

3. Dr.C.K.Narayana and Shri P.Ravichamy attended the conference organized at Indian Food Park and arranged an Exhibition on Value added banana products at Virudunagar on 29th December 2002.

4. Ms.M.S.Saraswathi, Shri. Ramajayam and Shri P.Ravichamy attended the conference organized at M.S.Swaminathan Research Foundation on the occasion of "National Fair on Women Scientists and Entrepreneurs and shaping India's Biofuture" held at Golden Jubilee Biotech Park, Chennai, during Jan.7 - 8, 2003 and arranged an exhibition depicting the technology related to Banana value

Fig. 26 Dr. M.S. Swaminathan, Chairman MSSRF, Chennai, visits NRCB Stall

added products. Around 600 farm women/entrepreneurs visited the exhibition stall. Dr. M.S. Swaminathan, Chairman MSSRF, inaugurated the exhibition.

5. Participated and exhibited Banana value added products at Anbil Dharmalingam Agricultural College & Research Institute, Trichy on 29th January 2003.
6. Dr. B.Padmanaban and Mr.P.Ravichamy arranged an exhibition for the 'Science Expo 2003' on 31st January and 1st February 2003 at Srimad Andavan College of Arts and Science, Srirangam, Trichy.
7. Participated in 'Agri Meet 2003' organised by Confederation of Indian Industries on 7th and 8th Feb. 2003. Shri.Jeevanandam, Hon. Minister for Agriculture, Government of Tamil Nadu visited our stall during the occasion (Fig. 27).

Fig. 27

5 EDUCATIONS AND TRAINING

The Scientists of the Centre were involved in guiding the P.G students for their project work and also in guiding M.Phil students from various colleges of Bharathidasan University, Tiruchirapalli.

Sl.No	Project Guide	Name of the Student	College / Institute
1	Dr.M.M.Mustffa Principal Scientist	Mr. Mohamed Khalid (M.Sc. Bio-Chem.)	Thanthai Hans Rover College, Perambalur.
		Mr.Subramanian (M.Sc. Micro- Bio.)	Thanthai Hans Rover College, Perambalur.
2	Dr.P.Sundararaju Senior Scientist	Ms. C.Sangeetha (M.Sc. Bio-Chem)	Srimad Andavan Arts & Science College, Trichy.
		Ms.C.Sheeba (M.Sc. Micro- Bio.)	Cauvery College, Trichy.
		Ms.T.Sasikala (M.Sc. Micro-Bio.)	Cauvery College, Trichy.
3	Dr.B.Padmanaban Senior Scientist	Ms. K. Komala (M.Sc. Micro-Bio.)	Cauvery College Trichy.
4	Dr.C.K.Narayana Senior Scientist	Mr.K.Gopinath (M.Sc. Bio-Chem)	Thanthai Hans Rover College,Perambalur.
		Mr. A.Asaithambi (M.Sc. Bio-Chem)	Thanthai Hans Rover College,Perambalur.
5	Dr.S.Uma Senior Scientist	Mr. S.Siva Arumugam (M.Sc. Bio-Tech)	Srimad Andavan Arts& Science College, Trichy.
		Mr. Ramesh Kumar (M.Sc. Bio-Tech)	Srimad Andavan Arts & Science College, Trichy.
		Ms. S.Sudha (M.Sc. Bio-Tech)	JJ College of Arts & Science Pudukottai.
6	Dr. R. Thangavelu Scientist (SS)	Ms. P.Sudha (M.Sc. Bio-Chem)	Srimad Andavan Arts & Science College, Trichy.
		Ms. B.Subashini (M.Sc. Micro- Bio.)	Cauvery College, Trichy.
		Ms.B.Sangeetha (M.Sc. Micro- Bio.)	Cauvery College, Trichy.

Sl.No	Project Guide	Name of the Student	College / Institute
7	Dr.R.Selvarajan Scientist (SS)	Ms. Arthi H.Naidu (M.Sc. Bio-Chem)	Srimad Andavan Arts & Science College, Trichy.
		Ms.K.Kiruthiga (M.Sc. Bio-Chem)	Srimad Andavan Arts & Science College, Trichy.
		Ms. P. Vadivukkarasi (M.Sc. Micro- Bio.)	Cauvery College, Trichy.
		Ms.A.Juliet (M.Sc. Micro- Bio.)	Cauvery College, Trichy.
8	Dr.K.J.Jeyabaskaran Scientist (SS)	Ms.S.Chandra (M.Phil-Computer Science)	Srimathi Indira Gandhi College, Trichy.
		Ms.E.Kanimozhi (M.Phil-Computer Science)	Srimathi Indira Gandhi College, Trichy.

AWARDS AND RECOGNITION

1. **"AIPUB Fellow"** was conferred on Dr.S.Sathiamoorthy, Director, NRCB, Trichy for his lifetime contributions to banana research and development in India. Sponsored by Association for the Improvement in Production and utilization of Banana (AIPUB) at Global Conference on Banana held at Bangalore during 28-31, October, 2002.

Fig. 28

Dr. S. Sathiamoorthy, Director, NRC for Banana, receiving the 'AIPUB Fellow' Award from Shri. M. Shivanna Hon. Minister for Horticulture, Govt. of Karnataka.

2. Dr.S.Uma was awarded **"KADALI PURASHKAR AWARD"** for outstanding contribution to Banana Research and Development in India by Association for the Improvement in Production and Utilisation of Banana (AIPUB) at Global Conference on Banana held at Bangalore during 28-31, October, 2002.

Fig. 29

Dr. S. Uma, Senior Scientist, receiving KADALI PURASKAR Award from Shri. Ajit Singh, Hon. Union Minister for Agriculture, Govt. of India.

3. Best Poster Award for the poster entitled Characterization and ploidy analysis of indigenous wild *Musa* accessions and promising hybrids using flow cytometry, authored by Uma,S., S.Sathiamoorthy, N. Roux, R.Selvarajan, P.Durai, M.S.Saraswathi and M Manickavasagam at Global conference on Banana and Plantain, 28-31 Oct 2002, held at Bangalore, India.

LINKAGES AND COLLABORATION IN INDIA AND ABROAD

- NRCB is collaborating with INIBAP in *Musa* Germplasm Information System (MGIS) to build up a Global Database Net work. Passport data for 875 accessions and complete characterisation data for 290 accessions and photographs for 55 accessions have been updated for global database network.

- Collaboration with NBPGR, New Delhi and NRC on Plant Biotechnology for banana germplasm conservation, biotechnology and molecular characterisation in banana.

NRCB is collaborating with Banana and Plantain Network (BAPNET) for the South Asia and South East Asian countries. NRCB participated in the meeting at Philippines for formulating the network activity of the BAPNET in India.

RESEARCH PUBLICATIONS

a) Papers published in Journals

Narayana, C.K., S.Shivashankar, M.M.Mustaffa and S.Sathiamoorthy. 2002. Studies on suitability of varieties of banana and frying medium for production of chips. Beverage and Food World. Vol.29 (6): 29-30.

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9 LIST OF APPROVED ON-GOING PROJECTS

1. Crop Improvement

Management of genetic resources of banana (S.Uma)

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

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

2. Crop Production and Post harvest technology

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

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

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

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

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

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

3. Crop Protection

Insect pest management in banana (B.Padmanaban)

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

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

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

10 CONSULTANCY, PATENTS, COMMERCIALIZATION OF TECHNOLOGY

The technologies for production of Banana fruit and flower pickle and Banana fig were commercialized.

Consultancy on bio efficacy testing of Mancozeb flowable against Sigatoka leaf spot diseases has been continued for second year. The project will be completed by 31st May 2003.

International

Dr.S.Uma, Senior Scientist and Dr. R. Selvarajan, Scientist SS have been nominated by FAO, Rome as national consultants for Tissue culture and virology respectively for the ongoing "FAO/TCP Project on Improvement of Banana Production for Small Scale Growers".

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

Fifth Research Advisory Committee Meeting

The Fifth Research Advisory Committee (RAC) meeting was held at the NRCB Conference Hall on 23.4.2002. Dr.D.S.Rathore, ADH (Hort) Chairman, chaired the session and conducted the proceedings. Dr. S.Sathiamoorthy Director, NRCB welcomed the Chairman and RAC members and briefed the research achievements of NRCB. Subsequently, RAC members discussed with the concerned Scientists. Dr. P. Sundararaju, Member Secretary, RAC presented the Action Taken Report of the last RAC proceedings. After detailed discussions on going projects, the RAC members suggested the future programmes to be taken up in various areas of research in banana. The RAC Chairman in his concluding remarks appreciated the Director and the team of Scientists of NRCB for effectively conducting the research programs.

Dr.D.S.Rathore - Chairman
Asst. Director General (Hort),
Indian Council of Agrl.Research
Krishi Bhawan, New Delhi

Dr.S.K.Gupta - Member
Prof. of Soil Science&
Agril. Chemistry
Calcutta University, Kolkata.

Dr.S.K.Roy - Member
Emeritus Prof. (Hort)
Indian Agricultural
Research Institute, New Delhi.

Dr. N.K.Mohan - Member
Chief Scientist-HRS
Assam Agricultural University
Guwahati.

Dr.S.Sathiamoorthy - Member
Director
NRC for Banana, Trichy.

Dr.P.Sundararaju, - Member Secretary
Senior Scientist,
NRC for Banana, Trichy.

Fig. 30

STAFF RESEARCH COMMITTEE MEETING

The Seventh Annual Staff Research Council of NRCB was held on 27 and 28, November 2002 under the Chairmanship of Director, NRCB. The progress of the various ongoing projects and technical programme was discussed. All scientists attended the meeting. There were four technical sessions and the research progress of on going research projects was presented by the respective project leaders. The work done under 14 external aided projects were also presented by the Principal Investigators and reviewed the physical and research accomplishments.

Fig. 31

Quinquennial Review Team

Indian Council of Agricultural Research, New Delhi constituted the Quinquennial Review Team (QRT), consisting of the following members:

1. Dr. B. S. Chundawat - Chairman
   Vice-Chancellor (Rtd.),
   Gujarat Agrl. University,
   Anand, Gujarat.
2. Dr. H.C. Dass - Member
   Director (Rtd.),
   National Research Centre
   for Citrus, Nagpur.
3. Dr. P. Das - Member
   National Professor,
   Bhubaneshwar, Orissa.
4. Dr. Jeyarajan - Member
   Prof & Head (Rtd.),
   Dept. of Plant Pathology
   TNAU, Coimbatore.
5. Dr. T.Thangaraj - Member
   Dean,
   HC&RI, TNAU,
   Periyakulam.
6. Dr. M.M.Mustaffa - Member Secretary
   Principal Scientist,
   NRCB, Trichy.

The QRT chairman and members visited the National Research Centre for Banana, Trichy during 23.6.2002 to 27.6.2002 and 20 to 22nd December, 2002 and reviewed the progress of work during the period 1994 to 2002.

NATP Review meeting

NATP Review meeting of Coastal Agro Eco system by PI / Director on 12.9.2002 at NRCB , Trichy. The CCPI of the cooperating Centre progress was reviewed by the Director, NRCB, Trichy who is the Principal Investigator of the project.

Dr.N.Kumar	TNAU, Coimbatore
Dr.P.K.Valsalakumari	KAU, Trissur
Shri.D.Madava Rao	ARS, Kovvur
Shri.S.S.Deshmukh	BRS, Jalgoan (Maharashtra)

Fig. 32 QRT Team Field Visit

PARTICIPATION IN SEMINARS / SYMPOSIA / CONFERENCE / WORKSHOP ETC.

Name of Scientist	Name of Seminar / Symposia / Conference/Workshop	Period
Sathiamoorthy, S., Mustaffa.M.M., Sundararaju,P., Padmanaban,B., Pandey, S.D, Narayana,C.K., Uma, S., Selvarajan, R. and Jeyabaskaran, K.J.	Global Conference on Banana and Plantain, held at Bangalore.	28th - 31st October, 2002
Mustaffa.M.M., Sundararaju, P., Padmanaban,B.,and Thangavelu, R	"Banana Seminar" organized by EID Parry Ltd. at Sani Santhai, Erode and delivered a talk on 'Improved production Management on Banana'.	15th July 2002
Pandey,S.D.	NATP training/ workshop at NRCB Trichy.	24 - 25th Sept. 2002
	NATP- Workshop/Exhibition held at ARS Kovvur AP.	11-12 Dec. 2002
	Workshop on NATP project at CTCRI.	17-18th March, 2003
Narayana, C.K.	Seminar-cum-Training programme on Banana cultivation and Value addition held by KVK, Vampan, Pudukottai.	24th July 2002
	Seminar on "Priority Sector Credit" organized by Syndicate Bank Regional Office at R.R.Sabha, Trichy.	24th August, 2002
	Seminar on "Pre and Post harvest Management of Banana" held at Akepadu village of Kadapa district of A.P.	24th September 2002
	National Conference on Recent Trends in Plant Science Research, held at St. Thomas College, Pala.	November 14 & 15, 2002.
	Workshop on "Development of Banana/Plantain based Food Processing Industries in Kerala", organized by Kerala Bureau of Industrial Promotion at Hotel Residency in Trivandrum.	12th December, 2002
	Seminar on "Investment Opportunities in Food Processing", held at Indian Food Park in Virudunagar	29th December, 2002
	Seminar on Post Harvest Management of Horticultural Crops, organized by Dept. of Horticulture, Government of A.P., Hyderabad.	27th January, 2003
	'Agri Meet 2003' conducted by CII at Hotel Royal Southern, Trichy	8-9th February, 2003

Name of Scientist	Name of Seminar / Symposia / Conference/Workshop	Period
	6th Agricultural Science Congress held at Indian Institute of Soil Science / CIAE, Bhopal.	February 13-15th, 2003
Uma, S.	**International:**	
	3rd International Symposium on Cellular and Molecular Biology of Bananas and Plantains held at Leuven, Belgium.	9-11th, September 2002
	International workshop on ***Musa balbisiana-genome diversity*** held at Bangkok, Thailand.	8th-10th July, 2002
Jeyabaskaran, K.J.	National seminar on "Recent trends on sulphur and silicon nutrition of crops" held in AC and RI, Madurai.	12 to 13, June, 2002

Training courses / Meetings attended

Name of the Scientist	Title / venue/ organized by	date
International		
Dr. M.M. Mustaffa	First "BAPNET" steering committee meeting as the country representative at Los Banos, Laguna, Philippines.	6-11, October 2002.
Dr.S.Uma	Banana Breeders meet and Genetic Working Group meeting at Leuven, Belgium.	6-7th, September, 2002
	PROMUSA - A global meet of banana researchers held at Leuven, Belgium.	11-13 September, 2002
National		
Dr.B.Padmanaban	Farmers meeting on Banana production technology, held at Chennampatti, Erode District, Tamil Nadu.	7th April, 2002
	Farmers meeting on Banana production technology, organized by TANUVAS, Trichy at Kuzhumani, Trichy.	20.1.2003
	Farmers meeting on Banana production technology, organized by Rastriya Chemicals and Fertilizers at NRCB, Trichy.	17.2.2003
Dr.S.D.Pandey	On Spot training course on drip irrigation technology for horticultural crops held at IARI, New Delhi.	October 18 to 31, 2002
Dr.M.M.Mustaffa & Dr.S.D.Pandey	Financial Review meeting of NATP organized by National Director NATP at College of Agriculture Pune.	31stJanuary, 2003

Name of the Scientist	Title / venue/ organized by	date
National		
Dr.R.Selvarajan	Training on "Disease management through host resistance' organized by Advanced center for plant pathology, Div. of plant pathology, IARI, New Delhi.	21/8 to 9/9/02
	ICAR sponsored winter school on "Biological, serological, electron microscopy, tissue culture and molecular techniques for early detection and elimination leading to management of plant viruses in agro eco system perspectives" organized by CPPS, Dept of Plant Pathology, TNAU, Coimbatore.	18th Jan to 19th February 2003
Dr.S.Uma	High level Review meeting of ICAR institutions at Bangalore.	05.10.2002
	Meeting on Plant Genetic Resources (PGR) activities in Indian organized by DDG (Hort).	28.03.2002
Mr.V.Kumar	Winter School on "System Approach to plant nutrition for sustainable crop production" organised by Directorate of Oil Seeds Research, Hyderabad.	September 18-Octobr 8, 2002

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

A 'Banana Farmer's Field Day' was organized by NRCB in collaboration with Rashtria Chemicals and Fertilizers Ltd., (Govt. of India Under taking), on 17th February 2003 at NRCB Campus. Dr.S. Sathiamoorthy, Director, NRCB presided over the function and gave awards to 10 progressive Banana Growers for their lifetime contribution to banana industry. Shri. R.R. Selote, DGM, Marketing, RCF, Mumbai and Scientists from NRCB spoke on various aspects of banana cultivation. About 250 farmers, 20 officials from various fertilizer/pesticide, AIR, Trichy Farm division and other department officials participated. Progressive banana farmers, NRCB Scientists staff members were felicitated on this function.

Fig. 33a

Fig. 33b

Fig. 34 Mr. Gopalakrishnan, a progressive farmer from Panikkampatti village receiving the "Best Banana Grower" award from the Director Dr. S.Sathiamoorthy during the banana farmer's field day on 17-2-2003

14 DISTINGUISHED VISITORS

S.No	Name & Designation	Institute	Date of Visit
1	Dr.D.S.Rathore Asst.Director General(Hort)	Indian Council of Agrl. Research Krishi Bhawan, New Delhi	23.4.2002
2	Dr.S.K.Gupta Professor (Soil Science)	Dept. of Soil Science & Agril. Chemistry, Calcutta University.	23.4.2002
3	Dr.S.K.Roy Emeritus Prof. (Hort)	Indian Agricultural Research Institute, New Delhi.	23.4.2002
4	Dr. N.K.Mohan Chief Scientist - HRS	Assam Agricultural University, Guawahati.	23.4.2002
5	Dr. B. S. Chundawat Rtd. Vice - Chancellor	Gujarat Agrl. University, Anand, Gujarat.	23.6.2002
6	Dr. H.C. Dass (Rtd. Director)	National Research Centre for Citrus, Nagpur	23.6.2002
7	Dr. P. Das Professor	Bhubaneshwar, Orissa	23.6.2002
8	Dr. Jeyarajan Prof & Head (Rtd,)	TNAU, Coimbatore	23.6.2002
9	Dr. T.Thangaraj Dean	HC&RI, Periyakulam, TNAU	23.6.2002
10	Dr. S. Nagarajan Director	IARI, New Delhi	20.7.2002
11	Shri G.Dhanavel IAS , Commissioner (Hort)	Government of Tamil Nadu, Chennai	13.08.02
12	Dr.V.Rajagopal	Rtd. V.C, TNAU, Coimbatore	31.8.02
13	Dr.N.Kumar, Professor and Head (Fruits)	Dept. of Pomology, TNAU, Coimbatore	12.9.2002
14	Dr.P.K.Valsalakumari	KAU, Trichur	12.9.2002
15	Shri.D.Madhava Rao	ARS, Kovvur	12.9.2002
16	Shri.S.S.Deshmukh	BRS, Jalgoan (Maharastra)	12.9.2002
17	Erick Beura	Total Petrol, Mumbai	
18	Dr.Agustin B.Molina, Regional Co-ordinator	INIBAP, Philippines	26.10.02

15 PERSONNEL

RESEARCH MANAGEMENT

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

SCIENTIFIC

Dr.M.M.Mustaffa, M.Sc.,(Ag.) Ph.D.	Principal Scientist (Hort.)
Dr.P.Sundararaju, M.Sc., Ph.D.	Senior Scientist (Nema.)
Dr.B.Padmanaban, M.Sc., Ph.D.	Senior Scientist (Ento.)
Dr S.D.Pandey, M.Sc., (Hort.) Ph.D.	Senior Scientist (Hort.)
Dr.C.K.Narayana, M.Sc., (Hort) Ph.D.	Senior Scientist (Hort.)
Dr.S.Uma, M.Sc., (Hort) Ph.D.	Senior Scientist (Hort.)
Mr.V.Kumar, M.Sc., (Hort),	Scientist (SS) (Hort.)
Dr.Thangavelu, M.Sc., (Ag.) Ph.D.	Scientist (SS) (Pl.Path.)
Dr.R.Selvarajan, M.Sc., (Ag.) Ph.D.	Scientist (SS) (Pl.Path.)
Dr.K.J.Jeyabhaskaran, M.Sc., (Ag.) Ph.D.	Scientist (SS) (Soil Science)
Mr.R.Natarajan, M.Sc., M.Phil.	Scientist (Eco. Bot.)
Ms.M.S.Saraswathi M.Sc., (Hort.)	Scientist (Hort.) from 3.5.2002.

TECHNICAL

Mr.RaghuRaman	T5 - Junior Garden Superintendent

ADMINISTRATION

Mr. B.Vijayakumar	Assistant Administrative Officer

AUDIT and ACCOUNTS

Mr.C.J.Stephen	Assistant Finance and Accounts Officer (Till 16.12.2002)

New Entrant

Ms.M.S.Saraswathi, Scientist was transferred from National Research Centre for Oil Palm, Pedavegi. Joined on 3.5.2002.

Transfered

Mr. C.J. Stephen, Assistant Finance and Accounts Officer was transferred and relieved on 16.12.2002 to join Central Marine Fisheries Research Institute, Cochin.

Probation Clearance

The following NRCB Staff were cleared the probation by the Institute DPC on 27.8.2002.

Shri. P.Ravichamy	T-3, Tech. Asst. (Journalism)
Ms. Anitha Shree	T-3, Tech. Asst. (Lab.)

ANY OTHER RELEVANT INFORMATION SUCH AS SPECIAL INFRASTRUCTURAL DEVELOPMENT

HINDI DAY

The Hindi Week was celebrated at NRCB during 14 to 20 September 2002. Mrs. Amuthavalli, Deputy Director, Central Hindi Teaching Scheme, Trichy, was the Chief Guest for the valedictory function on 20 September 2002 and distributed the prizes to the winners of various events viz., Hindi dictation, essay, recitation, signing, quiz etc.

Fig. 34

NRCB Foundation Day

Foundation day and annual day of the NRCB Recreation club was celebrated at NRCB on 31st August 2002. Dr. V. Rajagopal, Ex. Vice - Chancellor, TNAU, Coimbatore was the Chief Guest and Dr.S.Sathiamoorthy, Director, NRCB, Presided over the function. The staff members along with their family participated in different cultural programmes. The Chief Guest distributed prizes to the winners of various sports events and cultural activities.

Fig. 35a

Fig. 35b

SCIENCE DAY

National Science Day was celebrated at NRCB Trichy on 28th February 2003. The theme was '50 Years of DNA-the blue print of life'. To create awareness among students and teachers on the importance of science in the present days an "Open Day" was observed for the public especially to students. Over 500 students from various High Schools visited on the National Science Day.

Fig. 36

METEOROLOGICAL DATA

Month/Year	Temperature (C°)		Relative humidity (%)		Rainfall (mm)
	Minimum	Maximum	Minimum	Maximum	
Apr 2002	24.93	38.01	29.5	92.7	5.8
May 2002	25.78	38.14	34.22	84.5	118.9
Jun 2002	25.50	36.93	33.62	79.33	35.8
Jul 2002	26.60	38.2	29.05	68.73	1.7
Aug 2002	25.92	36.85	32.10	71.57	36.5
Sept 2002	25.14	36.98	30.21	79.26	40.1
Oct 2002	22.87	32.97	49.65	93.25	148.3
Nov 2002	21.54	31.14	68.56	94.15	72.0
Dec 2002	19.00	30.50	44.16	94.58	10.6
Jan 2003	18.03	30.02	37.68	90.43	2.6
Feb 2003	21.06	33.57	35.45	93.45	0
Mar 2003	20.81	36.12	26.63	91.99	4.5

PMEC

कार्यकारी सारांश

जनन द्रव्य प्रबंध :

अन्डमान और निकोबार द्वीप और आसाम एवं अरूणाचल प्रदेश के सर्वेक्षण के दौरान 38 नये जनन द्रव्यों का एकत्रीकरण कीया गया । इसके अलावा 208 जनन द्रव्य एन.बी.पी.जी.आर एवं त्रिचूर से एकत्रित किए गये एवं राष्ट्रीय केला अनुसंधान केन्द के प्रक्षेत्र जीन बैंक मे लगाया गया है । आर ए.पी.डी मारकर द्वारा 34 जनन द्रव्यो का मालिकुलर एवं मार्फोलाजिकल अध्ययन किया जा चुका है ।

उत्पादन :

विभिन्न कार्वनिक खादों का प्रभाव रस्थाली एवं करपूरावल्ली केले की जातियों पर देखा गया । इनमें 2.5 किग्रा. डिस्टीलरी स्लज, 1 किग्रा वर्मीकम्पोस्ट, 1 किग्रा नीम की खली एवं 2.5 किग्रा मुर्गी की खाद/ पौधा का प्रभाव पौधों की वानस्पतिक वृद्धि पर अच्छा देखा गया । सधन केला उत्पादन एवं फर्टीगेशन के अध्ययनों में द्वि पंक्ति पौध रोपण (1.2 X 1.2 X 2.0 मी) 5200 पौधे/हेक्टर एवं 3 पौधे /गड्ढा (1.8 X 3.6 मी), 4500 पौधे /हेक्टेर एवं प्रति पौधा 150 ग्राम नत्रजन, 50 ग्राम फासफोरस एवं 225 ग्राम पोटेशियम तत्वों की फर्टीगेशन द्वारा पूर्ति का पौधों की वृद्धि एवं उत्पादन पर अच्छा प्रभाव देखा गया । करपूरावल्ली जाति पर सुक्ष्म तत्वो के प्रभावों का अध्ययन किया गया एवं आयरन को जमीन में देने एवं जिंक (जस्ता) एवं बोरान का पर्णीय धिड़काव करने से पौधों की वृद्धि एवं उत्पादन पर अच्छा प्रभाव देखा गया ।

तुड़ाई-उपरांत संभलाव :

ने पूवन जाति के फलों पर 100 पी.पी.एम.जी.ए का छिड़काव करके जीरो एनरजी कूल चेम्बर में रखने पर फलों की भंडारण क्षमता (कच्चे एवं पके) पर काफी अच्छा प्रभाव देखा गया । फलो कां स्वाद पालीथीन में बंद करके जीरो एनरजी कूल चैम्बर में रखने पर अच्छा पाया गया, कमरे मे सामान्य तापमान पर रखे फलों की अपेक्षा । वीरूपक्षी केले को 500 पी.पी.एम इथरेल से उपचारित करके पालीथीन थैलियों मे बंद करके रखने से 7 दिन तक केले नहीं पके परंतु सामान्य तापमान पर बिना पालीथीन के रखे फल 3 दिन में ही अच्छे पक गये ।

फसल सुरक्षा : केले की फसल को नुकसान पहुचाने वाले 5 नये कीटों का पता लगाया गया है । तना छेदक कीट की जनन द्रव्यो के प्रति प्रतिरोधिता जानकारी के लिए नयी तकनीकि का विकास किया गया है । केले के विविल कीट प्रवन्ध हेतु तना जाल (Psedostem Trap) तकनीकि का विकास किया गया है । केले के तना छेदक कीट के लिए केले को कुछ प्रतिरोधी जनन द्रव्यों का भी चयन किया है । कुछ फंफूदों एवं सूत्रकृमियों का चयन किया गया है जो कि केले के विविल कीट के प्रवंधन मे, हायक हो सकते हैं ।

सूत्रकृमियों के संख्या में 50% नत्रजन की मात्रा नीम की खली या सूखी नीम की पत्तीयों या सी. जेन्सिया की पत्तीयों से देने सें कमी पायी गयी हैं । सूत्रकृमियों के प्रबंध मे सहायक फफूंदो का केले की कटाई के बाद तनों का पीटीयोल का उपयोग करके सफल प्रवर्धन किया गया है, टि.वीरिडी बयो एजेंट का दो बार प्रयोग 20 ग्राम प्रति पौधा सुत्रकृमियों के नियंत्रण में काफी प्रभावी पाया गया है, साथ ही साथ पनामा विल्ट बिमारी प्रकोप में भी कमी देखी गयी है । इकोनीम एवं निम्बीसिडीन का सूत्रकृमियों नियंत्रण मे काफी अच्छा प्रभाव देखा गया है । इनका प्रभाव कार्बाफ्युरान के बराबर पाया गया ।

केले के तुड़ाई उपरांत फैलने वाली शीर्ष गलन (क्राउन राट) बीमारी के नियंत्रण के लिए एक वैक्टीरिया की पहचान की गयी है, जो फफूंदनाशी के बराबर प्रभावी है । सोलेनम डोरवम के रस की 50% सान्द्रता का केले के फलों पर छिड़काव एन्थ्रेक्नोज बिमारी के नियंत्रण में काफी सहायक पाया गया है । पैराफीन तेल 5% एवं फफूंदनाशी दवाओं की आधी साद्रता (प्रोपीकोना जोल, कार्वेन्डा जीम या मै-कोजेब) का छिड़काव केले के पत्ती धब्बा रोग (Leaf spot or Sigatoka) के फैलाव को काफी नियत्रित करता है । इससे पैदावार में 20 प्रतिशत तक बढ़ोत्तरी देखी गयी है ।

केले के बीबीटीपी (केले का शीर्ष गुच्छा रोग) विषाणु रोग की पहचान के लिए डाट व्लाट तकनीकि का विकास किया गया है । केले का धारी विषाणु रोग (BSV) पी सी आर (PCR) तकनीकि के द्वारा पहचाना जा सकता है । आर टी - पी सी आर (RT-PCR) का विकास केले के ब्रेक्टमोजेक विषाणु की पहचान के लिए किया गया है । पूवन जाति के केले में विक्कल विकार में केले के धारी विषाणु (BSV) की उपस्थिति पायी गयी है ।

तकनीकि स्थानान्तरण :

किसानों को प्रक्षेत्र पर सलाह, किसान गोष्ठी एवं भाषणों द्वारा सही पौध सामग्री प्राप्त करने, कम खर्च में अधिक उत्पादन सही फसल सुरक्षा आदि के बारे में जानकारियां दी गयी । इसके अलावा छोटे किसानो एवं महिलाओं को केले के प्रसंस्करण एवं उसके मूल्यवर्धन के बारे में प्रशिक्षण दिया गया ।


NRCB