# Annual Report 1997 – 98


NATIONAL RESEARCH CENTRE ON BANANA
(Indian Council of Agricultural Research)
Trichy – 620 017.

RMCU

# ANNUAL REPORT

## 1997 – 98

राष्ट्रीय केला अनुसंधान केन्द्र
(भारतीय कृषि अनुसंधान परिषद)
त्रिची – 620 017 तामिलनाडू

**NATIONAL RESEARCH CENTRE ON BANANA**
(Indian Council of Agricultural Research)
**TRICHY - 620 017.**

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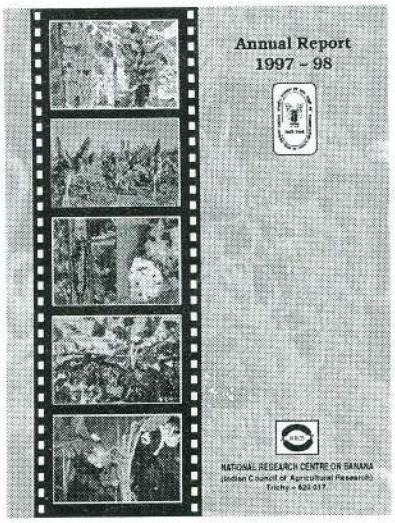


**FRONT COVER PAGE**

From top to bottom

1. Bunches of Kanthali and FHIA–01 (right)
2. Nendran orchard infested with nematode
3. Pseudostem infested with weevil (left)
   rhizome infested with weevil borer (right)
4. Wilt affected cultivar Monthan
5. Nendran bunch with short peduncle
   (BBMV infected)

**BACK COVER PAGE**

Illustration shows a banana orchard, packing of bunches, banana leaves and a market scene and a retail shop for banana.

**PHOTOGRAPHY**

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# ANNUAL REPORT 1997-98

## 1. PREFACE

I have great pleasure in presenting the Annual Report 1997-98, for the National Research Centre on Banana (NRCB) in the Golden Jubilee Year of Independence of India which depicts a panorama of research activities and achievements of the centre involving a multidisciplinary team approach. The centre, as in the past conducted research on all aspects of banana with an objective, to enhance the production and productivity of banana through basic and strategic research, to serve as a national repository for banana germplasm, to act as a centre for training and updating the research methodologies and technologies of banana besides collaborating with national and international agencies in achieving the above mandate. In this report major activities of the centre are covered under four major programmes in executive summary.

During the period under report spectacular development has been made by the centre in various aspects like infrastructure development, maintaining close linkages with farmers, entrepreneurs and department of horticulture besides conducting the research programmes and human resource upgradation. During the year, the centre has also brought out the final version of "VISION-2020, NRCB PERSPECTIVE PLAN" in printed form. Seminar on 'Appraisal meeting for achieving the targeted production of banana' was organised at the centre and suckers of two promising and high yielding cultivars FHIA-1 (Gold Finger) and Saba were distributed to the progressive farmers to study their performance in plain as well as in hills. Consultancy services were also initiated by the Centre in order to generate its own resources by offering training programmes with regard to the production of disease free quality planting material, testing of agro-chemicals, diagnostic services for pest, nematode, fungal and viral disease problems and post harvest technologies to reduce storage losses etc.

I would like to express my gratitude to Dr.S.P.Ghosh, Deputy Director General (Hort.), ICAR and Dr.H.P.Singh, former Director, NRCB and present Horticulture Commissioner, Govt.of India, New Delhi, for their constant guidance and encouragement.

I wish to complement with appreciation of all the Scientists, Technical, Administrative and Supporting Staff of the Centre who put their efforts for all success and also in the compilation, editing and preparation of this Annual Report.

**Dr. P. Sundararaju**
*(Actg. Director)*

## 2. EXECUTIVE SUMMARY

The National Research Centre on 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, started functioning effectively from 1st April, 1994. The mandate of the Centre is **to enhance the production and productivity through basic and strategic research**. The vision of the NRCB is to **improve the production and productivity through utilization of genetic resources, development of improved cultivars, improved production technologies, protection against insect, pests, nematodes and diseases, and reduced post harvest losses**. In the last four years, the centre has made appreciable progress with respect to infrastructural development as well as in the research.

### Research Achievements

Keeping the Perspective Plan in view, and the recommendations of RAC, the programme at the Centre has been initiated under four major missions viz., Genetic Improvement, Production Technology, Plant Health Management and Post harvest Technology. Trials under International Musa Testing Programme were also undertaken. Although majority of the Scientists joined at the Centre in second part of 1996, Centre has made appreciable progress with respect to crop improvement, production technology and plant health management programme.

Explorations were made in the Southern parts of Kerala and Tamil Nadu. Twenty seven virus free accessions were collected and added to the *Musa* genebank which includes the variability in Ney Poovan (AB), Rasthali (AAB-Silk), Nendran (Plantain - AAB), *M.balbisiana* (BB/BBB) etc. Explorations from Shevroy hills, Yercaud and Tirupathi yielded a seeded wild AA diploid and a wild, seeded *M.balbisiana* accession respectively. Potential male parents were identified through pollen germination studies. Results of crossing suggest that Hatidat and Kanai Bansi as potential male parents with wide genomic group and sub-group compatibility. Extent of seed set per successful cross is high with Hatidat compared to Kanai Bansi.

Hybrid seeds obtained by crossing Pisang Awak and exhibited high percentage of germination and better survival in the nursery. Streptocyclin (0.1%) + Citrimide (0.1%) combination for 5 minutes, mercuric chloride (0.1%) for 3 minutes followed by 3-4 sterile water rinses has been found better decontamination method among various combinations tried.

Among four treatments, T1 (1/2 MS + Fe + Vit + Ascorbic Acid + Activated charcoal(0.25 g/l)) and T3 (1/2 MS + Fe + Vit., + Ascorbic acid + NAA ( 2 µm)) gave better rooting response interms of number of roots, root length (root and shoot dry matter) thickness, ramification and field survival in cv.Robusta and Karpuravalli.

The exotic accessions for their suitability to Indian conditions accn.no. 0697 belonging to Bluggoe sub group was found to be superior with respect to yield and salt tolerance, accn.no.0692 is a tall, robust plant growing to 3.2 to 3.5m and with a pseudostem circumference of 75.8cm. It has a potential to yield a bunch weighing 35-38 Kg with 12-14 hands in 330-345 days. It has excellent cooking quality, firm pulp and longer green life of 6 days from date of harvest. It is found to be better for wine preparation compared other culinary cultivars. Evaluation for fertility suggests that it can be successfully used as a potential female parent.

The centre has developed a software to document the data on germplasm and to develop a database. This has been successfully installed at the centre and a database has been created for more than 50 accessions comprising of wild and cultivated accessions.

Hybridization attempts and the results obtained suggest that among various diploids tried Hatidat, Amrit Sagar among acuminata group and Thiruvananthapuram among AAB are proved to be better pollen parents. Hatidat has wider compatibility with varied genomic combinations.

The phyllochron ranged from 5.84 days to 11.88 days and in general the phyllochron found gradually increased with the increase in mean temperature and humidity.

Results revealed that application of more organic source of nutrition favoured better plant growth, shorter crop duration, higher bunch weight and increased T.S.S. in all the varieties. Irrespective of varieties, the crop duration was extended by the application of 100% N from inorganic source. Application of more percentage of organic sources of nutrition increased plant vigour, yield and fruit quality which may be attributed by the change in physio-chemical and nutritional properties of the soil as wellas significantly reduced nematode population.

The Experiment on assessment of losses due to weeds revealed that maintenance of weed free condition upto six months after planting, enhanced more vegetative growth, produced better bunches and reduced the crop duration. There was 33.15 percent loss in bunch weight under unweeded plots besides, it also increased the crop duration by more than four months over the control.

It was very interesting to note that the leaf K/Na ratio had positive and significant correlation (r=0.2131**) with the yield. It has been found that banana leaves should have the K/Na ratio of more than one for the optimum yield.

Based on root and leaf K/Na ratio studies, Saba has the capacity of excluding Na and absorbing more K at the root level and this variety has high root and leaf K/Na ratio in the saline and saline sodic soil.

Survey conducted in Tamil Nadu and Pondicherry revealed that the occurrence of 12 genera of plant parasitic nematodes associated with the crop. It was observed that the

nematodes *Pratylenchus coffeae, Meloidogyne incognita* and *Helicotylenchus multicinctus* were the dominant species. Samples of both soil and root collected at NRCB farm has 15 genera of plant parasitic nematodes. Among them four species, viz. *R.similis, P.coffeae, H.multicinctus* and *M. incognita* are the predominant species.

Population fluctuation study revealed that the distinct increase of *R.similis* population was noticed during the months of January-April which later reduced to negligible level from May to October. Again a steady increase was noticed from November to December.

Minimum nematode population was recorded in plots where Neem cake had been applied as a main source of Nitrogen. The nematode *P.coffeae* was recorded a maximum number in cv.Nendran followed by Karpuravalli and Robusta.

Preliminary screening of Musa germplasm available at NRCB was done in the field in order to identify the resistant/tolerant reaction to major nematode pathogens viz. *R.similis, P.coffeae, M.incognita* and *H.multicinctus*. Among the 567 germplasm screened, 45 cultivars were found to be highly susceptible to *P.coffeae*, six cultivars to *R.similis*; 41 to *M.incognita* and four to *H.multicinctus*. The rest of the cultivars are free from nematodes.

Sigatoka incidence was observed in all the varieties grown in Tamil Nadu during the survey. The maximum incidence of more than 80% was noted in Robusta, Poovan and Monthan varieties and minimum incidence of Sigatoka was observed in Karpuravalli at bunch maturing stage. The functional leaves during bunch maturity stage was also more (13) in Karpuravalli and less in Robusta and Rasthali.

The fusarium wilt incidence was maximum in Rasthali and Monthan and less incidence in Karpuravalli. The unknown malady 'Neer Vazhai' (upto 10 plants/acre) was also observed in Nendran orchards.

Germplasms were evaluated for their reaction to wilt and Sigatoka under field conditions. From the evaluation, the accessions belong to *Musa balbiciana* , Pisang Awak, Monthan and Bluggoe groups which have more 'B' genome in their genomic constitution were found to be less susceptible to Sigatoka leaf spot as there was less incidence of disease, more YLS value and functional leaves compared to other groups which have more 'A' genome in their genomic constitution.

Varieties such as local Peyan (ABB), Enna Benian (AAB), Thiruvananthapuram (AAB), Kalibow (AAB), Petite Naine (AAA), Vadakkan Kadali (AA) and Pisang Raja (AAB) were found to be free from Sigatoka leaf spot disease.

The hybrids PA-03-22 (EMB-404) and FHIA-03 and natural germplasms such as Cultivar rose, Yangambi-KM-5, Pisang Jari Buaya and Pisang Lilin were found to be resistant to Sigatoka. Whereas the hybrids, FHIA-1, FHIA-23, EMB-402, GCTCV-119, GCTCV-215 and cultivars such as Burro Cemsa, Saba, Bluggoe and Williams were found to be susceptible to Sigatoka.

The IMTP (Sigatoka) Genotypes were evaluated for their reaction to Sigatoka incidence under natural field condition. Among the genotypes evaluated, SH-343669, Saba, Pisang Ceylan and local cultivar Robusta were found to be susceptible to Sigatoka and PV-03644, PA-03622, Pisang lilin, Pisang Berlin, Niyarma Yik were found to be resistant.

The disease development time which was recorded throughout the crop period ranged from 34-193 days and more DDT value was recorded in the variety Saba.

Significant influence of temperature and RH on the DDT was observed in all the susceptible genotypes. However, the degree of influence varied from variety to variety. It was also observed that for 1° rise in temperature there was 6 to 14 days increase in Disease Development Time. Similarly, for 1 percent rise in RH there was 1.5 to 5 days decrease in DDT.

Maximum of 60% BBMV infection in a Nendran orchard and 24.0% BSV in Poovan variety was observed during the survey conducted in Tamil Nadu and Kerala. The particles of BBMV and BSV were observed from the samples collected from both bracts and fingers of Pacha Bontha Batheesa under EM.

In germplasm 36 accessions are found to have BBMV infection. In 15 accession symptoms were observed on Bract, leaf and pseudostem of main plant and also on suckers. Seven accessions had symptoms only on suckers but not in main plants.

Survey conducted in few districts of Tamil Nadu revealed the following insect pests viz., Tobacco caterpillar, *Spodoptera litura* (F.), Leaf thrips, *Helinothrips kadaliphilus* R&M, Flower thrips, *Thrips hawaiensis* (Morgan), Bag worm, *kophene cuprea* M. and Banana Mealy bug, *Pseudococcus* sp. Incidence of leaf thrips and bagworm was very severe in Trichy taluk, whereas Pseudostem borer and Rhizome weevil borer were found to be very severe in Periyakulam and Coimbatore districts respectively. Occurrence of *Spodoptera litura* (F.) indicated a maximum feeding damage on Monthan and lesser in Pachanadan variety.

The data revealed that chilling injury was caused when the fruits were stored at 10°C at the end of 5 days. However, application of $CaCl_2$ and AA reduced the degree of damage as assessed by fruit quality parameters.

Experiments were conducted to extend the green life of 'Karpuravalli' variety of banana under various conditions. The findings showed that pre-cooling of bunches in water for one hour followed by storage at room temperature increased the green life to 8 days as against 4 days in control.

The study was performed on 69 accessions belonging to five genomic groupings namely AA, AAA, AAB, ABB and BBB. The fruits were harvested at three maturity levels namely, 75, 90 and 100 days after fruit set. They were stored at 25°C±2°C in perforated polythene bags. Observation on fruit ripening were recorded at the time when the peel colour started to turn from green to yellow.

In general, the green life showed an inverse relationship with maturity. The maximum green life was displayed by accn.no.0097 at 3/4$^{th}$ maturity and similarly the longest yellow life was recorded by accn.no.0122.

## 3. INTRODUCTION

The National Research Centre on Banana (NRCB) was established on recommendations of the task force committee appointed by the Indian Council of Agricultural Research w.e.f. 21st August, 1993, started functioning effectively from 1st April, 1994. It is located about 14 km. west of Trichy (11.50 latitude 74.50 E longitude and 90 m. above mean sea level). The centre receives the precipitation of 800-900 mm annually both from North-East and South-West monsoons. Climate is tropical with the highest mean temperature in April-May. The farm has a total area of 38 ha., the office-cum-laboratory is located in rented building hired at 44, Ramalinga Nagar South Extn., Vayalur Road, Trichy.

### 3.1 : Salient Research Achievements in the past.

**3.1.1 : Crop improvement :** Emphasis has been paid on collection, conservation and evaluation of genetic diversity and the centre has assembled the major diversity from all parts of the country totalling a 670 accessions of which 32 are exotic collections. These accessions are planted in the field gene bank and efforts are under way for *in vitro* conservation. Many of the accessions collected have started fruiting and morphological evaluation of the gene pool is in progress. Accessions of North Eastern regions were genomically classified. Technique for *in-vitro* handling of germplasm has been standardised and is being used for handling of *in vitro* germplasm of banana. Four promising high yielding clones two of Monthan and one each in Pisang Awak and Silk sub groups were identified, which are being multiplied for further evaluation. Major research achievements include,

a. Many of the *Musa* species and sub species used in global hybridization programmes have been introduced.

b. *Musa* accessions have been assigned the genomic status and are further characterized using INIBAP's *Musa* descriptor.

c. Tentative key has been prepared for the first time for the identification of Indian bananas.

d. Data base has also been developed for the *Musa* germplasm.

As a first step in improvement, systematic evaluation has been done to identify the donor source of resistance to major diseases. Efforts have been made to identify the parents for combining the desired characters. Breeding has been started using triploid and diploid crosses. To cut short long period required for the development of varieties in banana, promising global hybrids, resistant to sigatoka and fusarium were introduced through the collaboration of INIBAP, which were evaluated in the field. FHIA-1, Gold Finger / a Pome hybrid / a Saba hybrid are found promising for subsistence cultivation in India.

**3.1.2 : Production Technology :** In order to improve the quality of banana which can have export value, attempts are being made for the refinement of production technologies. In this direction, trials have been laid out for production system, canopy management, recycling of nutrients, efficient water management, bio-control and integrated management of insect pests nematodes and diseases.

**3.1.3 : Crop Protection :** Survey conducted has indicated that Banana streak virus (BSV) and banana bract mosaic virus (BBMV), which were not reported earlier, are present in the country at alarming levels. These viral diseases may become serious, if the spread is continued through infested plants. Kokkan disease, hitherto known as disease of unknown etiology was identified, using serological techniques, to be BBMV. Management strategies for these diseases are being developed.

**3.1.4 : Post Harvest Technology :** Although India is the largest producer of banana having annual production of 13.0 million tonnes, yet its share in the world trade is unrecognised. Therefore, emphasis has been given to refine the technologies aimed to produce quality fruits having export potentiality. Germplasm was evaluated for post harvest characteristics, which indicated wide variability for shelf life and other quality parameters.

**3.2 : Mandate**

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

**3.3 : Growth**

Banana research in the past has been conducted through AICRP on Tropical Fruits as well as at national institute Viz. Indian Institute of Horticultural Research, Bangalore. There are 8 centres in SAUs located in Banana growing regions. At national level, about 45 scientists are engaged in banana research. However, growth of NRCB is indicated here which was established exclusively to work on banana. Organization set-up of NRCB is given in Fig.1.

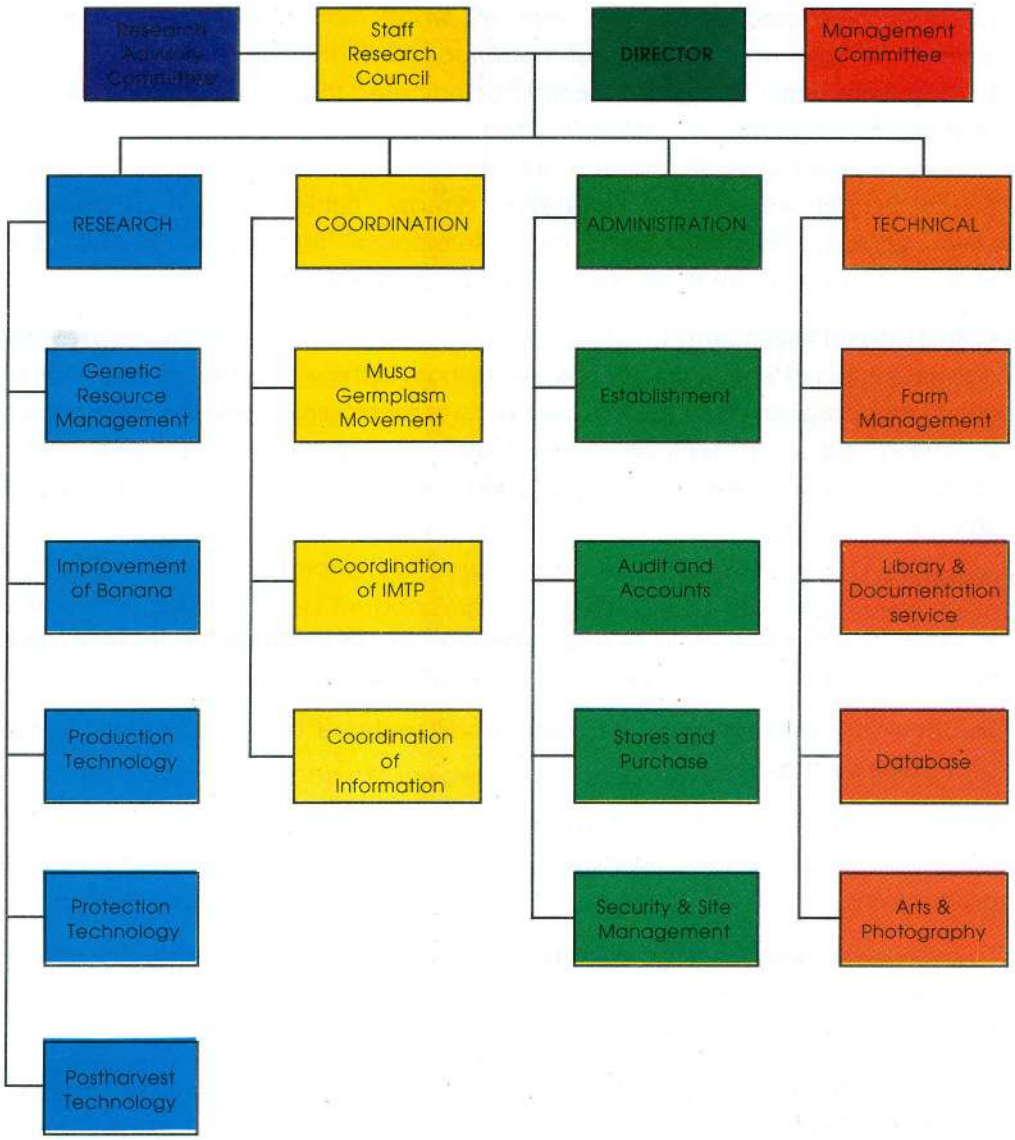



**Fig. 1 : ORGANISATIONAL STRUCTURE OF NRCB, TRICHY**

### 3.4 : Budget and Man Power (as on March 31, 1998)

#### 3.4.1 : Budget for 1997-98

(Rs. in lakhs)

| Sl. No. | Head | B.E. | R.E. | Expenditure amount |
|---|---|---|---|---|
| 1. | Establishment charges | 5.00 | 21.00 | 30.95 |
| 2. | Travelling allowances | 1.50 | 1.50 | 1.50 |
| 3. | Other charges including equipments | 45.00 | 45.00 | 40.28 |
| 4. | Works | 43.50 | 43.50 | 38.25 |
| | Total | 95.00 | 111.00 | 110.98 |

Revenue from Farm Produce : Rs.2.34 lakhs

The Finance & Accounts earlier maintained at IIHR, Bangalore were transferred to NRCB, Trichy w.e.f. 23.1.98 consequent upon the joining of the Assistant Finance & Accounts Officer at NRCB, Trichy.

#### 3.4.2 : Manpower

| Grade | Sanctioned | In position | Vacant |
|---|---|---|---|
| Scientific | 16 | 10 | 6 |
| Technical | 15 | 15 | - |
| Administration | 9 | 9 | - |
| Supporting | 7 | 7 | - |
| Total | 47 | 41 | 6 |

## 4. RESEARCH ACHIEVEMENTS

### 4.1 : CROP IMPROVEMENT

**CROP IMPROVEMENT**
**(General Leader : H.P. Singh)**

Exploration made in Tamil Nadu yielded 27 new accessions having variability in Ney Poovan, Rasthali, Nendran, *Musa balbiciana* etc. The varieties such as Hatidat, Kanai Bansi are identified as potential male parents with wide compatibility. A modified score card to assign genomic status has been developed to accommodate the existing diversity among the Indian clones. Exotic accession, Saba has proved its superiority to adopt to saline sodic soils of India with yield stability. To overcome the contamination and also for better regeneration the size of the explant was found to be 3 $cm^3$. Rooting media for the varieties Robusta and Karpuravalli has been standardized. The use of ascorbic acid 10 mg/l and activated charcoal 0.25 g/l reduced the blackening of explant and media. While the streptocyclin 20 mg/l was found to contain the initial culture contamination when most of the varieties tested. Embryo culture was found to be successful in Pisang Awak (ABB), Monthan (ABB), Bankela (ABB), *Balbiciana* clones and *M.velutina* (ornamental).

Banana was considered intractable to conventional breeding until recently. Triploidy, sterility and parthenocarpy make genetic improvement through conventional breeding of this crop very cumbersome.

Efforts are made to overcome these constraints and improve banana through following major strategies. (a)Germplasm management where collection and conservation of germplasm is attempted for providing wide genetic base to support current and future breeding programmes. (b)Conventional Breeding programme in which hybridization programme is undertaken involving diploid breeding to evolve synthetic diploids with required traits, tetraploidy breeding and interploidy and interspecific hybridizations. (c)Biotechnological approaches where *in-vitro* management of germplasm, multiplication of test accessions and embryo culture programmes are in progress.

#### 4.1.1 : Germplasm enhancement and utilization (S.Uma)

Under this programme, emphasis has been given to collect and conserve wild and cultivated germplasm representative of the diversity existing in the Musa genepool and to make it accessible to the researchers involved in crop improvement programmes. This involves evaluation of the accessions for desirable traits and evolve a database with global network among workers. Apart from this, to analyse the possibility of selecting superior accessions for direct use as cultivars.

### 4.1.1.1 : Collection and Conservation

During the period under report, explorations were made in the Southern parts of Kerala and Tamil Nadu. Twenty seven new virus symptom free accessions including the variability in Ney Poovan (AB), Rasthali (AAB-Silk), Nendran (Plantain - AAB), *M.balbisiana* (BB/BBB) etc. were added to the musa genebank. (Table 1) Explorations from Shevroy hills, Yercaud and Tirupathi yielded a seeded wild AA diploid and a wild, seeded *M.balbisiana* accessions.

**Table 1 : List of Accessions added during 1997-98**

| S.No. | Name of Accession | No. | Place |
|---|---|---|---|
| 01. | Chengali Kodan | 1 | Kannara |
| 02. | Nedu Nendran | 1 | Kannara |
| 03. | Kaliethan | 1 | Kannara |
| 04. | H-1 | 1 | Kannara |
| 05. | Matti | 3 | Kannara, Palode and Kumarapuram |
| 06. | Kadali | 2 | Kannara, Palode |
| 07. | Pisang Lilin | 2 | Kannara, Palode |
| 08. | Yangambi Km5 | 1 | Kannara |
| 09. | Red Banana | 3 | Trivandrum, Peringamala, Tirupati |
| 10. | Adukkan | 1 | Palode |
| 11. | Bhaskara Keli | 1 | Kasaragod |
| 12. | Kozhikode | 1 | Kumarapuram |
| 13. | Poomkadali | 1 | Naanadu |
| 14. | Java | 1 | Perangimala |
| 15. | Padathi | 1 | Perangimala |
| 16. | Chingan | 1 | Marugur |
| 17. | Rasakeli | 2 | Marugur |
| 18. | *M.balbisiana* | 1 | Tirupati |
| 19. | Poovilla Chundan | 1 | Then Tirupperai |
| 20. | Thuzhuvan | 1 | Nagercoil |

Field genebanks are the most common means of conserving diversity for vegetatively propagated crop plants. At NRCB, all the collected accessions are conserved in the field genebank in "Base collection block" under wetland system of cultivation irrespective of their genomic status. After preliminary characterization, shifted to "Working collection block" where each germplasm is maintained with four replications.

### 4.1.1.2 : Evaluation of germplasm accessions

Germplasm was evaluated for various morphological quantitative and qualitative parameters and relative contribution of A and B genomes on these parameters. Extent of genetic diversity among clones and their relative contribution on various characters

contributing to genetic diversity were studied. Screening of desirable accessions for various biotic and abiotic stresses was carried out.

#### 4.1.1.3 : Evaluation of germplasm for male and female fertility

Success of breeding programme in a male vs female sterile crop like banana depends on the selection of potential parents. Germplasm was evaluated and screened for polliniferous parents in field and potential male parents were identified through pollen germination studies. Though 63 accessions exhibited free pollen germination, initial breeding efforts were limited to the use of only diploids as male parents. Six accuminata diploids were used to improve various characters of different genomes and the detail of the crosses made is presented (Table 2).

**Table 2 : Details of successful crosses in terms of seed yield**

| Accessions | Genomic combination | No. of crosses made | No. of seeds set | % of embryoless or aborted seeds | Extent of seed set per cross |
|---|---|---|---|---|---|
| Ladisan x Hatidat | ABB x AA | 220 | 42 | 38.20 | 0.19 |
| Marabale x Amrit sagar | AAB x AA | 116 | 20 | 10.00 | 0.172 |
| Gauria x Hatidat | ABB x AA | 78 | 92 | 58.69 | 1.179 |
| Borkal x Hatidat | BB x AA | 84 | 02 | 100.00 | 0.024 |
| Borbutia x Hatidat | BBB x AA | 63 | 87 | 90.80 | 1.381 |
| Bankela x Hatidat | ABB x AA | 210 | 228 | 60.56 | 1.085 |
| Saapkal x Amrit sagar | ABB x AA | 186 | 103 | 35.89 | 0.554 |
| Karpura x Hatidat chakkarkeli | ABB x AA | 221 | 55 | 50.90 | 0.249 |
| Lamby x Hatidat | ABB x AA | 80 | 02 | 100.00 | 0.025 |
| Sahil Baig x Amrit sagar | ABB x AA | 145 | 04 | 75.00 | 0.028 |
| Pachabale x Amrit sagar | ABB x AA | 140 | 11 | 46.00 | 0.078 |

Results of crossing suggest that Hatidat (AA) and Kanai Bansi (AA) are found to be potential male parents with wide genomic group and sub-group compatibility. Extent of seed set per successful cross is high with Hatidat compared to Kanai Bansi.

**Table 3 : Genomic Distribution of Musa accessions to different plant parameters**

| Parameter | Range | AA | AAA | AB | AAB | ABB | BB/BBB | ABBB |
|---|---|---|---|---|---|---|---|---|
| Plant Height | 1.00-2.00 | 8 | 18 | 2 | 7 | - | - | - |
| | 2.10-3.00 | 7 | 26 | 33 | 115 | - | 2 | - |
| | 3.10-3.50 | 1 | 2 | 3 | - | 126 | 3 | 5 |
| | 3.50-above | - | - | - | - | 12 | 10 | - |
| L/B ratio | 2.00-2.40 | - | 5 | 2 | 1 | - | - | - |
| | 2.50-2.90 | 6 | 16 | 14 | 62 | 57 | - | - |
| | 3.00-3.40 | 8 | 22 | 20 | 55 | 76 | - | - |
| | 3.50-above | 2 | 3 | 2 | 4 | 52 | - | - |
| Pseudostem circumference | 4.0-65.0 | 6 | 40 | 36 | 57 | 40 | - | - |
| | 66.0-80.0 | 9 | 6 | 2 | 65 | 81 | 3 | 5 |
| | 81.0-above | - | - | - | - | 17 | 21 | - |
| Days to shooting | 270-300 | 7 | 30 | - | 8 | - | - | - |
| | 301-325 | 8 | 10 | 34 | - | - | - | - |
| | 326-350 | - | 6 | 6 | 4 | 29 | - | 2 |
| | 351-above | - | - | - | - | 109 | 15 | 3 |
| Photosynthe-tically leaves at harvest | 2.0-4.0 | 3 | 10 | 6 | 10 | - | - | - |
| | 5.0-7.0 | 6 | 16 | 18 | 110 | 8 | - | - |
| | 8.0-above | 6 | 20 | 14 | 2 | 130 | 15 | 5 |
| Yield (Kg) | 2.0-5.0 | 6 | 20 | 17 | 15 | - | 1 | - |
| | 6.0-10.0 | 6 | 19 | 22 | 38 | 31 | 3 | 4 |
| | 11.0-20.0 | 3 | 6 | 1 | 68 | 72 | 1 | 1 |
| | 21-above | - | 1 | - | 1 | 36 | 10 | - |
| Total No. of fingers | 10-50 | 10 | 30 | 22 | 20 | 26 | 2 | - |
| | 51-100 | 4 | 6 | 17 | 11 | 71 | 4 | 2 |
| | 101-200 | 1 | 8 | 1 | 70 | 21 | 7 | 3 |
| | 201-above | - | 2 | 4 | 21 | 20 | 2 | - |
| No. of fingers/ hand | 2-4 | 2 | 21 | 22 | 15 | 31 | 2 | - |
| | 5-10 | 7 | 19 | 16 | 37 | 61 | 3 | 5 |
| | 10-above | 6 | 6 | 2 | 70 | 46 | 10 | - |
| T.S.S. Brix °C | 1-20 | - | 18 | - | 2 | 2 | - | - |
| | 21-25 | 9 | 20 | 16 | 54 | 56 | - | - |
| | 26-30 | 7 | 8 | 22 | 60 | 70 | 10 | 5 |
| | 31-above | - | - | - | 6 | 10 | 5 | - |

Variability was also noted with respect to number of hands with seeds, fruits with seeds and number of seeds per fruit. Seeds exhibited variation with respect to size, shape, colour, wrinkleness of seed coat and germinability. Seeds produced by crossing Pisang Awaks as one of the parents exhibited high germination percentage and better survival in the nursery.

#### 4.1.1.4 : Evaluation for growth, yield and quality

Superiority of clones was expressed interms of growth or yield parameters with a great inter and intra-genomic diversity and the extent of variability expressed in Table 3.

In crop improvement, evaluation of clones for high yield with superior quality is emphasised for breeding new clones. Inter-intra group and subgroup variation was noticed with respect to yield variation noticed was high in ABB and BBB sub group while it was minimum in AA diploids.

#### 4.1.1.5 : Taxonomic Evaluation

All the accessions collected from primary and secondary centres were planted in base collection block. After preliminary taxonomic evaluation, tentative genomic status was assigned and planted in working collection block in their respective genome for detailed characterization. Simmonds and Shepherds 15 character classification aided by Silayo's and Chomchalow's modified score card were used for morphotaxonomic grouping.

Scoring of 400 accessions and their evaluation for tentative grouping using existing score card posed few problems of ambiguity and discontinuity in the score range. To accommodate existing diversity among Indian clones, the modified score card is given in Table 4.

**Table 4 : Modified score card for grouping of Indian bananas**

| Genomes | Score card of | | |
|---|---|---|---|
| | Simmonds & Shepherd (1982) | Silaloy & Chomchalow(1987) | Singh & Uma (1996) |
| AA/AAA | 15-23 | 15-25 | 15-25 |
| AAB | 24-46 | 26-46 | 26-45 |
| AB | 49 | - | 46-49 |
| ABB | 59-63 | 59-63 | 59-65 |
| ABBB | 67 | - | 66-69 |
| BB/BBB | - | 70-75 | 70-75 |

After initial grouping, detailed characterization is carried out using modified "Musa descriptor" (INIBAP) and a tentative key for the classification of Indian bananas has been

developed. This provides a systemic approach for the identification of individual cultivars and assists in the differentiation of closely related varieties. Key also helps in recognising the synonyms and eliminating the duplicates.

### 4.1.2 : Biotechnological approaches for improvement (S.Uma)

#### 4.1.2.1 : *In-vitro* Germplasm Management

For culture initiation, maximum duration admissible from extraction from soil to culture initiation has been worked out. Initiating within 24 hours of extraction was found advantageous and it was feasible upto 48 hours. Beyond which explant contamination was more than 85 per cent.

To develop a simple and economical decontamination method, eight different surface sterilization treatments like various combinations of fungicide, antibiotics, mercuric chloride, alcohol and Sodium hypochlorite with different treatment durations were tried. Of these, streptocyclin (0.1%) + citrimide (0.1%) combination for 5 min., mercuric chloride (0.1%) for 3 min. followed 3-4 sterile water rinses has been found beneficial. Percentage of success varied with genome and subgroup. Among diploids, Ney Poovan (AB) recorded 40 % and among tripliods (AAB), silk recorded 58.4%, Poovan 50.2%, Nendran, Pachanadan - 61.3%, Robusta - 88.4%. Among the ABB genome, Pisang Awak-45.4%, Monthan-35.8% and Saba - 60.8%.

Among the different treatments to standardise the size of the explant, 3.0 $cm^3$ was found optimum keeping in view the surface sterilization, survival regeneration and also the recoupment of the contaminated explants.

To overcome apical dominance in accessions belonging to AB (Ney Poovan ) and AAB (Mysore - Poovan) genomes, eight different treatments with 1,2,3 and 4 vertical cuts at explant initiation and first subculturing stages were advocated. Suppressions of apical dominance, activation of axillary resulting enhanced number of shoots were noticed with two vertical cuts 'V' at first sub-culturing stage (of the apical dome keeping the base intact).

Four different rooting media were tried in commercial cultivars like Robusta (AAA), Karpuravalli (ABB).

T1 = 1/2 MS + Fe + Vitamin + Ascorbic Acid + Activated charcoal (0.25 g/l)
T2 = 1/2 MS + Fe + Vitamin + Ascorbic Acid + BAP (1 µm) + 1AA (1 µm)
T3 = 1/2 MS + Fe + Vitamin + Ascorbic acid + NAA ( 2 µm)
T4 = M.S. + Fe + Vitamin + Ascorbic acid + BAP (1 µm) + 1BA ( 5 µm)

Among these, T1 and T3 gave better rooting response interms of no. of roots, root length (root and shoot dry matter) thickness, ramification and field survival (Table 5). Varietal difference was noticed both in nursery and field, of which Robusta was found to perform better with respect to in-vitro retrieved plantlets. Nendran cultivar performed better in T1,

while tetraploid (AAAB) accn. FHIA-01 responded to full MS + Fe + Vit + Ascorbic acid + NAA (2 Um) with 0.25 g/l activated charcoal and reduced concentration of sucrose to 20 g/l.

**Table 5 : Rooting Response cultivars to different rooting media**

| Variety | Treatment (Rooting media) | Root Length (cm) | | No.of well formed | | Shoot length roots | | No. of leaves (cm) | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1st wk | 7th wk | 1st wk | 7th wk | 1stwk | 7th wk | 1st wk | 7th wk |
| Robusta(AAA) | T1 | 4-5 | 20-22 | 3 | 5-6 | 4.0 | 11-12 | 2 | 5 |
| | T2 | 1.5-2 | 10-13 | 2 | 3-4 | 2.5 | 6-7 | 2 | 5 |
| | T3 | 3..0 | 20-24 | 2 | 4-5 | 2.5 | 8-10 | 2 | 4 |
| | T4 | 0.5-1 | 3-20 | 2 | 5 | 2.5 | 7-10 | 2 | 4 |
| Karpuravalli (ABB) | T1 | 2-3 | 20-25 | 2 | 2-3 | 3.5 | 10 | 3 | 6 |
| | T2 | 0.5-1 | 16-18 | 2 | 3-4 | 3.0 | 8 | 2 | 5 |
| | T3 | 1-2 | 20-22 | 2-3 | 4-5 | 2.5 | 12 | 2 | 5 |
| | T4 | <0.5 | 14-16 | 2 | 3-4 | 2.5 | 7-8 | 2 | 4 |

Various stages of hardening of *in-vitro* retrieved plantlets have been identified following a series of hardening studies (Table 6).

**Table 6 : Hardening Requirements of tissue cultured plants**

| | Stages of Hardening | Light intensity µmol/M²/S) | R.H. (%) | Duration (days) |
|---|---|---|---|---|
| 1. | Plants along with culture containers | 40-45 | 65-70 | 4-5 |
| 2. | Plants in netted pots | 40-45 | 60-70 | 10-12 |
| 3. | Plants in polybags | 200-225 | 50-60 | 10-15 |
| 4. | -do- | 500-600 | 50-60 | 30 |
| 5. | -do- | 600-700 | 50-60 | 50-60 |

#### 4.1.2.2 : *In-vitro* Conservation

Tetraploid (ABBB, AABB) clones and bispecific clones (Mysore-AAB, Silk-AAB, Nendran - AAB, Pisang Awak-ABB) have exhibited enhanced number of shoot primordia with the addition of Myo-inositol (100 mg/l). The same response was not noticed with Pome (AAB) and Ney Poovan (AB) sub-groups.

Blackening of explant is a major constraint for faster multiplication. Treatments like additions of antioxidant, activated charcoal, frequency of sub-culturing were tried in different combinations. Ascorbic acid-10 mg/l and activated charcoal (0.25 g/l) reduced blackening in ABB genomes. Increase the sub-culturing frequency from 4-5 weeks to 3 weeks (20-22 days) also reduced blackening and loss of cultures by 26.4% in Pisang Awak (ABB), 16.8 % in Monthan (ABB) and 24.3% in Balbisiana clones.

Some accessions like Gandevi (high yielding banana clones with a potential to yield 60 kg. bunch), Palayankodan (AAB), Pisang Jari Buaya (AA) Rasthali (AAB-Silk) which were more prone to initial culture contamination were tried with different antibiotic (Streptocyclin) concentrations. Streptocyclin 20 mg/l was found to contain the initial culture contamination in all the above varieties.

#### 4.1.2.3 : Embryo culture

Banana exhibits strong male and female sterility. Seed set in bispecific triploid commercial cultivars is a major constraint in Musa crop improvement. Seeds exhibit seed coat dormancy for a period ranging from 1 week to 6 months apart from embryo dormancy. Banana seeds harvested at yellow stage of fruits were treated with 0.1 % $HgCl_2$, soaked in water for 48 hours, surface sterilized with $HgCl_2$ (0.1%) before embryo extraction. Embryos were inoculated onto the medium containing MS + minor salts + glycine - 2 mg, thiamine 0.1 mg, Nicotinic HCl - 0.5 mg. Pyridoxine HCl - 0.5 mg. Ascorbic acid - 10 mg, sucrose (33 g) and devoid of growth regulators. Among the test accessions tried, Pisang Awak (ABB), Mortman (ABB), Bankela (ABB), Balbisiana clones and *Musa velutina* (ornamental) were established through embryo culture and are being evaluated for other growth parameters.

### 4.1.3 : Germplasm Utilization

Germplasm is evaluated for a number of parameters like growth, duration, yield, quality and reaction to biotic and abiotic stresses. Results assist in identification of promising accessions which find their utility directly as superior selections. While evaluating the exotic accessions for their suitability to Indian conditions accn.no. 0697 belonging to Bluggoe sub group was found to be superior with respect to yield and salt tolerance, accn.no.0692 is a tall, robust plant growing from 3.2 to 3.5 m. and with a pseudostem circumference of 75 to 80cm. It has a potential to yield a bunch weighing 35-38 Kg with 12-14 hands in 330-345 days. fruits are dark green, stout, angular without a beak. Main utility of this accession is that it does not exhibit any salt injury even when grown under pH

8.5-9.0 while rest of the accessions could not survive. Chemical analysis suggested maximum K/Na ratio both in root and leaf tissues (6.59 and 8.54 respectively) (Table 7).

Evaluation suggested its excellent cooking qualities with its firm pulp and longer green life of 6 days from date of harvest. It has also proved its suitability for wine preparation among other culinary cultivars. Evaluation for fertility suggests that it can be successfully used as a potential female parent.

**Table 7 : Comparative evaluation of accession 0692 with local bluggoe**

| Parameters | Local bluggoe | Accession 0692 |
|---|---|---|
| Crop duration (months) | 12-13 | 11-12 |
| Average bunch weight(Kg) | 17-18 | 35-38 |
| Number of hands | 4-5 | 9-11 |
| Average number of fingers/hand | 12-13 | 14-16 |
| Average number of fingers/bunch | 60-68 | 126-166 |
| T.S.S. | 18-20 | 18-20 |
| Wilt incidence | Nil | Nil |
| Susceptibility to Sigatoka (PDI) | 18-23.5 | |
| Salt susceptibility (scale 0-6) | 3 | 0 |
| Female fertility | fertile | fertile |

#### 4.1.3.1 : Performance of ratoon crop of promising selections

**Accn.no.0016 :** This selection in Monthan group was allowed for third ratoon and yield stability analysis was carried out for three years. Results suggest Accn.no. 0016 as a stable yielding selection. Sigatoka injury was noted to be lower than local Monthan and fusarium wilt was not noticed from past four years.

**Accn.no.0030 :** After one plant crop and first ratoon, 0030 was affected by wilt pathogen exhibiting field tolerance for 2 seasons. New planting has been taken up and growth parameters are being recorded.

**Accn.no.0052 :** First and second ratoon of accession 0052 exhibited stable yields with 18-20 Kg comparable with local Monthan even under severe salt injury. Irrespective of season of shooting,it maintained 6-7 leaves with salt injury of scale 5.5-6.

**Accn.no.0079 :** Second ratoon of Accn.0079 of Pisang Awak continued to exhibit short stature compared to local Karpuravalli with stable yields of 23 Kg on an average.

#### 4.1.4 : Breeding for biotic and abiotic stresses (S.Uma)

Banana has male and female sterility characters with varying degrees among genomes, groups and subgroups. Evaluation of accessions for their male and female fertility becomes a pre-requisite to proceed through conventional breeding. In the present programme six fertile diploids and an unique (AAB) accession were selected for their

desirable traits like resistance to Sigatoka, tolerance to wilt, nematodes etc. Different accessions from AA, AAA, AB, AAB-Mysore, Pome, Silk, ABB-Pisang Awak, Bluggoe, Monthan, Peyan and nonseeded Balbisiana clones were used as female parents. Variation with respect to genomic compatibility between AA diploid and others was noticed the details are presented in Table 8.

Hybridization attempts and the results obtained suggests that among various diploids tried Hatidat, Amrit Sagar among acuminata group and Thiruvananthapuram among AAB are proved to be better pollen parents. Hatidat has wider compatibility with varied genomic combinations. Results of hybridization, insterms of seed yield also suggested that crosses involving Hatidat resulted in maximum seed yield 1.381 and 1.179 for every cross attempted with Bluggoe (ABB) subgroups followed by Pisang Awak (ABB) combination (Table 6). But percentage of embryoless seeds was more with Saapkal.

The growth and yield parameters of IMTP wilt and sigatoka test plants are presented in the Table 9 & 10.

**_Musa_ Germplasm Information System (MGIS)**

*Musa* Germplasm Information System (MGIS) facilitates germplasm curator with a management tool for their collections and assemble the information available in these collections and form an international database for use by the researchers working on conservation and improvement programmes. International Network for Improvement in Banana and Plantain (INIBAP) centralises the information from all genebanks at global level after verifying its validity and co-ordinates all the activities of the system. As a first level programme, it organised training programme for the genebank curators in which a Scientist from NRCB was trained. The Institute is provided with a software to document the data on germplasm and to develop a database. This has been successfully installed at the centre and a database has been created for more than 50 accessions comprising of wild and cultivated accessions.

**Table 8 : Evaluation of diploids for genomic compatibility and production of *Musa* hybrids.**

| Diploid accessions (AA) | Number of accuminata crosses attempted with | | | | | | | | | | Non-seeded balbisiana clones | Total No. of crosses made | F With fertile crosses | Total No. of seed set |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AA | AAA | ABB | AAB | | | ABB | | | | | | | |
| | | | | Mysore | Pome | Silk | Pa | Bg | Mon | Py | | | | |
| Hatidat | – | 1240 | – | 823 (C) | 912 (C) | 522 | 2050 (C) | 1478 (C) | 388 (C) | 32 | 698 (C) | 8223 | 956 | 508 |
| Amrit Sagar | – | 522 | 474 | 720 | 1113 (C) | 120 | 1195 (C) | – | – | – | – | 4144 | 587 | 142 |
| Kanai Bansi | – | – | – | – | – | – | 701 | – | 335 | 114 | – | 1151 | – | – |
| Sanna Chenkadali | – | 308 | – | 252 | 333 | – | – | – | – | – | – | 893 | – | – |
| Matti | – | – | – | – | 98 | – | 82 | 54 | – | 114 | – | 348 | – | – |
| Anai komban | – | – | – | – | – | – (C) | 2300 | 232 | – | – | – | 2532 | 102 | 71 |

C : Compatible combination

**Table 9 : Growth and Yield Parameters of IMTP (wilt) test plants**

| Name of the Accession | Mean Plant Ht. (cm) | Pseudostem Circumference | | Photosynthetically Active leaves | Days for shooting | Days for maturity 75% | Crop duration (days) | Mean wt. of bunch |
|---|---|---|---|---|---|---|---|---|
| | | At shooting | At harvest | | | | | |
| FHIA-01 | 207.0 | 72.5 | 14.1 | 6.2 | 227.6 | 114.5 | 342.1 | 16.4 |
| FHIA-03 | 239.1 | 88.0 | 13.1 | 6.3 | 260.1 | 106.2 | 366.3 | 21.6 |
| FHIA-17 | 242.2 | 66.2 | 9.2 | - | 365.2 | - | - | - |
| FHIA-23 | | | | | | | | |
| PV03-44 | 247.8 | 68.2 | 14.6 | 5.4 | 222.8 | 160.2 | 383.0 | 8.6 |
| PA03-22 | 178.2 | 65.1 | 15.1 | 7.2 | 195.3 | 158.4 | 354.2 | 9.4 |
| GCTCV-119 | | | | | | | | |
| GCTCV-225 | 142.2 | 47.2 | 13.4 | - | 344.0 | - | - | - |
| Bu | 289.0 | 81.4 | 15.2 | 6.8 | 237.6 | 121.4 | 359.1 | 30.4 |
| Pisang Mas | 260.0 | 59.0 | 14.0 | - | - | - | - | - |
| Saba | 308.7 | 82.0 | 15.5 | 8.6 | 258.2 | 104.5 | 362.7 | 31.5 |
| Pisang Nagka | 266.8 | 71.4 | 10.8 | 4.1 | 335.2 | 98.4 | 438.6 | 8.5 |
| cv. Rose | 167.9 | 44.6 | 13.6 | 4.2 | 216.5 | 128.4 | 344.9 | 3.6 |
| YKM 5 | 200.0 | 59.7 | 9.2 | 4.4 | 320.0 | 68.3 | 388.5 | 3.2 |
| Pisang Jari buaya | 284.2 | 59.7 | 12.2 | 7.1 | 270.2 | 130.4 | 400.6 | 14.3 |
| Calcutta | | | | | | | | |
| GM | 284.0 | 67.4 | 12.1 | - | 360.0 | - | - | - |
| Bluggoe | 303.5 | 90.0 | 14.5 | 7.2 | 299.1 | 116.2 | 415.3 | 2.65 |
| Williams | 138.0 | 97.5 | 10.0 | 7.4 | 303.0 | 98.4 | 401.4 | 15.1 |
| P.ceylan | 260.0 | 75.0 | 11.0 | 6.2 | 298.0 | 110.2 | 408.2 | 17.6 |
| Rasthali | 170.0 | 55.0 | 11.0 | 4.4 | 320.0 | 118.4 | 438.4 | 10.6 |

**Table 10 : Growth and Yield Parameters of Sigatoka accessions**

| Name of the Accession | Mean Plant Ht. (cm) | Pseudostem Circumfer-ence (cm) | Photosynthetically Active leaves | | Days for shooting | Days for maturity | Crop duration (in days) | Mean bunch wt. (in kg.) | Mean No. of hands | Mean No. of fingers |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | At shooting | At harvest | | | | | | |
| FHIA-23 | | | | | | | | | | |
| PV03-44 | 249.2 | 61.4 | 15.3 | 3.2 | 280.4 | 90.4 | 370.8 | 2.2 | 5.2 | 64.3 |
| PA03-22 | 165.3 | 52.4 | 14.3 | 3.4 | 265.3 | 120.3 | 385.6 | 3.0 | 4.3 | 69.3 |
| SH34-36-9 | 265.4 | 70.1 | 9.2 | 4.6 | 295.4 | 95.3 | 390.7 | 8.4 | 11.2 | 148.3 |
| YKM 5 | | | | | | | | | | |
| Saba | 280.4 | 73.7 | 16.4 | 8.4 | 340.2 | 118.4 | 458.6 | 15.4 | 10.4 | 130.2 |
| Pisang Ceylan | 242.9 | 59.4 | 14.2 | 6.4 | 344.5 | 106.3 | 450.8 | 6.5 | 12.2 | 154.6 |
| Calcutta | | | | | | | | | | |
| P.lilin | 154.2 | 36.4 | 9.2 | 3.1 | 230.2 | 96.4 | 326.6 | 2.1 | 4.2 | 46.3 |
| P.beslin | | | | | | | | | | |
| N.yik | | | | | | | | | | |
| Robusta | 228.4 | 62.4 | 10.1 | 4.2 | 304.4 | 110.4 | 414.8 | 6.4 | 7.2 | 98.6 |

## 4.2 : CROP PRODUCTION

**CROP PRODUCTION**
**(General Leader : H.P. Singh)**

This mega project consists of three sub-projects viz. Agro Techniques, Soil Science and Plant Physiology.

In general the application of more organic source of nutrition favoured better plant growth, shorter crop duration, higher bunch weight and increased T.S.S. in all the varieties tested. The Phyllocron (the time taken for emergence of leaf) of different commercial cultivars ranged from 5.84 to 11.88 days and it was increased gradually with the gradual increase in mean temperature and humidity. Maintenance of banana field as weed free upto 6 months after planting resulted in enhanced vegetative growth, bunch weight and lesser crop duration.

Studies on sodic injury indicated that severity of sodic injury in the saline sodic soils, depends upon the leaf K concentration. Studies on K/Na ratio with yield revealed that the leaf K/Na ratio was positive and significant correlation was noticed. It was testing also found that the variety Saba has the capacity to exclude Na and absorb more K at the root level and thus variety has high root and leaf K/Na ratio in the saline and saline sodic soil. Standardization of the procedure for measurement of membrane stability under salt stress in banana was worked out. Studies revealed that variety Karpuravalli has got field tolerance capacity due to its higher membrane stability than Nendran.

### 4.2.1 : Standardization of agrotechniques for banana production productivity

#### 4.2.1.1 : Effect of edaphic factors on the growth, yield and quality and incidence of leaf spot disease in different banana cultivars. (V.Kumar)

**Pachanadan**

Significant differences were recorded among the treatments for all the characters. The results showed that the plants under T3 took less time for flowering (281.2 days) but matured late (140.5 days) which was on par with T1 (138.5 days) and T2 (138.8 days). This delay in maturity of bunches may be attributed to the coincidence of bunch emergence and maturity during comparatively cooler weather conditions. The number of fingers per hand (15.00) and fingers per bunch (114.75) and the bunch weight (11.48 kg) were found to be more under T1 and was less under T4 (Table 11a).

**Nendran**

In Nendran, the time taken for flowering varied from 275.72 (T5) to 322.53 days (T1) and the maturity period varied from 96.75 (T4) to 108.5 days (T3). Significant differences were also recorded on bunch weight, number of hands and fingers per bunch. T5 recorded the maximum bunch weight (13.05 ) with more number of hands/bunch (6.25) and a minimum was recorded under 4.58 (T3).

**Robusta**

Significant differences were recorded for all the characters and the plants under T6 flowered early (307.75 days) while the plants under T1 took more time (373.0 days). Maximum number of hands (9.13) and fingers (135.25) per bunch and no. of fingers/hand (17.7) were recorded under T6. The time taken for fruit maturity was less (107.25 days) in T4 while it was maximum under T3 (117.0days).

**Rasthali**

In Rasthali, significant differences were recorded for time taken for flowering, bunch weight and number of hands per bunch. The bunch weight was maximum (14.2kgs) under T2 followed by T5 (12.8 kgs) and it was the minimum under T1 (10.55 kgs). The number of fingers per hand was maximum under T5 (Table 11b).

**Poovan**

In Poovan, both the interval between planting and flowering as well as flowering and harvest were found less under T6 (321.48 and 110.00 days respectively) whereas T1 recorded maximum time for flowering (371.28 days) and T2 took more time for maturity (129.00 days). The bunch weight was more under T5 (17.78 kgs) followed by T6 (17.03 kg) which also recorded maximum number of hands (12.00) and fingers (169.38) per bunch.

**Karpuravalli**

Like Robusta and Poovan cultivars, the plants under T6 flowered significantly earlier (367.33 days) when compared to other treatments but it also took more time for bunch maturity (137.75 days). Maximum bunch weight (18.95 kgs) with more number of hands (10.75) were recorded under T4 where the number of fingers per hand (17.13) and number of fingers per bunch (159.38) were maximum under T6.

The phyllochron (time taken for emergence of a leaf) were recorded regularly at monthly interval from all the cultivars and were correlated with the weather parameters prevailed during the period (Table 12). Significant differences were recorded with different treatments in all the cultivars. The phyllochron ranged from 5.84 days to 11.88 days and in general the phyllochron found gradually increased with the gradual increase in mean temperature and humidity.

**Table 11a : Effect of edaphic factors on flowering and yield parameters of banana cultivars Pachanadan, Nendran and Robusta**

| | Time taken for | | Bunch Weight (Kgs) | No. of hands/ bunch | No. of fingers/ hand | Total No. fingers/ bunch |
|---|---|---|---|---|---|---|
| | Flowering (Days) | Maturity (Days) | | | | |
| Pachanadan: | | | | | | |
| T1 | 301.45 | 138.50 | 11.48 | 8.13 | 15.00 | 114.75 |
| T2 | 316.85 | 138.75 | 9.88 | 7.63 | 14.25 | 106.38 |
| T3 | 281.20 | 140.50 | 8.77 | 7.63 | 14.13 | 102.63 |
| T4 | 337.86 | 120.75 | 8.73 | 7.13 | 14.33 | 99.00 |
| T5 | 302.60 | 119.50 | 10.50 | 8.38 | 14.88 | 109.63 |
| T6 | 305.45 | 118.75 | 11.00 | 9.00 | 13.25 | 105.88 |
| CD (P=0.05) | 18.587 | 8.667 | 1.330 | 0.624 | 0.868 | 6.641 |
| Nendran: | | | | | | |
| T1 | 322.53 | 100.00 | 9.83 | 5.40 | 10.50 | 65.13 |
| T2 | 302.98 | 105.00 | 10.95 | 5.28 | 10.88 | 62.00 |
| T3 | 311.83 | 108.50 | 10.13 | 4.58 | 10.13 | 58.13 |
| T4 | 289.83 | 96.75 | 9.08 | 5.65 | 8.75 | 53.13 |
| T5 | 275.72 | 103.75 | 13.05 | 6.25 | 10.13 | 60.63 |
| T6 | 281.68 | 101.75 | 12.00 | 5.60 | 10.63 | 63.13 |
| CD (P=0.05) | 19.131 | 5.681 | 1.016 | 0.383 | N.S. | 5.210 |
| Robusta: | | | | | | |
| T1 | 373.00 | 110.75 | 14.65 | 8.94 | 15.13 | 121.00 |
| T2 | 347.72 | 111.00 | 13.45 | 8.63 | 16.00 | 128.43 |
| T3 | 321.73 | 117.00 | 12.45 | 8.13 | 14.25 | 116.63 |
| T4 | 314.33 | 107.25 | 13.43 | 7.50 | 15.13 | 120.63 |
| T5 | 316.35 | 110.50 | 17.78 | 8.50 | 15.00 | 117.38 |
| T6 | 307.75 | 113.00 | 17.03 | 9.13 | 17.70 | 135.25 |
| CD (P=0.05) | 22.020 | 5.935 | 3.208 | 0.526 | 1.567 | 12.513 |

T1 - June planted
T2 - August planted
T3 - October planted
T4 - December planted
T5 - February planted
T6 - April planted

**Table 11b : Effect of edaphic factors on flowering and yield parameters of banana cultivars Rasthali, Poovan and Karpuravalli:**

| | Time taken for | | Bunch Weight (Kg) | No. of hands/ bunch | No. of fingers/ hand | Total No. fingers/ bunch |
|---|---|---|---|---|---|---|
| | Flowering (Days) | Maturity (Days) | | | | |
| Rasthali: | | | | | | |
| T1 | 374.25 | 105.25 | 10.55 | 6.88 | 12.88 | 90.25 |
| T2 | 383.10 | 105.25 | 14.20 | 7.75 | 13.00 | 95.38 |
| T3 | 352.10 | 110.75 | 10.58 | 6.50 | 13.25 | 90.13 |
| T4 | 383.48 | 107.25 | 11.33 | 7.63 | 13.25 | 90.00 |
| T5 | 341.63 | 109.00 | 12.80 | 8.13 | 13.70 | 90.88 |
| T6 | 346.75 | 107.25 | 12.48 | 7.75 | 13.00 | 89.13 |
| CD (P=0.05) | 15.964 | N.S. | 2.537 | 0.608 | N.S. | N.S. |
| Poovan : | | | | | | |
| T1 | 371.28 | 116.75 | 14.65 | 11.38 | 17.38 | 169.13 |
| T2 | 365.25 | 129.00 | 13.45 | 9.63 | 14.75 | 145.63 |
| T3 | 350.65 | 119.25 | 12.45 | 10.75 | 17.50 | 163.00 |
| T4 | 354.88 | 112.00 | 13.43 | 10.38 | 16.75 | 145.63 |
| T5 | 345.33 | 113.50 | 17.78 | 10.75 | 16.38 | 161.00 |
| T6 | 321.48 | 110.00 | 17.03 | 12.00 | 17.25 | 169.38 |
| CD (P=0.05) | 19.968 | 6.776 | 3.208 | N.S. | N.S. | 12.295 |
| Karpuravalli: | | | | | | |
| T1 | 414.13 | 128.25 | 13.83 | 9.38 | 15.88 | 131.88 |
| T2 | 397.75 | 127.25 | 15.08 | 9.25 | 16.38 | 139.00 |
| T3 | 385.50 | 134.25 | 14.65 | 9.50 | 16.63 | 142.13 |
| T4 | 397.33 | 126.75 | 18.95 | 10.75 | 15.38 | 156.75 |
| T5 | 383.13 | 124.25 | 15.25 | 9.38 | 16.13 | 141.50 |
| T6 | 367.33 | 137.75 | 16.92 | 10.00 | 17.13 | 159.38 |
| CD (P=0.05) | 11.647 | 9.041 | 1.483 | N.S. | N.S. | 12.460 |

T1 - June planted
T2 - August planted
T3 - October planted
T4 - December planted
T5 - February planted
T6 - April planted

**Table 12 : Phyllochron (Days/leaf) of banana cultivars under different weather parameters:**

| Treatment | Mean Temperature (°C) | Mean relative humidity (RH | Pachanadan | Robusta | Rasthali | Poovan | Karpuravalli |
|---|---|---|---|---|---|---|---|
| T1 (July) | 30.75 | 54.25 | 7.04 | 5.79 | 5.84 | 8.48 | 10.63 |
| T2 (August) | 30.65 | 53.40 | 8.07 | 8.31 | 7.41 | 9.49 | 6.41 |
| T3 (September) | 29.50 | 63.80 | 8.72 | 8.51 | 8.07 | 10.92 | 7.96 |
| T4 (October) | 27.70 | 75.20 | 9.81 | 9.47 | 9.50 | 10.93 | 9.56 |
| T5 (November) | 26.50 | 84.80 | 8.85 | 9.26 | 10.30 | 11.46 | 8.52 |
| T6 (December) | 26.30 | 84.50 | 9.95 | 10.29 | 9.15 | 11.88 | 8.79 |
| C.D.(P=0.05) | | | 0.719 | 1.561 | 0.940 | 3.889 | 0.739 |

### 4.2.1.2 : Effect of organic and inorganic nutrition on growth, yield and fruit quality of different banana cultivars. (V.Kumar and K.J.Jeyabaskaran)

Observations were recorded on growth (plant height, pseudostem circumference, number of leaves and crop duration), yield (bunch weight, number of hands and fingers/ bunch and total yield) and fruit T.S.S. in fruit ratoon crop of five banana cultivars (Rasthali, Robusta, Poovan, Monthan and Karpuravalli). The effect of different sources of Nitrogen on the physico-chemical properties were also studied and the results are presented in Table 13.

Application of 25%N FYM + 50% N neem cake + 25%N urea recorded more vigorous plants interms of increased plant height, pseudostem circumference, number of leaves shorter crop cycle and produced more yield and also increased the fruit T.S.S. in Rasthali, Robusta and Poovan cultivars. Whereas, T4 25% N FYM + 25% n neem cake + 50% N urea was found to have more favourable effect on growth, yield and fruit quality of Monthan and Karpuravalli followed by T5. Irrespective of the cultivars all these parameters were found to be the least in plants received 100% N inorganic source of Nitrogen i.e. urea besides extending the crop duration.

In addition, application of more organic nutrition improved the soil physico-chemical properties as it reduced the pH and bulk density and increased the porosity of the soil Table 14. The organic carbon content (0.68%) and K/Na ratio (0.47) were found significantly more under T5 followed by T4 and were least under T1 (0.28% and 0.21 respectively).

### 4.2.1.3 : Assessment of losses due to weeds in banana cv. Karpuravalli. (V.Kumar)

Observations recorded on plant growth and yield parameters (Table 15) revealed that in the unweeded plants (T1) there was 26.45 and 25.03 per cent reduction in plant height and pseudostem circumference compared to T8 i.e. weed free condition maintained upto 9 months after planting (MAP). The presence of weeds also extended the flowering time (462.75 days) and maturity (143.00 days), reduced the bunch weight (33.15 per cent) and number of hands and fingers per bunch. Weed free conditions maintained upto 9 months favoured the plants to produce heavy bunches (16.8 kgs) with more number of hands (11.63) and fingers (157.75) which was on par with T7 (Weed free upto 6 MAP). From the above results it is clear that first six months of growth of banana is sensitive to weeds and the presence of any weeds which competes with the young banana plants will affect the initial growth and development of plants which reflects not only in poor bunch weight but also increased crop duration.

The results from the Experiment I revealed that the plant growth and yield showed significant variations depending on the weather prevailed during the early stages of the growth and at flowering and post flowering stages of all the cultivars. The near optimum

**Table 13 : Influence of Organic and inorganic sources of nutrition on plant growth, yield and quality of banana cultivars (Ist ratoon)**

| Treatments | Plant Height (cm) | Pseudostem Circumference | No. of leaves/ (cm) | Crop durtion plant (Days) | Bunch weight (Kg) | Total yield (Kg) | T.S.S. (°B) (t/ha.) |
|---|---|---|---|---|---|---|---|
| RASTHALI | | | | | | | |
| T1 | 216.50 | 57.68 | 14.83 | 360.38 | 11.35 | 35.03 | 22.50 |
| T2 | 212.13 | 59.68 | 15.40 | 339.50 | 11.73 | 36.05 | 23.48 |
| T3 | 207.25 | 57.80 | 15.48 | 344.25 | 12.38 | 38.19 | 23.78 |
| T4 | 215.00 | 60.40 | 16.53 | 330.38 | 12.35 | 38.11 | 24.05 |
| T5 | 217.63 | 63.05 | 17.80 | 319.88 | 14.13 | 43.59 | 24.35 |
| T6 | 210.50 | 60.50 | 14.88 | 329.00 | 12.28 | 37.13 | 24.20 |
| C.D.(P=0.05) | N.S. | 2.584 | 0.724 | 14.571 | 1.177 | 3.764 | 0.839 |
| ROBUSTA | | | | | | | |
| T1 | 215.50 | 53.65 | 15.25 | 333.25 | 13.98 | 43.15 | 22.15 |
| T2 | 208.50 | 55.50 | 14.60 | 320.25 | 14.75 | 45.55 | 22.60 |
| T3 | 203.75 | 55.08 | 14.00 | 318.75 | 14.65 | 44.98 | 22.60 |
| T4 | 210.50 | 57.50 | 15.13 | 311.25 | 15.53 | 47.90 | 23.35 |
| T5 | 235.08 | 66.25 | 16.92 | 302.50 | 17.10 | 52.78 | 24.15 |
| T6 | 211.25 | 55.10 | 13.80 | 320.25 | 14.73 | 45.45 | 22.50 |
| C.D.(P=0.05) | 8.302 | 3.919 | 1.093 | 10.990 | 1.074 | 3.341 | 0.621 |
| POOVAN | | | | | | | |
| T1 | 244.08 | 58.95 | 12.80 | 376.38 | 12.10 | 37.35 | 22.45 |
| T2 | 240.65 | 58.05 | 14.05 | 360.13 | 13.15 | 40.60 | 23.00 |
| T3 | 251.93 | 61.93 | 13.15 | 361.88 | 13.48 | 41.63 | 22.90 |
| T4 | 248.33 | 63.93 | 13.98 | 355.50 | 13.98 | 43.18 | 23.50 |
| T5 | 285.88 | 69.53 | 15.53 | 340.80 | 15.20 | 46.95 | 23.95 |
| T6 | 254.15 | 62.13 | 12.95 | 358.38 | 13.95 | 43.10 | 23.05 |
| C.D.(P=0.05) | 11.065 | 4.244 | 1.191 | 11.705 | 0.925 | 2.873 | 0.499 |
| MONTHAN | | | | | | | |
| T1 | 273.80 | 61.15 | 14.45 | 389.38 | 13.90 | 43.80 | 19.63 |
| T2 | 276.25 | 63.43 | 15.48 | 380.88 | 14.68 | 45.25 | 20.25 |
| T3 | 270.75 | 63.05 | 15.38 | 377.38 | 14.98 | 46.20 | 20.40 |
| T4 | 287.75 | 69.48 | 15.68 | 362.88 | 15.90 | 49.05 | 21.35 |
| T5 | 279.00 | 67.63 | 16.15 | 358.75 | 15.75 | 48.60 | 20.50 |
| T6 | 272.50 | 62.38 | 15.08 | 380.25 | 14.70 | 45.53 | 19.60 |
| C.D.(P=0.05) | N.S. | N.S. | N.S. | 15.086 | 0.758 | 2.333 | 0.864 |
| KARPURAVALLI | | | | | | | |
| T1 | 290.40 | 63.30 | 15.15 | 419.60 | 14.53 | 44.83 | 25.80 |
| T2 | 285.15 | 65.58 | 16.38 | 401.90 | 15.03 | 46.37 | 26.35 |
| T3 | 298.38 | 68.38 | 16.00 | 412.05 | 16.05 | 49.45 | 26.75 |
| T4 | 307.98 | 71.30 | 17.20 | 393.30 | 17.35 | 53.55 | 27.20 |
| T5 | 298.98 | 69.40 | 16.22 | 399.25 | 16.78 | 51.77 | 26.70 |
| T6 | 295.40 | 66.80 | 15.35 | 402.30 | 15.60 | 48.14 | 26.00 |
| C.D.(P=0.05) | 7.305 | 4.323 | 1.044 | N.S. | 1.199 | 3.702 | 0.592 |

**Table 14 : Effects of different sources of nitrogen on soil physio-chemical properties of banana plantation**

| Treatments | pH | E.C. (dS/m) | Organic Carbon (%) | K (ppm) | Na (ppm) | K/Na | Bulk density ($Mg/m^3$) | Porosity (%) |
|---|---|---|---|---|---|---|---|---|
| T1 | 8.8 | 0.17 | 0.28 | 191 | 717 | 0.21 | 1.35 | 49.7 |
| T2 | 8.6 | 0.18 | 0.34 | 215 | 729 | 0.30 | 1.32 | 50.0 |
| T3 | 8.4 | 0.24 | 0.52 | 263 | 695 | 0.38 | 1.31 | 50.6 |
| T4 | 8.2 | 0.26 | 0.59 | 297 | 704 | 0.43 | 1.30 | 50.9 |
| T5 | 8.1 | 0.26 | 0.68 | 320 | 700 | 0.47 | 1.28 | 51.8 |
| T6 | 8.4 | 0.21 | 0.43 | 240 | 699 | 0.35 | 1.32 | 50.4 |
| CD (P=0.05) | 0.23 | 0.029 | 0.049 | 24.6 | 34.4 | 0.049 | 0.017 | 0.70 |
| | | | | | | | (n=120) | |

T1 = (100% N inorganic)
T2 = (25% N FYM + 75% N inorganic)
T3 = (25% N neemcake + 75% N inorganic)
T4 = (25% N FYM + 25% N NC + 50% N inorganic)
T5 = (25% N FYM + 50%N neemcake + 25% N inorganic)
T6 = (25% N FYM + Green manure + 75% N inorganic)

**Table 15 : Estimation of losses due to weeds in growth and yield of banana cv. Karpuravalli**

| Treatment | Plant Height (cm) | Pseudostem Circumference (cm) | No. of leaves | Time taken for | | Bunch Weight (Kg) | No. of hands per Bunch | No. of fingers per Bunch |
|---|---|---|---|---|---|---|---|---|
| | | | | Flowering (Days) | Harvest (Days) | | | |
| T1 | 244.15 (26.45) | 56.70 (25.03) | 15.38 (16.32) | 462.75 | 143.00 | 11.23 (33.15) | 7.58 (34.82) | 112.13 (28.92) |
| T2 | 268.63 (19.08) | 61.63 (18.51) | 15.50 (15.67) | 423.00 | 135.50 | 12.65 (24.70) | 8.73 (24.94) | 124.50 (21.08) |
| T3 | 287.03 (13.53) | 66.00 (12.73) | 15.55 (15.40) | 417.00 | 140.25 | 12.53 (25.42) | 8.85 (23.90) | 139.50 (11.57) |
| T4 | 292.15 (11.99) | 69.13 (8.59) | 16.75 (8.87) | 398.00 | 116.78 | 14.43 (14.11) | 9.80 (15.74) | 145.25 (7.92) |
| T5 | 251.38 (24.27) | 58.25 (22.98) | 16.40 (10.77) | 406.50 | 138.00 | 11.98 (28.69) | 8.78 (24.51) | 125.25 (20.60) |
| T6 | 288.50 (13.09) | 66.00 (12.73) | 16.17 (12.02) | 398.88 | 129.63 | 13.90 (17.26) | 9.70 (16.60) | 135.75 (13.95) |
| T7 | 312.45 (5.87) | 70.80 (6.28) | 17.75 (3.43) | 372.75 | 121.13 | 15.83 (5.77) | 10.33 (11.18) | 147.75 (6.34) |
| T8 | 331.95 | 75.63 | 18.38 | 367.50 | 110.62 | 16.80 | 11.63 | 157.75 |
| C.D.(P=0.05) | 12.845 | 3.470 | 1.329 | 10.223 | 9.027 | 1.248 | 0.822 | 12.507 |

Figures in the paranthesis indicate the percentage of loss over T8

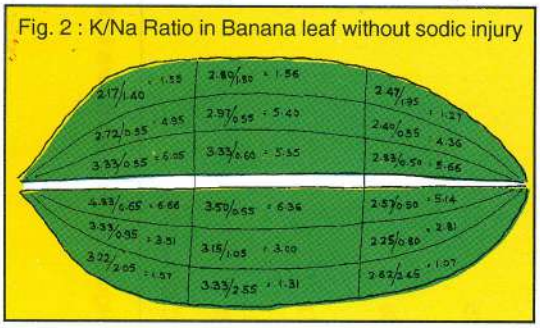
temperature and humidity with less wind velocity favoured optimum plant growth and development. Studies on phyllochron revealed that there was a steady increase in phyllochron (days taken for leaf emergence) with a gradual decrease in temperature and humidity.

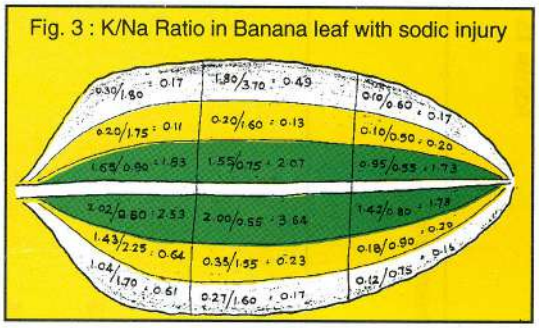
From the Experiment on organic and inorganic nutrition trial it was observed that application of 25% N FYM + 50% N neemcake + 25% N inorganic improved the growth, enhanced the bunch weight, reduced the crop duration and increased the fruit T.S.S. in banana cultivars Rasthali, Robusta and Poovan. Whereas, for Monthan and Karpuravalli cultivars applications of 25% N FYM + 25% N neemcake + 50% N inorganic were found optimum to increase the plant height, pseudostem circumference, number of leaves and bunch weight and fruit T.S.S. Irrespective of all cultivars, the plant growth, yield and quality was found to be less in plants supplied with 100% N inorganic. In addition, application of more organic nutrition improved the physio-chemical properties of the soil which in turn favoured the better growth and development of plants under T4 and T5.

### 4.2.2 : Soil - Plant Relationship

#### 4.2.2.1 : Studies on Sodic Injury in Banana Leaves with Reference to Sodium and Potassium Accumulation Pattern (K.J.Jeyabhaskaran)

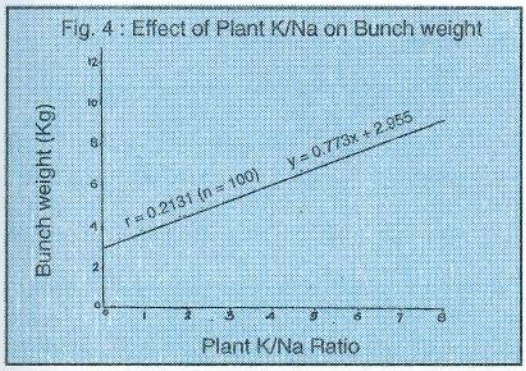
The marginal chlorosis in the banana leaves due to salt injury is one of the major problems in the regions of saline and saline sodic soils. Heavy yield loss is observed due to this salt injury as the active photosynthetic regions of the leaves are affected. The correlation studies on leaf and soil Na contents and salt injury level clearly indicated that Na is the main causal element for this 'so called' salt injury. Based on the above findings, a study was conducted to find out the Na accumulation pattern in the banana leaves. In this study leaves with and without salt injuries were collected and cut into different segments as shown in the fig. 2 and 3. Each segment was analysed for both Na and K contents by



flame photometry. The leaf Na concentration gradually increased from base to tip and from midrib portion to the marginal regions and the reverse was true in case of leaf K concentration. It was very interesting to note that the greenish (healthy) segments of the injured leaf had K/Na ratio of more than one and affected (injured) segments had the K/Na ratio of less than one. The K/Na ratios of all the segments of healthy leaf were found to be more than one. The overall Na concentration of both injured and healthy leaves were more or less same (1.36 and 1.12 per cent, respectively). The overall K concentration of both injured and healthy leaves were of deficient and sufficient levels, respectively (1.02 and 3.13 per cent, respectively). This study clearly indicated that severity of sodic injury in banana leaves in the saline sodic soils, depends upon the leaf K concentration.

Another interesting phenomenon observed in this study was a gradual decrease of K/Na ratio from midrib portion to the marginal regions of leaves. This clearly answers the question, why does the salt injury (or sodic injury) spread from the margin towards midrib portion with an yellow front ?




Based on these findings, leaf samples from 100 banana plants of different varieties were collected from saline sodic patches of NRCB farm and analysed for their K/Na ratio. In the end of the experiment the yield data of the same plants were also collected. Simple correlation was worked out between leaf K/Na and yield. It was noted that the leaf K/Na had positive and significant correlation (r=0.2131**) with the yield (fig. 4). From the above experiments, it was inferred that the banana leaves should have the K/Na ratio of more than one for the optimum yield.

**4.2.2.2 : Studies on Na excluding and K absorbing Capacity of Different Varieties of Banana in Saline Sodic Soil**

To study the Na excluding capacity of banana crop, leaf and corresponding root samples were collected in three replications from banana crops of different varieties like Burro Cemsa, Saba, Pisang Ceylan, Rasthali, Monthan, Bluggoe, Pisang Awak and Robusta that are cultivated in saline sodic patches of NRCB farm where the exchangeable soil Na contents ranged from 2.17 to 3.26 cmol kg-1 and exchangeable soil K ranged from 0.72 to 0.82 cmol kg-1. The root and leaf samples were analysed for Na and K. The mean root Na ranged from 0.48 to 0.78 per cent and mean leaf Na ranged from 0.27 to 0.35 per cent (Table 16). The variety, Saba recorded the minimum root Na. Except Pisang Ceylan and Rasthali, all the varieties had no significant difference in root

N content. More sodium accumulation was observed in the roots of Pisang Ceylan and Rasthali. Eventhough all the varieties had no significant difference in the leaf Na, the Saba recorded the minimum value.

The root K and leaf K significantly varied from 2.17 to 3.39 and from 1.81 to 2.48 per cent, respectively. The varieties, Saba and Burro Cemsa recorded the maximum root K and leaf K, respectively.

The root K/Na and leaf K/Na ranged significantly from 3.00 to 6.59 and from 6.69 to 8.54, respectively. The Saba recorded maximum root and leaf K/Na ratios. From the above findings, it was found that the performance of the variety, Saba is very good. It is concluded that the variety, Saba has the capacity of excluding Na and absorbing more K at the root level and this variety has high root and leaf K/Na ratio in the saline and saline sodic soil.

**Table 16 : Root and leaf Na & K of different varieties of banana (%)**

| Sl. No. | Variety | Root | | | Leaf | | |
|---|---|---|---|---|---|---|---|
| | | Na | K | K/Na | Na | K | K/Na |
| 1. | Burro Cemsa | 0.55a | 3.12bc | 5.73cd | 0.30 | 2.48d | 8.38b |
| 2. | Saba | 0.52a | 3.39c | 6.59d | 0.27 | 2.26bc | 8.54b |
| 3. | Pisang Ceylan | 0.78b | 3.09bc | 4.14ab | 0.28 | 2.11bc | 7.48ab |
| 4. | Rasthali | 0.73b | 2.17a | 3.00a | 0.32 | 2.21bc | 6.97a |
| 5. | Monthan | 0.48a | 2.48a | 5.15bcd | 0.30 | 2.05ab | 6.85a |
| 6. | Bluggoe | 0.58a | 2.71ab | 4.70bc | 0.28 | 1.81a | 6.79a |
| 7. | Pisang Awak | 0.63a | 3.18bc | 5.05bc | 0.30 | 1.99ab | 6.69a |
| 8. | Robusta | 0.60a | 3.23bc | 5.39bcd | 0.35 | 2.36c | 6.74a |
| | CD (P=0.05) | 0.185 | 0.553 | 1.516 | NS | 0.293 | 1.341 |

(**Note** : Values with same letter have no significant difference in a column)

### 4.2.2.3 : A Computer Programme in BASIC for Soil Suitability Classification for Banana Based on Soil Texture

Banana crop comes up in variously textured soils. Generally, banana is not coming up well in light sandy soils and heavy clay soils but in medium textured soils, like silty clay loam, clay loam, silty loam, loam etc. Every farmer, before cultivating banana in his field, he should know whether his farm soil is suitable for banana or his farm soil requires any

amendment for cultivation. For this purpose a computer programme in BASIC was developed at NRCB for soil suitability classification for banana based on soil texture. This programme will be highly useful during the analysis of efficiency of banana orchards in different banana growing regions.

### 4.2.3 : Physiological studies for banana improvement

#### 4.2.3.1 : Standardization of the procedure for measurement of membrane stability under salt stress in banana. (R.H.Laxman)

Under salt tolerance studies, efforts were made to standardise the measurement of membrane stability in Banana. The root tissue bits 5 mm diameter and 10 mm long were incubated, in NaCl solution with different concentrations ranging from 0.25M to 1.50M, for 3 hours. After the incubation, tissue samples were rinsed with distilled water and transferred to vials containing 10 ml of distilled water. Electric conductivity (EC) was measured after keeping the samples overnight. Among the two commercial varieties tested, Karpuravalli which is found field tolerant, also showed higher membrane stability than Nendran.

#### 4.2.3.2 : Studies on nutrient deficiency

During the survey many netrient deficiency symptoms were observed in banana plantations. The iron deficiency in cultivar nendran showed severe chlorosis.

*chlorosis induced by iron deficiency in banana*

## 4.3 : CROP PROTECTION

**CROP PROTECTION**
**(General Leader : P.Sundararaju)**

Research programmes on Nematodes, Fungus, Viruses and Insect pests are kept under crop protection mega programme. Survey conducted in 10 districts of Tamil Nadu and Pondicherry revealed that out of 12 genera of plant parasitic nematodes identified, the nematodes such as *Pratylenchus coffeae, Meloidogyne incognita, Helicotylenchus multicinctus* were the predominant species. The population of *Radopholus similis* increased in the months of January to April. It was also found that 50% N applied through neem cake reduced the nematode population of *P.coffeae*. Germplasm evaluation studies against Sigatoka revealed that varieties such as local Peyan (ABB), Thiruvananthapuram (AAB), Pisang Raja (AAB) and Vadakkan Kadali (AA) were found to be resistant to yellow Sigatoka. It was also found that 1°C rise in temperature raised the disease development time (DDT in days) from 6 to 14 days and 1% rise in RH decreased the DDT value to 1.5 to 5 days.

Maximum of 60% BBMV infection in a Nendran orchard and 24.0% BSV in Poovan variety was observed during the survey conducted in Tamil Nadu and Kerala. The particles of BBMV and BSV were also observed from the samples collected from both bracts and fingers of Pacha Bontha Batheesa under EM. Important insect pests such as tobacco caterpillar, pseudostem weevil, rhizome borer, lacewing and bagworm were recorded during the survey made in Tamil Nadu.

### 4.3.1 : Studies on banana nemotodes and their management

#### 4.3.1.1 : Survey for Nematode (P.Sundararaju)

A total of 108 each of soil and root samples were collected from different places in 10 districts of Tamil Nadu and Pondicherry, revealed the occurrence of 12 genera of plant parasitic nematodes associated with the crop Table 17. It was observed that the nematodes *Pratylenchus coffeae, Meloidogyne incognita* and *Helicotylenchus multicinctus* were the dominant species associated with banana in most of the districts surveyed. The burrowing nematode, *Radopholus similis* was recorded in Srirangam and Lalgudi taluks of Trichy district, Vathalagundu taluk of Dindigul district and Upparpatty taluk of Theni district. The other important nematodes found associated with

banana were *Rotylenchulus reniformis, Heterodera oryzicola, Hoplolaimus* sp., *Tylenchorhynchus* sp., *Rotylenchus, Hirschmaniella* sp., *Hemicriconemoides* sp. and *Tylenchus* sp. Soil and root samples collected from all the banana experimental fields at NRCB Farm revealed the presence of 15 genera of plant parasitic nematodes. Among them four species, viz. *R.similis, P.coffeae, H.multicinctus* and *M. incognita* were the predominant species.

**Table 17 : Occurrence of major plant parasitic nematodes recorded from the rhizosphere of banana in different districts of Tamil Nadu and Pondicherry**

| Sl. No. | District | No.of samples collected | No. of samples yielded major nematode pathogens | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Radopholus similis* | | *Pratylenchus coffeae* | | *Meloidogyne incognita* | | *Helicotylenchus multicinctus* | |
| | | | Soil | Root | Soil | Root | Soil | Root | Soil | Root |
| 1. | Trichy | 45 | - | 5 | - | 35 | 8 | 14 | 4 | 8 |
| 2. | Karur | 11 | - | - | - | 2 | 2 | 5 | 2 | 5 |
| 3. | Salem | 03 | - | - | - | 2 | - | - | - | - |
| 4. | Villuppuram | 03 | - | - | - | - | - | - | - | - |
| 5. | Kanchipuram | 04 | - | - | - | - | - | 2 | - | 2 |
| 6. | Cuddalore | 09 | - | - | - | 4 | 1 | 3 | - | 2 |
| 7. | Thanjavur | 07 | - | - | - | 5 | 1 | 3 | - | 2 |
| 8. | Dindigul | 04 | - | 1 | - | 1 | - | 1 | 3 | 2 |
| 9. | Madurai | 04 | - | - | - | - | - | 2 | 1 | 1 |
| 10. | Theni | 13 | - | 2 | - | 3 | 1 | 3 | 6 | 3 |
| 11. | Pondicherry | 05 | - | - | - | 2 | 3 | 4 | - | 2 |
| | Total | 108 | - | 8 | - | 52 | 16 | 39 | 16 | 31 |

\- indicates did not yield any nematodes

#### 4.3.1.2 : Population fluctuations studies on major nematodes

In order to study the population fluctuation of *R.similis* on three cultivars viz. Kalyan Bale, Alukkel and Kalibow (Tissue culture) and *P.coffeae* on variety Nendran which are highly susceptible to the respective nematodes, root samples were collected at monthly interval during 1997 and nematode populations were assessed. Drastic increase of *R.similis* population during the months of Jan.-April which later reduced to negligible level from May to October. Again a steady increase was noticed from November to December *P.coffeae* on cultivar Nendran showed a maximum population from October to December and minimum population in the month of May to August (Fig.5 to 8.)

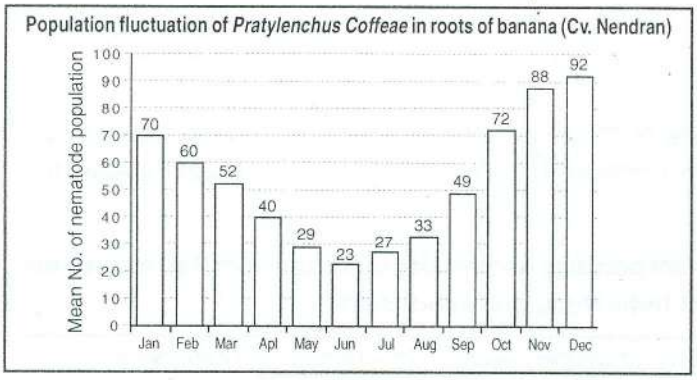



Fig. 5

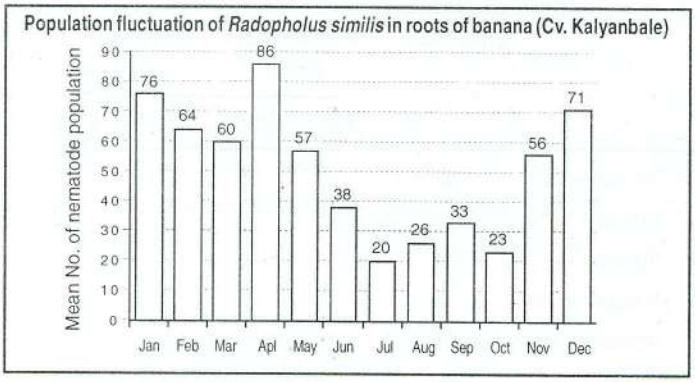



Fig. 6

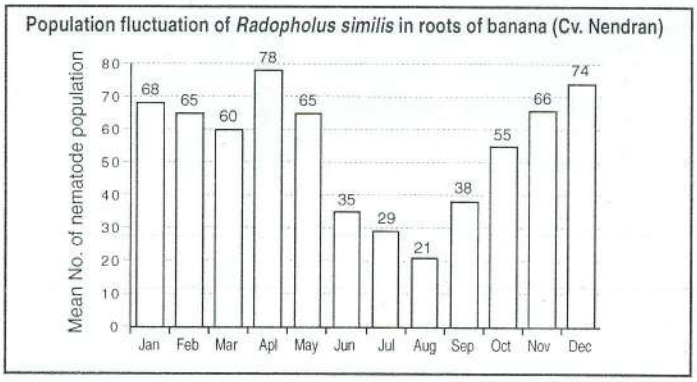



Fig. 7

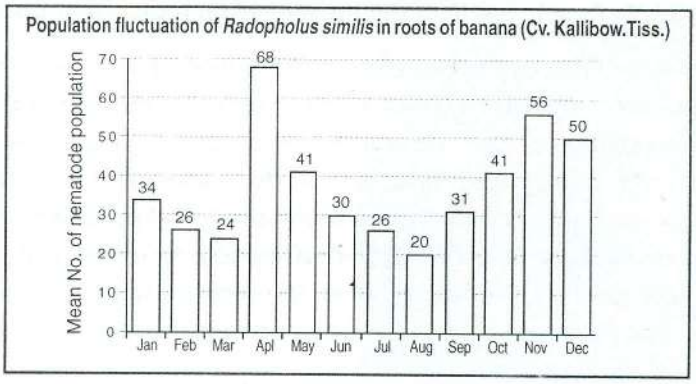



Fig. 8

#### 4.3.1.3 : Effect of organics and inorganics on population build up of *Pratylenchus coffeae*

The effect of organic and inorganics on population build up of *P.coffeae* was studied in all six commercial cultivars Nendran, Karpuravalli, Rasthali, Monthan, Poovan and Robusta. Samples of both soil and root were collected from all the six cultivars and assessed for nematode population. Maximum population of *P.coffeae* was recorded in cultivar Nendran followed by Karpuravalli and Robusta. Among the six treatments sampled, minimum nematode population was recorded in treatment No.5, where 50% N was applied through Neem Cake. Plants grown in treatment No.3 and 4 also showed the minimum nematode population, as those plants received 25% N through Neem cake. Whereas, maximum nematode population was recorded in treatment No.1, 2 and 6 where neem cake was not applied. This study clearly indicated the Neem cake in the Nematode control.

#### 4.3.1.4 : Evaluation of *Musa* germplasm against major Nematodes under field conditions

A preliminary field screening among 567 *Musa* germplasm available at NRCB against the pathogens viz. *R.similis, P.coffeae, M.incognita* and *H.multicinctus*. Indicated that only 45 cultivars were found to be highly susceptible to *P.coffeae*, 6 cultivars to *R.similis;* 41 to *M.incognita* and 4 to *H.multicinctus*. The rest of the cultivars were free from nematodes.

### 4.3. 2 : Insect Pests Management in Banana (B.Padmanaban)

#### 4.3.2.1 : Survey

Survey conducted in few districts of Tamil Nadu revealed the following insect pests viz., Tobacco caterpillar *(Spodoptera litura* (F.), Pseudostem weevil *(Odoiporus longicollis)* (Oliv.), Rhizome borer *(Cosmopolites sordidus* G.), Leaf thrips *(Helinothrips kadaliphilus* R&M), Flower thrips *(Thrips hawaiensis* (Morgan), Banana lace wing *(Stephanitis typicus* Dist.), Bag worm *(Kophene cuprea* M.), Banana Mealy bug *(Pseudococcus* sp.). Incidence of leaf thrips and bag worm was very severe in Trichy taluk, and pseudostem weevil was very severe in Coimbatore district whereas pseudostem weevil and rhizome borer was severe in Periyakulam district. Occurrence of *Spodoptera litura* (F.) on some commercial banana cultivars like Karpuravalli, Rasthali, Monthan, Nendran, Pachanadan, Robusta, Poovan and Ney Poovan indicated a maximum feeding damage on Monthan and lesser in Pachanadan variety.

***Pseudostem showing weevil infestation***

Observation on banana aphid, *Pentalonia nigronervosa* was recorded on nendran cultivars having various categories of BBMV infection like, (i) Aborted bunch (ii) Travellers palm apperance (iii) Lean and lanky plants with short and long peduncle and (iv) Healthy (Table 25.). Statistical analysis of aphid population indicated significant differences among healthy and infected categories and difference between severe and verysevere infection. (CD : P = 0.05 3.17, C.V. % = 21.77) Correlation was worked out between the aphid population and yield of BBMV infected nendran cultivars indicated significant negative correlation (r = 0.859, n = 40, y = – 5545599 + 15.87477).

*Rhizome borer infested plant robusta showind malformation peduncle*

**4.3.3 : Fingal and bacterial disease management in Banana (R.Thangavelu)**

**4.3.3.1 : Survey**

**Wilt affected Rasthali orchard**

Rowing survey on fungal diseases of banana was conducted in 43 banana orchards covering major banana growing regions in different districts of Tamil Nadu such as Villupuram, Cuddalore, Thanjavur, Madurai, Periakulam, Theni, Trichy and Pondicherry indicated the following major varieties such as Poovan, Nendran, Monthan, Rasthali, Robusta, Karpuravalli and Ney Poovan. Sigatoka incidence was observed in all the varieties and the observations on the incidence of Sigatoka, Wilt and number of functional leaves in case of Sigatoka disease were noted and are presented.

Maximum incidence of more than 80% was noted in Robusta, Poovan and Monthan varieties and less incidence of Sigatoka was observed in Karpuravalli at Bunch Maturing stage. The functional leaves during bunch maturity stage were also more (13) in Karpuravalli and less in Robusta and Rasthali.

The fusarium wilt incidence was observed in Monthan, Rasthali and Karpuravalli and the maximum incidence was recorded in Rasthali and Monthan and less incidence in Karpuravalli.

#### 4.3.3.2 : Evaluation of germplasm against Wilt and Sigatoka diseases of banana under field conditions

Germplasm maintained at NRCB farm, was evaluated for their reaction to wilt and Sigatoka diseases of banana Table 18. Observations on disease incidence, Youngest Leaf Spotted(YLS) and number of functional leaves were taken at vegetative, flowering and harvest phases.

The results indicated that the accessions belong to *Musa balbiciana* Pisang Awak, Monthan and Bluggoe groups which have more 'B' genome in their genomic constitution were found to be less susceptible to Sigatoka leaf spot as there was less incidence of disease more YLS value and functional leaves compared to other groups which have more 'A' genome in their genomic constitution. Maximum incidence of Sigatoka, less YLS value more YLS value indicates more resistance and functional leaves were recorded in Cavendish-AAA followed by Nendrapadathi (AAB), Pome (AAB), Mysore (AAB), Silk (AAB) which contain more 'A' genome in their genomic constitution. However, in each genomic group wide variations in the incidence of disease, YLS and functional leaves were also observed.

Varieties such as local Peyan (ABB), Enna Benian (AAB), Thiruvananthapuram (AAB), Kalibow (AAB), Petite Nine (AAA) Vadakkan Kadali (AA) and Pisang Rajah (AAB) were found to be free from Sigatoka leaf spot disease. From this it can be concluded that resistance donors for Sigatoka pathogen are present in all the genomic groups which can be better exploited in breeding programmes to develop Sigatoka resistant/tolerant high yielding banana clones (Table 18).

#### 4.3.3.3 : Evaluation of IMTP(wilt) accessions for their reaction to wilt and Sigatoka diseases

A trial was laidout to observe the reactions of different exotic hybrids/varieties against wilt pathogen under natural field condition. So far no incidence of wilt was observed in any of the IMTP (wilt) accessions. Besides, screening these accessions against wilt, reaction of these accessions against Sigatoka leaf spot disease was also recorded at vegetative (6 months after flowering) flowering and at harvest phases. The observations on the disease incidence and YLS were taken and the same is presented in Table 19.

Observations, indicated that the hybrids PA-03-22 (EMB-404) and FHIA-03 and natural germplasm such as Cultivar rose, Yangambi-KM-5, Pisang Jari Buaya and Pisang Lilin were found to be resistant to Sigatoka as these accessions were free from Sigatoka incidence. Whereas the hybrids such as FHIA-1, FHIA-23, EMB-402, GCTCV-119, GCTCV-215 and cultivars such as Burro Cemsa, Saba, Bluggoe and Williams were found to be susceptible to Sigatoka as these accessions recorded high incidence of Sigatoka and less YLS value at all phases evaluated. However the varieties such as Pisang Nanga and Pisang Mas were moderately tolerant to Sigatoka as these recorded less incidence and more YLS value.

**Table18 : Evaluation of germplasm against Sigatoka leaf spot under natural field conditions**

| Sl. No. | Name of the Group | Vegetative Phase | | | Flowering Phase | | | Harvest phase | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | YLS | Functional leaves | Disease severity | YLS | Functiona leaves | Disease severity | YLS | Functional leaves | Disease severity |
| 1. | Pisang Awak-ABB | 13.2 | 14.0 | 27.2 | 15.0 | 16.2 | 50.0 | 11.2 | 13.4 | 58.1 |
| 2. | Monthan-ABB | 9.1 | 10.6 | 44.5 | 14.0 | 15.7 | 52.2 | 9.5 | 13.5 | 55.9 |
| 3. | Bluggoe-ABB | 11.5 | 12.6 | 39.5 | 12.7 | 13.7 | 54.6 | 9.4 | 10.3 | 58.3 |
| 4. | Pome-AAB | 10.9 | 14.8 | 38.9 | 9.1 | 10.2 | 59.8 | 4.2 | 5.5 | 78.8 |
| 5. | Silk-AAB | 9.6 | 10.3 | 49.7 | 9.3 | 10.3 | 65.0 | 4.8 | 6.3 | 62.0 |
| 6. | Cavendish-AAA | 8.3 | 9.7 | 49.1 | 9.0 | 10.7 | 58.4 | 5.3 | 7.2 | 70.92 |
| 7. | Nendrapadathi-AAB | 9.4 | 11.0 | 43.6 | 8.7 | 9.4 | 62.0 | 4.1 | 5.1 | 80.1 |
| 8. | Poovan - AAB | 10.0 | 11.0 | 37.3 | 9.7 | 11.2 | 56.4 | 5.6 | 7.1 | 70.7 |
| 9. | Neypoovan - AB | 12.5 | 13.9 | 42.8 | 10.9 | 13.0 | 55.9 | 5.3 | 6.7 | 55.2 |
| 10. | Kunnan - AB | 11.9 | 12.8 | 48.5 | 12.8 | 13.9 | 54.5 | 6.3 | 7.6 | 69.0 |
| 11. | M.balbisiana-BB | 14.2 | 15.3 | 32.1 | 18.5 | 20.7 | 38.1 | 10.0 | 12.0 | 50.0 |

**Table 19 : Evaluation of IMTP (Wilt) accessions against the Sigatoka incidence**

| Sl. NO. | Name of the varieties/ Hybrids | Vegetative Phase | | Floweirng Phase | | Harvest Phase | |
|---|---|---|---|---|---|---|---|
| | | Disease Severity | YLS | Disease Severity | YLS | Disease Severity | YLS |
| 1. | SH-3484(FHIA-01) | 29.0 | 10.4 | 44.1 | 7.7 | 79.3 | 3.5 |
| 2. | SH-3565(FHIA-03) | N.I. | - | N.I. | - | N.I. | - |
| 3. | SH-3649(FHIA-17) | 47.1 | 4.54 | 60.5 | 8.1 | - | - |
| 4. | SH-3444(FHIA-23) | 55.2 | 6.4 | 65.2 | 7.8 | 79.9 | 4.0 |
| 5. | PV-03-44(EMB-402) | 28.2 | 10.2 | 42.0 | 10.7 | 83.4 | 3.6 |
| 6. | PA-03-22(EMB-404) | NI | - | NI | - | NI | - |
| 7. | GCTCV-119 | 48.5 | 3.5 | - | - | - | - |
| 8. | GCTCV-215 | 44.5 | 5.4 | 40.0 | 12.0 | 78.2 | 5.0 |
| 9. | Burocemsa | 37.6 | 10.9 | 56.4 | 8.8 | 86.5 | 2.5 |
| 10. | Pisang Mas | 55.6 | 8.3 | 45.8 | 9.5 | 60.0 | 7.0 |
| 11. | Saba | 30.7 | 12.0 | 53.2 | 9.2 | 78.80 | 4.1 |
| 12. | Pisang Nanga | 57.6 | 7.5 | 64.1 | 9.0 | 68.9 | 7.0 |
| 13. | Cultivar Rose | NI | - | NI | - | NI | - |
| 14. | Yangambi KM-5 | NI | - | NI | - | NI | - |
| 15. | Pisang Jari Buaya | NI | - | NI | - | NI | - |
| 16. | Pisang Lilin | NI | - | NI | - | NI | - |
| 17. | Calcutta IR 124 | - | - | - | - | - | - |
| 18. | Gros Michel | 65.1 | 8.2 | - | - | - | - |
| 19. | Bluggoe | 40.3 | 10.5 | 55.7 | 9.6 | 80.10 | 3.5 |
| 20. | Williams | 39.4 | 9.0 | 58.9 | 9.0 | 78.8 | 3.0 |
| 21. | Pisang Ceylan | 46.1 | 9.0 | 57.2 | 7.5 | 77.9 | 4.2 |
| 22. | Local cultivar - Rasthali | 62.6 | 9.5 | 59.9 | 8.0 | 79.8 | 2.5 |

#### 4.3.3.4 : Evaluation of IMTP (Sigatoka) accessions for their reaction to Sigatoka Leaf Spot disease

The IMTP (Sigatoka) Genotypes were evaluated for their reaction to Sigatoka incidence under natural field conditions. The observations on Disease severity, YLS, Disease Development time (in days) and LER (leaf emergence rate) were recorded to asses their resistance nature (Table 20).

Among the genotypes evaluated, SH-343669, Saba, Pisang Ceylan and local cultivar Robusta were found to be susceptible to Sigatoka disease. Genotypes such as PV-03644, PA-03622, Pisang Lilin, Pisang Berlin, Niyarma Yik were found to be resistant.

Among the susceptible genotypes, the YLS value was more in Saba at all phases evaluated followed by SH-343669 and Pisang Ceylan.

The disease development time which was recorded throughout the crop period which ranged from 34-193 days and more DDT value was recorded in the variety Saba.

With regard to LER, it was maximum in the variety Pisang Lilin followed by PA-03622, Saba, PA-03622, Pisang Ceylan, SH-343669, Niyarma Yik, local cultivar Robusta and Pisang Berlin.

The influence of weather factors such as temperature and RH on the disease development time (in days) was also calculated to develop the forecasting model for Sigatoka (Table 21).

In General, significant influence of temperature and RH on the DDT was observed in all the susceptible genotypes. However, the degree of influence varied from variety to variety. It was also observed that 1°C rise in temperature increased the Disease Development Time (DDT) by 6 to 14 days. Similarly 1 per cent rise in RH, decreased the DDT by 1.5 to 5 days.

**Table 20 : Evaluation of IMTP (Sigatoka) accessions for their reaction to Sigatoka leaf spot**

| Sl. No. | Genotype | No. of plants | Growing phase | | Shooting phase | | Harvest phase | | LER | DDT-range (Disease development time in days |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | D.S. | YLS | D.S. | YLS | D.S. | YLS | | |
| 1. | SH-3444 | - | - | - | - | - | - | - | - | - |
| 2. | PV-03644 | 22 | NI | - | NI | - | NI | - | 00.93 | - |
| 3. | PA-03622 | 26 | NI | - | NI | - | NI | - | 00.99 | - |
| 4. | SH-343669 | 16 | 37.80 | 9.5 | 43.2 | 10.1 | 50.1 | 7.8 | 00.80 | 34-138 |
| 5. | Yangambi KM-5 | - | - | - | - | - | - | - | - | - |
| 6. | Saba | 26 | 37.70 | 10.2 | 44.1 | 12.9 | 52.6 | 8.5 | 00.95 | 40-193 |
| 7. | Pisang Ceylan | 18 | 28.50 | 8.8 | 35.9 | 10.4 | 48.2 | 6.0 | 00.85 | 40-149 |
| 8. | Calcutta-IR24 | - | - | - | - | - | - | - | - | - |
| 9. | Pisang Lilin | 3 | - | - | - | - | - | - | 1.28 | - |
| 10. | Pisang Berlin | 10 | - | - | - | - | - | - | 00.75 | - |
| 11. | Niyarma Yik | 11 | - | - | - | - | - | - | 00.78 | - |
| 12. | Local cultivar Rasthali | 22 | 39.6 | 9.2 | 45.6 | 10.6 | 57.8 | 5.5 | 00.77 | 34-139 |

**Table 21 : Effect of weather factors on the disease development time (in days) of Sigatoka pathogen:**

| Varieties | Temperature | | | | Relative Humidity | | | |
|---|---|---|---|---|---|---|---|---|
| | Regression equation | Correlation co-efficient | Co-efficient determination | Increase in DDT for ie rise in temp. | Regression equation | Correlation co-efficient | Co-efficient determination | Decrease in DDT for 1% increase in RH. |
| SH-343669 | y=14.4 x - 314.2 | 0.2960* | 8.76 | 14.36 | y=2.5 x - 255 | 0.8257* | 68.8 | 2.54 |
| Saba | y=10.9x - 218.2 | 0.6047* | 36.5 | 10.97 | y = 4.9x - 446 | 0.86378* | 74.61 | 4.86 |
| Pisang Ceylan | y = 7.4x - 134.6 | 0.5429* | 29.4 | 7.36 | y = 1.6x - 193 | 0.4971* | 24.72 | 1.50 |
| Robusta | y = 5.8x - 88.2 | 0.58189* | 33.85 | 5.83 | y = 3.3x – 324 | 0.8258* | 68.20 | 3.30 |

* Significant at 5% level.

### 4.3.4 : Studies on Viral Diseases and their Management (R.Selvarajan)

#### 4.3.4.1 : Survey

Both the BBMV and the BSV incidence have been observed in commercial cultivars in Southern Districts of Tamil Nadu and Keral,(Table 22). In Agricultural College, Vellaiyani, Kerala more than 50% plants of Ney Poovan had severe BBMV infection. In a plant, necrotic streaks on petiole, midrib and pseudostem have been observed. Necrosis found to be deep seated in pseudostem of infected plants.

In a State Govt. Banana Nursery, Peringamala, Kerala, out of 49 cultivars maintained 14 had severe BBMV infection. The cultivars are Thiruvananthapuram Palayankodan, Red Banana, Monthan, Rasthali, Jawa, Krishnavazhai, Kareem Kadali, Sakkai, Matti, Mysore Ethan, Padathi, Pisang Lilin and Adukkan.

**Table 22 : Survey for BBMV and BSV incidence in Tamil Nadu and Kerala.**

| Area | Cultivar | Percent Incidence | | No. of plants observed |
|---|---|---|---|---|
| | | BBMV | BSV | |
| Dharmapuri | Poovan | - | 1.45 | 2000(4)@ |
| Tirunelveli | " | 1.0 | 8.02 | 700(2) |
| Nagercoil* | " | - | 6.5 | 300(2) |
| | " | 10.2 | 17.5 | 500(1) |
| | Robusta | 0.75 | - | 400(1) |
| | Poovan | 1.40 | 1.40 | 360(1) |
| Tuticorin* | Poovan | - | 16.6 | 2000(1) |
| Trivandrum | Neypoovan | 50.0 | - | 110(1) |
| | Kaliethan | 6.9 | - | 160(1) |
| | Nendran | 3.4 | - | 264(1) |

* In Tuticorin district cultivars and Monthan Poovilachendun (700), Nendran (400), Rasthali (1000) and Monthan(1000) had no viral disease incidence. In Nagarcoil cultivar Matti (900) did not show any viral disease symptoms. Figures in the paranthesis are number of plants observed in respective cultivars.

@ Figures in the paranthesis are number of orchards surveyed.

**Table 23 : Survey for BSV & BBMV incidence in Trichy district of Tamil Nadu.**

| Area | Cultivars | Percent Disease Incidence | | Total | No. of plants observed in each orchard |
|---|---|---|---|---|---|
| | | BBMV | BSV | BBMV&BSV | |
| Vayalur | Poovan | 0.9 | 0.6 | 0.3 | 1000 |
| | Poovan | 0.9 | 0.58 | 0.58 | 1200 |
| | Nendran | 18.0 | - | - | 72* |
| Kuzhumani | Nendran | 0.20 | - | - | 2400 |
| | Neypoovan | 1.7 | - | - | 875 |
| Chinnakaruppoor | Robusta | 1.0 | - | - | 300 |
| Sirugamani | Nendran | 0.0 | - | - | 1200 |
| | Nendran | 0.33 | - | - | 1500 |
| Thottiyam | Poovan | 13.10 | 10.5 | 3.9 | 76* |
| Kattuputhur | Rasthali | - | - | - | 2000 |
| | Poovan | - | 3.2 | - | 380 |
| Lalgudi | Robusta | 0.25 | - | - | 1200 |
| | Poovan | 24.5 | 4.9 | 4.9 | 102* |
| Malliampathu | Nendran | 60.1 | - | - | 2088 |
| | Nendran | 13.5 | - | - | 1062 |
| | Nendran | 17.1 | - | - | 675 |
| | Nendran | 13.5 | - | - | 1453 |

* A few randomly selected plants were observed for the disease incidence.

The BBMV infection in Nendran cultivar in Trichy district ranged from 0 to 60.1 per cent (Table 23). The BSV infection in Poovan variety ranged from 0.9 to 24.5% which is much lesser than the last year record. Around 25 plants were observed to have Neer Vazhai malady in cultivar Nendran.

#### 4.3.4.2 : Variations in symptoms induced by BBMV

Banana bract mosaic virus disease is characterised by presence of spindle shaped pinkish to redish streaks on pseudostem and midrib, typical mosaic and spindle shaped dark streaks on bracts, mosaic on leaf petiole, peduncle and fingers. However during this year survey various symptoms have been noticed on BBMV infected plants. Mild spindle shaped mosaic pattern on upper side of the leaf and the lower side coresponding to spindle shaped mosaic, thick waxy coating has been observed during winter months and the rest of the year the symptoms are absent. Severe necrotic streaks on pseudostem, petiole and midrib has been observed for the first time in Cvs Neypoovan, Robusta and Nendran. In Cv. Pachabontha batheesa severe necrosis on peduncle, fingers, rachis, bracts and also on leaf lamina. Mild necrotic streaks became severe at later stage of finger development and cracking of fingers due to necrosis has also been noticed. In the infected plant, after complete development of bunch, there was a male phase followed by an unusal female phase with 4-5 hands has been observed. The fingers of extended female phase also had similar necrosis symptom. The EM observation of necrosis fingers revealed the presence of BBMV and BSV particles. Extension of female phase after short male phase was observed in Cv. Nendran in the farmers field. In Cv Nendran unusual orientation of bunch with long peduncle and very short peduncle, abortedness, lean & lanky tall plants have been observed. In Cv Poovan necrosis was severe on leaf lamina, pseudostem and petiole when BBMV and BSV are present.

*Necrosis of bunch induced by BBMV and BSV*

*Unusal long peduncle symptom induced by BBMV*

*Unusual orientation of bunch*

*Traveller palm appearance*

#### 4.3.4.3 : Fixed plot survey :

Regular visits were made to a Nendran orchard in Malliampathu. In that orchard 44% BBMV incidence was recorded in the month of November (Before bunch emergence)

and the banana aphid *'Pentalonia nigronervosa'* occurrence was also high in the same orchard. After emergence, the BBMV incidence rose to 58.1% and in January the incidence reached to 60%. In some of the plants suckers had BBMV symptoms but not the main plant. In a Neer Vazhai plant,2 out of 5 suckers showed typical BBMV symptoms but the main plant and remaining suckers had no symptoms of BBMV. It is suspected that BBMV would have been transmitted by aphids from infected to healthy plants and the other possibility is plants would have expressed the symptoms in later stage i.e. after a certain time of latent period. Aphid population on those plants has been observed to have more numbers than other plants. Different degrees of symptoms due to BBMV were noticed in that orchard. Besides BBMV symptom,i.e. includes pinkish streaks on pseudostem, spindle shaped mosaic on leaves, mosaic on fingers and bracts, plants had different categories of symptoms and their per cent occurrence in the Orchard have been given in the table 24.

**Table 24 : Fixed plot survey in a Nendran orchard in Malliampathu village of Trichy district**

| Sl. No. | Categories of BBMV infected plants | % occurrence |
|---|---|---|
| 1. | Poor plant development and emergene of bunch | 6.46 |
| 2. | Rotting of cigar leaf and no bunch emergence | 6.95 |
| 3. | BBMV + Neer Vazhai malady | 0.34 |
| 4. | Bunches with long peduncle | 8.21 |
| 5. | Bunches with very short peduncle and horizontal orientation of bunch | 5.05 |
| 6. | Typical travellers palm appearance of plant | 0.97(-) |
| 7. | Lean, lanky and tall plants | 2.77 |
| 8. | BBMV+ apparently healthy bunches | 29.31(+) |
| 9. | Healthy | 39.81 |

**Table 25 : Effect of BBMV on yield parameters of cultivar Nendran**

| Sl. No. | Categories of symptom | Bunch weight (kg) | Total hands | Average fingers | Finger length (cm.) | Finger width (cm.) | Aphid Population |
|---|---|---|---|---|---|---|---|
| 1. | Aborted bunch | 1.08 | 4.6 | 8.70 | 9.90 | 7.30 | 25.55 |
| 2. | Travellars palm appea rance. | 2.25 | 4.3 | 8.30 | 14.90 | 11.50 | 25.19 |
| 3. | Lean & Lanky, plants with short & long peduncles | 4.39 | 5.1 | 9.80 | 18.60 | 12.80 | 16.39 |
| 4. | Healthy | 15.15 | 6.6 | 11.80 | 27.7 | 17.60 | 11.37 |
| 5. | CD at 5% | 0.70 | 0.99 | 1.24 | 1.86 | 1.49 | 3.17 |

In the fixed plot survey, the yield parameters were taken at the time of harvest are given in the table 25. Bunch weight, total number of hands, finger length and width of healthy, BBMV free plants were significantly different from BBMV with aborted bunch, traveller

palm appearance, lean and lanky plants with short and long peduncle categories. The infected plants have given bunches of less weight, malformed, underdeveloped fingers makes them not saleable. Hence the loss could be cent per cent. The minimum bunch weight in BBMV plants are due to undeveloped fingers.

#### 4.3.4.4 : EM observation

The bracts and epidermal layer of finger of Pacha Bontha Batheesa, which had Necrotic symptoms on leaves, bracts and fingers had both the flexous nod shaped particles and bacilliform particles. But the leaf samples of Neypoovan which also had necrotic symptom had only BBMV particles under Electron Microscope.

#### 4.3.4.5 : Transmission studies (R. Selvarajan & B. Padmanabhan)

The Banana aphid *Pentalonia nigronervosa* were allowed to feed on infected cvs. of Robusta, Karpuravalli and Nendran for 5-10 minutes. Aphids were strained for an hour before acquisition feeding. Then the aphids were allowed to feed on healthy tissue cultured plants for 30 mts. and then killed by spraying 0.2% phosphomidan. The plants are maintained in insect proofcages. Till date no symptom was observed. The banana lace wing bug was also used to transmit BBMV in Neypoovan. Out of 5 plants inoculated only one had developed symptoms.

#### 4.3.4.6 : BBMV Incidence in germplasm

BBMV infection in germplasm collection is identifiess by the presence of typical external symptoms induced by virus. BBMV infected accetions are being transferred to virology block for further test using immunodiagnosis. Totally 36 accessions are found to have BBMV infection. In 15 accession symptoms were observed on Bract, leaf and pseudostem of main plant and also on suckers. Seven accessions had symptoms only on suckers but not in main plants.

### 4.3.5 : Diseases of unknown Etiology

#### 4.3.5.1 : Neervazhai

During this year survey less than 1% of nendran plants had neervazhai malady in a few orchards has been observed and in the most of the orchards no incidence was found. It is the first time that BBMV infection has been noticed on Nendran plants having 'Neer Vazhai' malady.

#### 4.3.5.2 : Floral malformation in Nendran

In the survey, a nendran plant with BBMV showed 'Neervazhai' like symptoms, but a heavy floral malformation which is distinguished from 'Neervazhai'. At the bunch 4-5 ovaries fused together and branched 2-3 times at the tip, inturn the branched tips had bunch of florets. The malformed hands, fingers are shown in the figure. The etiology of this malady is being studied. However, BBMV is suspected to be the cause of change in hormonal balance, hence the floral malformation.

## 4.4 : POST HARVEST TECHNOLOGY

**POST HARVEST TECHNOLOGY**
**(General Leader S.Shivashankar)**

The chilling injury caused when the fruits stored at 10°C for 5 days could be reduced due to the application of Calcium chloride($CaCl_2$)and ascorbic acid(AA). The ascorbic acid treatment in cold storage maintained the normal ripening process and fruit quality parameters for atleast one week. Fruits stored at 14°C along with ethylene absorbent (Soilrite with $KMnO_4$) enhanced the storage life of fruits to 21 days. Out of 69 accessions evaluated for shelf life the accn.no.0097 harvested at 3/4 th maturity and the accn.no. 0122 had exhibited maximum green and yellow life respectively.

### 4.4.1 : Post harvest Evaluation of Germplasm

The objective of the study was to evaluate the banana accessions existing in the germplasm collections for postharvest storage life with the goal of identifying accessions with longer shelf life.

The study was performed on 69 accessions belonging to five genomic groupings namely AA, AAA, AAB, ABB and BBB. The fruits were harvested at three maturity levels namely, 75, 90 and 100 days after fruit set. They were stored at 25°C±2°C in perforated polythene bags. Observation on fruit ripening were recorded at the time when the peel color started to turn from green to yellow. (Green life) and from ripening to rotting (Yellow life). The data on disease incidence and fruit quality parameters after ripening were also collected. The results showed market differences in the green life (3-18 days) and yellow life (2-10 days) of accessions were recorded. In general, the green life showed an inverse relationship with maturity. The maximum green life of 18 days was displayed by Accn.No.0161(AAA) while the longest yellow life of 10 days was recorded by Accn.No.0066. (Fig. 9 to 13).

The existence of such wide differences in the post harvest shelf life of banana accessions has been documented for the first time in this report. This study highlights the importance of post harvest evaluation in further breeding programs.

### 4.4.2 : Studies on effect of Pre-harvest conditions on fruit quality

#### 4.4.2.1 : Experiments on bunch covering

An observational trial to study the effect of bagging and application of 2,4-D on the development of the newly emerging bunches in two separate experiments were carried out.

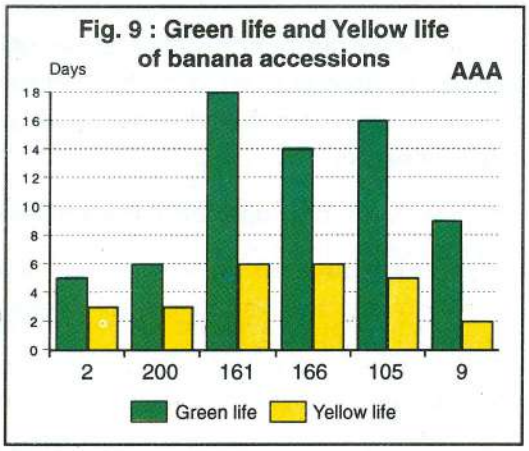


Fig. 9 : Green life and Yellow life of banana accessions
AAA
Days
18
16
14
12
10
8
6
4
2
0
2
200
161
166
105
9
Green life
Yellow life

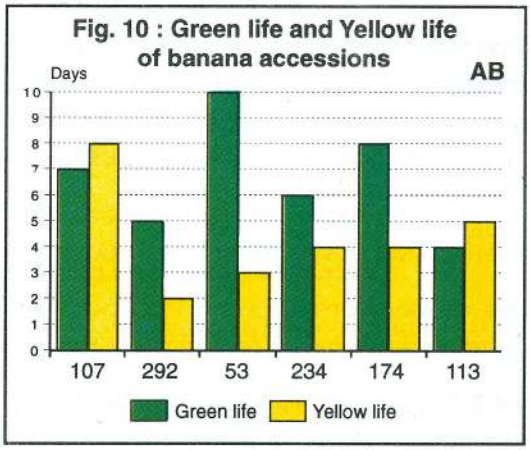


Fig. 10 : Green life and Yellow life of banana accessions
AB
Days
10
9
8
7
6
5
4
3
2
1
0
107
292
53
234
174
113
Green life
Yellow life

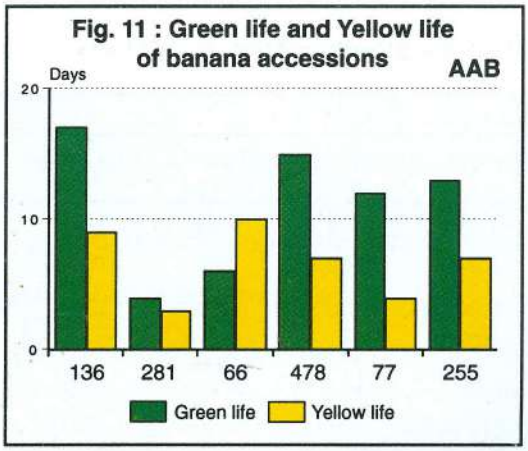


Fig. 11 : Green life and Yellow life of banana accessions
AAB
Days
20
10
0
136
281
66
478
77
255
Green life
Yellow life

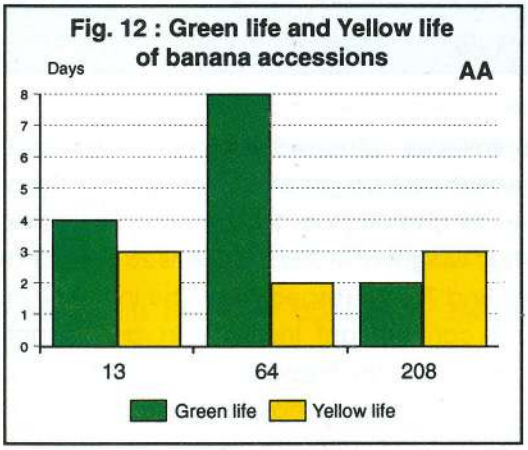


Fig. 12 : Green life and Yellow life of banana accessions
AA
Days
8
7
6
5
4
3
2
1
0
13
64
208
Green life
Yellow life

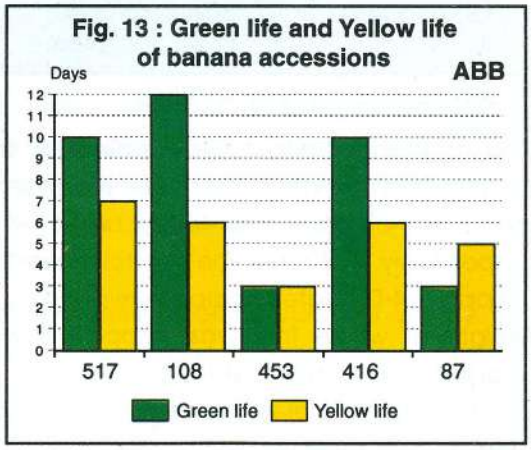


Fig. 13 : Green life and Yellow life of banana accessions
ABB
Days
12
11
10
9
8
7
6
5
4
3
2
1
0
517
108
453
416
87
Green life
Yellow life

Blue polythene bags were used to cover the newly emerged bunch with the aim of improving yield and especially the postharvest quality. The covers were perforated to allow for aeration and prevention of build up of humidity in the vicinity of the developing fruit. Unbagged controls were used for comparison of results.

Contrary to expectation, the covered bunches showed damage and premature ripening. Moreover, rodent pests began to proliferate under the covers.

The observations showed that polythene bunch covers are not suited for Trichy conditions where the temperature remain high for most part of the year.

#### 4.4.2.2 : Effect of pre harvest spray of 2,4-D on fruit growth

The newly emerging bunches were sprayed with 2,4-D at concentration of 25 and 50 ppm immediately following the opening of the last hand. Observation on bunch yield and fruit quality were made and compared against control (Table 26).

**Table 26 : Effect of 2,4-D on the growth of Karpuravalli fruits**

| Parameter | 50 DAS | | | 80 DAS | | |
|---|---|---|---|---|---|---|
| | Control | 25ppm treated | 50ppm treated | Control | 25ppm treated | 50ppm treated |
| Fruit length (cm) | 7.97 (0.27) | 9.67 (0.52) | 9.58 (0.32) | 8.97 (0.31) | 10.42 (0.63) | 9.97 (1.01) |
| Fruit girth (cm) | 9.00 (0.07) | 9.50 | 10.00 | 10.15 | 10.57 | 11.32 |
| Fresh weight of fruit(g) | 34.05 (0.56) | 46.33 (3.82) | 51.91 (2.88) | 49.38 (1.00) | 61.97 (6.76) | 70.97 |
| Dry weight of fruit (g) | 6.3 (0.31) | 7.3 (0.63) | 9.3 (1.15) | 11.74 (0.31) | 15.54 (1.90) | 18.91 (1.17) |
| Fruit volume (cc) | 39.25 (1.24) | 53.00 (4.56) | 61.3 (4.40) | 46.25 (1.25) | 58.25 (6.88) | 68.75 (4.73) |

* DAS denotes days after shooting

The results showed that 2,4-D application at both levels increased fruit size, volume and bunch yield in relation to control. The average fresh fruit weight at 50 DAS was 34.05g in control as compared to 46.33g and 51.91g in 25 and 50 ppm 2,4-D treated samples respectively. At 80 DAS, the control showed a fruit weight of 49.38g whereas 25 ppm and 50 ppm 2,4-D treated samples weighed 61.97g and 70.79g respectively. The increase in weight of whole fruit was associated with a concomitant increase in dry weight suggesting that the increase in weight was in fact due to the higher accumulation of dry matter and not merely an increase in moisture content. An increase of fruit length, girth and volume were also observed in the 2,4-D treated bunches.

The bunch yield at harvest was significantly higher by 32% and 41% in 25ppm and 50 ppm treated plants over control respectively. Bioassay confirmed the absence of 2,4-D residue in the fruit. The data confirms the earlier reports and could be recommended to growers for increasing the banana yield without any residual toxicity.

**4.4.3 : Storage studies**

**4.4.3.1 : Effect of low temperature storage on ripening and quality of banana**

Banana fruit is sensitive to cold which manifests as injury symptoms when stored at 10°C or less. The aim of the experiment was to study if differences existed among varieties with different genomic composition.

Mature fruit samples of Robusta (AAA), Karpuravalli (AAB) and Monthan (ABB) were stored at 10°C after giving various treatments for upto 30 days. Samples were analysed at the end of 5,10,15 and 30 days for chilling injury symptoms.

The data clearly showed that variation in chilling injury exists within and among dessert and cooking varieties of banana Table 26. The cooking variety 'Monthan' exhibited greater tolerance to cold. Pretreatment with $CaCl_2$ and Ascorbic acid helped to reduce the chilling injury symptoms in all the varieties. The process of ripening was not inhibited until after 30 days of storage at 10°C, although the fruit quality was adversely affected. Robusta was the worst affected followed by Karpuravalli and Monthan (Table 27).

**4.4.3.2 : Effect of storage parameters on green life**

The process of ripening in banana is initiated at harvest and reaches completion in a few days. The time that elapses between the time of harvest and the change in peel color from green to yellow is known as the 'Green life' and is a very useful parameter commercially.

The influence of storage conditions on the shelf life of Karpuravalli variety of banana was studied with the aim of finding the optimum storage parameters for an extended storage life.

The fruit in hands immediately after bunch harvest were subjected to various treatments and allowed to ripen normally. The treatment condition and the shelf life are summarised in Table 28. The time taken for ripening was found to vary significantly among the treatments. While the control fruits stored at room temperature (Min.24°C-Max.34°C) had a green life of 4 days, it could be extended upto 21 days at a storage temperature of 15°C when kept with $KMnO_4$ in perforated polybags.

These results could be applied for the extended storage of Karpuravalli variety of banana.

**Table 26 : Chilling injury in banana stored at 10°C before ripening**

| | Blackening | | | | Discoloration | | | |
|---|---|---|---|---|---|---|---|---|
| | Days of Storage | | | | Days of Storage | | | |
| | 5 | 10 | 15 | 30 | 5 | 10 | 15 | 30 |
| Robusta | 5.11 | 4.83 | 3.50 | 1.33 | 5.11 | 3.50 | 2.61 | 1.22 |
| K.Valli | 5.55 | 5.27 | 5.16 | 1.38 | 5.50 | 4.83 | 4.94 | 1.27 |
| Monthan | 5.89 | 5.50 | 5.27 | 5.44 | 5.83 | 5.61 | 5.55 | 5.05 |
| S.Ed. | 0.103 | 0.167 | 0.195 | 0.137 | 0.130 | 0.160 | 0.148 | 0.209 |
| C.D. (P=0.05) | 0.230 | 0.372 | 0.435 | 0.306 | 0.290 | 0.357 | 0.330 | 0.467 |
| Control | 5.27 | 4.83 | 4.11 | 2.38 | 5.22 | 4.38 | 4.00 | 2.33 |
| $Cacl_2$ | 5.44 | 5.05 | 4.50 | 2.66 | 5.39 | 4.16 | 4.16 | 4.66 |
| Ascorbic acid | 5.83 | 5.72 | 5.33 | 3.11 | 5.83 | 5.44 | 4.94 | 2.88 |
| S.Ed. | 0.179 | 0.181 | 0.184 | 0.137 | 0.191 | 0.147 | 0.184 | 0.212 |
| C.D. (P=0.05) | 0.399 | 0.404 | 0.411 | 0.305 | 0.426 | 0.328 | 0.410 | 0.473 |

Date is expressed on a scale of 1->6 in which 6 denotes the best quality

**Table 27 : Post-ripening characteristics of cold-stored fruits**

| | Appearance of spots | | | | Decay | | | | Discoloration | | | | Softness | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5 | 10 | 15 | 30 | 5 | 10 | 15 | 30 | 5 | 10 | 15 | 30 | 5 | 10 | 15 | 30 |
| Robusta | 4.17 | 3.28 | 2.56 | 1.50 | 3.89 | 3.94 | 3.72 | 2.44 | 3.67 | 3.39 | 1.44 | 1.11 | 4.16 | 4.28 | 3.22 | 3.83 |
| K.Valli | 4.33 | 4.05 | 3.28 | 1.22 | 4.83 | 4.67 | 4.67 | 2.00 | 3.94 | 4.00 | 3.94 | 1.17 | 5.28 | 5.11 | 4.83 | 3.89 |
| Monthan | 4.73 | 4.61 | 4.56 | 3.06 | 4.78 | 4.56 | 4.45 | 3.89 | 4.44 | 4.44 | 4.22 | 3.28 | 4.56 | 4.56 | 4.11 | 3.67 |
| S.Ed. | 0.178 | 0.182 | 0.165 | 0.130 | 0.093 | 0.161 | 0.183 | 0.121 | 0.110 | 0.137 | 0.120 | 0.097 | 0.214 | 0.163 | 0.079 | 0.120 |
| C.D. (P=0.05) | 0.397 | 0.406 | 0.367 | 0.290 | 0.207 | 0.359 | 0.409 | 0.270 | 0.244 | 0.305 | 0.267 | 0.216 | 0.477 | 0.364 | 0.176 | NS |
| Control | 3.83 | 3.61 | 3.05 | 1.67 | 4.05 | 3.89 | 3.78 | 2.50 | 3.56 | 3.56 | 2.83 | 1.61 | 4.50 | 4.62 | 4.16 | 3.67 |
| $Cacl_2$ | 4.50 | 3.78 | 3.50 | 1.78 | 4.50 | 4.39 | 4.00 | 2.67 | 4.16 | 3.89 | 3.11 | 1.78 | 4.61 | 4.44 | 4.05 | 3.78 |
| AA | 4.72 | 4.56 | 3.83 | 2.33 | 4.94 | 4.89 | 4.89 | 3.17 | 4.39 | 4.39 | 3.67 | 2.17 | 4.89 | 4.94 | 4.61 | 3.95 |
| S.Ed. | 0.097 | 0.121 | 0.125 | 0.174 | 0.139 | 0.195 | 0.149 | 0.171 | 0.156 | 0.154 | 0.139 | 0.129 | 0.127 | 0.154 | 0.131 | 0.204 |
| C.D. (P=0.05) | 0.217 | 0.270 | 0.278 | 0.389 | 0.311 | 0.435 | 0.332 | 0.394 | 0.347 | 0.343 | 0.311 | 0.289 | 0.282 | 0.343 | 0.292 | NS |

| | Rob. | K.Valli | Monthan | Rob. | K.Valli | Monthan | Rob. | K.Valli | Monthan | Rob. | K.Valli | Monthan |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Control | 2.54 | 2.96 | 3.79 | 2.79 | 3.87 | 4.00 | 2.00 | 3.08 | 3.58 | 3.79 | 4.71 | 4.08 |
| $Cacl_2$ | 2.58 | 3.17 | 4.42 | 3.21 | 3.83 | 4.54 | 2.25 | 3.25 | 4.17 | 3.87 | 4.71 | 4.08 |
| AA | 3.50 | 3.58 | 4.50 | 4.50 | 4.21 | 4.71 | 2.96 | 3.46 | 4.54 | 4.37 | 4.92 | 4.50 |
| .Ed. | 0.151 | 0.166 | 0.111 | 0.079 | 0.257 | 0.173 | 0.090 | 0.139 | 0.193 | 0.136 | 0.123 | 0.120 |
| C.D. (P=0.05) | 0.338 | 0.370 | 0.247 | 0.176 | NS | 0.385 | 0.201 | 0.309 | 0.431 | 0.303 | NS | 0.267 |

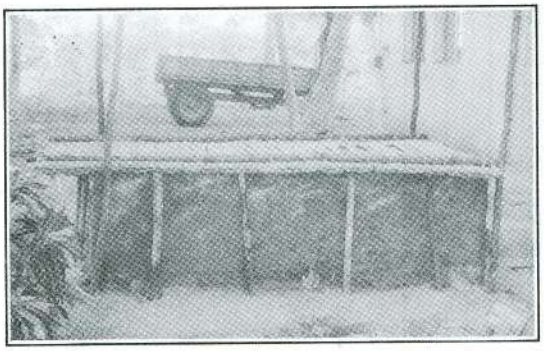
Date is expressed on a scale of 1->6

**Table 28 : Green life of cv.Karpuravalli as influenced pretreatment and storage temperature**

| Pretreatment of hands | Storage temp.(°C) | Green life (days) | Increase in green over control (days) |
|---|---|---|---|
| No treatment (control) | RT | 4 | - |
| Precooled in water for one hr. | RT | 8 | 4 |
| Precooled in water for one hr. | 14 | 11 | 7 |
| Precooled to 15°C for one hr. (in BOD incubator) | RT | 4 | NIL |
| Precooled to 10°C for one hr. (in refrigerator) | RT | 10 | 6 |
| Pretreated with 5% virosil for 3 min. | RT | 7 | 3 |
| Pretreated with 5% virosil for 3 min. | 14 | 12 | 8 |
| Pretreated with 5% virosil for 3 min. | 36 | 7 | 3 |
| Stored with sachets of $KMnO_4$ impregnated soilrite | 14 | 21 | 17 |

RT 27-33°C

#### 4.4.3.3 : Installation of Zero energy chamber



A prototype of zero energy chamber was installed in the research farm at a total cost of Rs.1200/-. The chamber has provision to store 200Kg. banana bunches at a time.

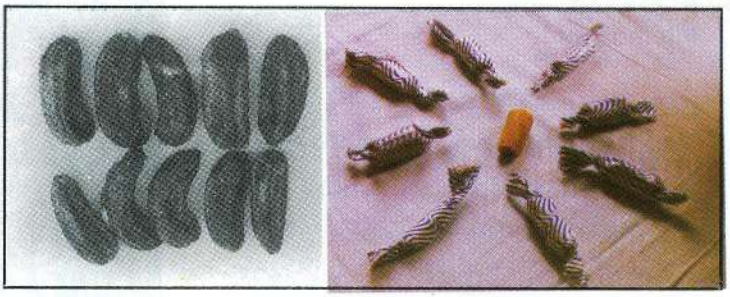
Observations on the temperature and humidity inside the chamber over several days showed that the temperature remains 10-12°C less than the ambient and relative humidity varies from 90-95%. Under these conditions, the green mature bunches could be stored for a longer period without loss of quality.

#### 4.4.4 : Processing and product development

#### 4.4.4.1 : Value added products

In an effort to reduce the post harvest losses and enhance the utility of banana, experiments were conducted with a view to developing processed products. The

following products namely banana figs, banana powder, banana chocolate and banana papads were developed during the year. All of these products were found to possess a shelf life of at least three months when stored in moisture proof polybags at ambient temperature.



*Banana Figs* *Banana Chacolates*

**4.4.4.2 : Evaluation of cultivars for wine preparation (S.Uma)**

Some of the commercial local cultivars were evaluated for their suitability to wine preparation along with exotic cultivars. During glut periods, wine is a better proposition for prolonged utilization of the fruit. Depending on T.S.S. content of the fruit, two treatments were given of the twelve potential accessions, Burro Cemsa followed by Saba were good among ABB culinary cultivars with equal quantities of sugar. But Karpuravalli (ABB) was best among dual purpose accessions with reduced sugar quantity.

## 5. TECHNOLOGY ASSESSED AND TRANSFERRED

NRC on banana is committed to undertake basic and strategic work under each identified thrust area. Since inception efforts are made to develop technique and technologies inspite of constraints of infrastructure and man power, yet in this perennial fruit it is too early for the development of any technology. However, the thrust area identified falls both under basic and strategic research. Information generated through basic research will be used for strategic programmes. Technology generated through AICRP has helped in improving production which includes high density planting, drip irrigation, fertigation and management of insect pests, nematodes and diseases.

## 6. EDUCATION AND TRAINING

A training on "Invitro propagation of banana for production of quality planting material" was conducted at the Centre from 19-31st May, 1997.

Shri K.Kamaraju, Lab Technician, attended training on "Appropriate Post harvest handling of fresh horticultural produce" at IARI, New Delhi during 1-12 September, 1997,

Shri S.Karthikeyan, Technical Assistant, attended "Computer training programme for ARIS personnel" at UAS, Bangalore from 15-23, September, 1997.

Mr.V.Kumar, Scientist, attended the Sixth Winter School on " Remote sensing in Agriculture with a special emphasis on Crop water management" held at Dept. of Agricultural Physics, IARI., New Delhi from 8-30th December, 1997.

**International**

Dr.S.Uma, Scientist(Sr.Scale), attended "Musa Germplasm Information System" training programme conducted by INIBAP at CIRAD-FLHOR, Guadeloupe, French West Indies from 10-17 October, 1997.

## 7. AWARDS AND RECOGNITIONS

Dr.H.P.Singh, Director, was conferred as fellow of National Academy of Agricultural Sciences, New Delhi for his contribution to horticulture research.

Dr.H.P.Singh, Director, chaired the Technical Session on Improvement in the Group Meeting of AICRP on Tropical fruits held at Dharwad on 27th November, 1997.

## 8. LINKAGES AND COLLABORATION IN INDIA AND ABROAD INCLUDING EXTERNALLY FUNDED PROJECTS

For the success in identified programmes in thrust areas, effective linkage with INIBAP will be required. Currently India is a member of INIBAP and International *Musa* Testing Programme (IMTP) has been initiated with their collaboration. Effective linkage of INIBAP shall be used for human resource development, exchange of germplasm sharing of products and processes and information. Linkages shall also be established with ACIAR, CATIE, Costa Rica, CORBANA-Costa Rica, IPGRI- Rome and FHIA-Honduras. In addition to international collaboration with INIBAP, linkages at national level with NBPGR, New Delhi, IIHR,Bangalore, Biotechnological Division of Bhabha Atomic Research Centre, Bombay and NRC on Biotechnology, Pusa, New Delhi will be established. Additionally, effective linkage will also be established with clients, and entrepreneurs committed for the improvement of banana

Dr.H.P.Singh, Dr.P.Sundararaju, Dr.S.Shivashankar and Dr.S.Uma attended the 'Interface with progressive banana farmers' headed by the District Collector V.Rajaram on 7.12.97

## 9. AICRP/ COORDINATION UNIT / NATIONAL CENTRES

Research on banana has been conducted under AICRP on Tropical Fruits since 1970 and the project has eight centres working on banana in eight banana growing regions. Significant achievements at National level are covered under scenario (6). Genetic resources are conserved at two centres viz. Coimbatore and Kannara but characterization is not complete. Accessions have been assessed for agronomic characters, resistance to sigatoka, fusarium wilt and nematodes. Conventional breeding has succeeded in the development of three hybrids which are being evaluated under

different agro-ecological conditions. Disease resistant diploids are available which can be used for breeding. H-1 from Kannara has promise due to short crop cycle, resistance to leaf spot, fusarium wilt and nematode.

Conventional method of propagation has been the use of suckers and rhizome and experiment conducted has suggested that *in vitro* plants provide uniformity and earliness apart from its freeness from disease. However, it has to be cost effective for commercial adoption. High density planting has been successfully exploited for improved productivity in all the regions. Double row system of planting has become popular in the region where drip irrigation has been adopted. Nutritional needs for different varieties have been standardised. Drip irrigation has been found to improve water use with enhanced yield. Effective weed management through the cover cropping with Cowpea is largely adopted.

Insects, nematode and disease problems in different states are identified and chemical control is advocated. Integrated management of nematode for different regions have been developed.

## GENERAL / MISCELLANEOUS

### 10. LIST OF PUBLICATIONS

#### 10.1 : Research papers

Singh, H.P., Kumar, V., Jeyabaskaran, K.J., Uma, S. and Thangavelu, R. (1997). Effect of organic and Inorganic source of nitrogen on banana production under high $p^H$ soil. International symposium on Banana in the sub tropics held at Tenerife, Spain on 10-14, Nov., 1997. pp.421-425.

Singh, H.P. and Prakash Patil, 1997. Efficacy of Nitrogen and Potassium on Growth and Yield of Banana cultivars. 'Ibid'.

Singh, H.P., Prakash Patil and Kumar, V., 1997. Assessment of Loss caused due to weeds in Banana cultivars under different agroclimatic conditions. 'Ibid'.

Singh, H.P., 1997. Perspective of Banana growing in Tropical and sub-tropical conditions in India. 'ibid'.

Singh, H.P. and Uma, S., 1997. Banana growing scenario and export perspective. Paper presented in the seminar on "Banana cultivation and opportunities of banana export" in KISAN-97 exhibition, at Pune, 23rd Nov., 1997.

Singh, H.P. and Uma, S., 1997. In-vitro propagation of banana - A case analysis. 'Ibid'

### 10.2 : Books / Chapters in Books

Sundararaju, P., 1998. Nematode parasites of banana. In Nematode Problems on Horticultural Crops and their management. (Eds.P.K.Koshy *et.al.*, 1998) CPCRI., Regional Station, Kayangulam.

Sundararaju, P., 1998. Nematode pests of palms. In Nematode Disease in plants (Ed.P.C.Trivedi, CBS publishers and Distributors, New Delhi. pp.320-334.

### 10.3 : Papers presented in Symposia / Seminar

Selvarajan, R. and Singh H.P., 1997. Occurrence, Geographical distribution and electron microscopy of BBMV in India. Paper presented in the International Conference on Integrated Disease Management for Sustainable Agriculture" held at New Delhi, 10-15 Nov., 1997. pp. 327 (Abst)

Singh, H.P. and Uma, S., 1997. "Collection, Conservation and Characterization of Musa germplasm at NRCB". In the proceedings of the AICRP meet held at UAS, Dharwad from 27.11.97 to 30.11.97. pp.410-413.

Uma, S. and Singh H.P., 1997. Evaluation of hybrids FHIA-01, FHIA-02 and FHIA-03 for Indian conditions 'Ibid' pp.414-416.

Singh, H.P. and Uma, S., 1997. Evaluation of hybrids and cultivars under International Musa Testing Programme (IMTP) 'Ibid'. pp.417-420.

Thangavelu, R. and Uma, S., 1997. Evaluation of Hybrids and Promising cultivars of banana against sigatoka leaf spot. Seminar on economically important diseases of crop plants and zonal chapter meeting of Indian phytopathological society (south zone) held on 18-20, Dec., 1997 at IIHR, Bangalore.(Abs)

Selvarajan, R., Thangavelu, R., Singh, S.J. and Singh, H.P., 1997. Geographical distribution, Sero-diagnosis and yield loss assessment of BSV in India. International conference on Integrated Management for Sustainable Agriculture, held on 10-15th Nov., 1997, New Delhi, India. P.223 (PIC-007) organised by Indian Phytopathological society, ICAR & IARI. (Abs)

Selvarajan, R. and Thangavelu, R., 1997. Status of Banana Diseases in Tamil Nadu. In Research Report compiled and edited by S.S.Yadav and Prakash Patil. All India Co-ordinated Research Project (Tropical fruits) IIHR, Hessaraghatta lake post, Bangalore - 560 089. (Abs) pp.426-430.

Singh, H.P., Uma, S. and Thangavelu, R., 1997. Evaluation of hybrids and cultivars under International Musa Testing Programme (IMTP) In Research Report (Citrus, Banana, Papaya, Pine apple and Sapota) compiled and edited by I.S.Yadav and Prakash Patil. All India Co-ordinated Research Project (Tropical fruits)(Abs)

Singh, H.P., Uma, S., Jeyabaskaran, K.J., and Thangavelu, R., 1997. Evaluation of Musa germplasm for yield, quality and reaction to Biotic and Abiotic stresses. In Research Report (Citrus, Banana, Papaya, Pineapple and Sapota) compiled and edited by I.S.Yadav and Prakash Patil. All India Co-ordinated Research Project (Tropical fruits). (Abs)

Sundararaju, P., Thangavelu, R. and Selvarajan, R., 1997. Plant health management-current status. In background papers for appraisal meeting for achieving the targetted productions of Banana held at NRC on Banana, Podavur, Trichy on 29, Nov., 1997, organised by NRCB and AIPUB 26-31.

Singh, H.P., Jeyabaskaran, K.J. and Uma, S., 1997. Screening of banana germplasm for sodium toxicity in India. In the proceedings of "International Symposium on Banana in the sub-tropics" held at Tenerife, Spain, from 10-14th Nov., 1997.

Singh, H.P., and Uma, S., 1997. Effect of plant geometry and density on growth and yield of banana under different agro-climatic conditions. In the proceedings of "International Symposium on Banana in the sub-tropics" held at Tenerife, Spain, from 10-14th Nov., 1997.

Jeyabaskaran, K.J., Thangavelu, R., Padmanaban, B. and Sundararaju, P., presented a research paper "Effect of Treated Domestic Sewage Effluents on Banana (cv.Rasthali)" in one day Seminar National Seminar on Applications of Treated Effluent for Irrigation on 23.03.98 at Regional Engineering College, Trichy.

Sundararaju, P., 1997. Health management of banana with special reference to plant parasitic nematode. Paper presented in the IX Biennial Workshop of AICRP (Nematodes), UAS, Bangalore, 25-26 Sept., 1997.

Sundararaju, P., Balasubramani, V. and Singh, H.P., 1997. Pheromone for Spodoptera management in Banana. Paper presented in the First National Symposium on Pest Management in Horticultural Cops. Environmental implications and Thrusts, Institution of Agricultural Technologies, Bangalore, 15-17 October, 1997.

Sundararaju, P. 1998. Nematode parasites of Banana. Review paper presented in the Group meeting of Nematologists of Horticultural Crops, CPCRI Regional Station, Kayangulam, 16-18 Jan., 1998.

**10.4 : Popular articles**

Sundararaju, P., 1997. How to save banana from Nematode? *Dinamani News paper* (Tamil) 18th August, 1997.

Sundararaju, P., 1997. Methods to protect banana from nematodes. *Dhina Thanthi News paper* (Tamil). 14th October, 1997.

Sundararaju, P., 1998. Agriculture based banana cultivation for export opportunities. *Valar Thozhil* (Tamil) 2-15 March, 1998. pp.4-5.

## 11. LIST OF APPROVED ON-GOING PROJECTS

I. Crop improvement (i)Germplasm enhancement and utilization (ii)Breeding for biotic, abiotic stresses and yield potential and (iii)Biotechnological approaches for improvement.

II. Production technology (i)Standardization of banana production (ii)Standardization of agrotechniques for banana production (iii)Soil health management and (iv)Physiological studies for banana improvement.

III. Crop protection (i) Insect pest management (ii) Studies on banana nematodes and their management (iii) Fungal and bacterial disease and management and (iv) Studies on viral diseases and their management.

IV. Postharvest technology (i) Post harvest Evaluation of Germplasm (ii) Studies on the effect of pre harvest conditions on fruit quality. (iii) Storage studies (iv) processing and product development.

## 12. CONSULTANCY, PATENTS, COMMERCIALISATION OF TECHNOLOGY

### 12.1 : Consultancy Services

In keeping with the guidelines issued by the ICAR for providing training, consultancy and undertaking of contract research and service, the centre has already started giving various kinds of consultancy service on identified areas and imparting training on topics related to the production, protection and processing aspects of banana. During 1997-98, the centre organised training programme on tissue culture of banana for mass multiplication of high quality disease free planting material and undertook three product evaluation trials on payment basis mainly for private entrepreneurs. The centre is also taking the lead in indexing of banana planting material for viruses like BSV, BBMV, CMV and BBTV which are assuming serious proportions of late. The centre has laid major emphasis on the dissemination of technology related to postharvest management aspects, fruit quality evaluation and utilization of banana in order to minimise the losses and enhance the income generation potential of banana.

## 13. RAC, INSTITUTE MANAGEMENT COMMITTEE, SRC, IJSC, ETC. MEETINGS WITH SIGNIFICANT DECISIONS

### 13.1 : Research Advisory Committee Meeting Members

| | |
|---|---|
| Dr.I.Irullappan,Ex-Dean, TNAU.<br>Vice President, Maxworth, Chennai. | - Chairman |
| Dr.H.P.Singh, Director<br>NRC on Banana, Trichy. | - Member<br>(upto 15.12.97) |
| Dr.P.Sundararaju, Director I/c. | - Member |

NRC on Banana, Trichy. (16.12.97 onwards)
Dr.S.Sambandhamurthy - Member
Dean(Rtd.), Hort.College & Res.Instt.
TNAU., Periyakulam.

Dr.A.K.Roy - Member
Director of Research,
A.A.U., Jorhat.

Dr.A.Summanwar - Member
Head, IARI. Regional Station,
Agricultural College, Pune.

Dr.Rajani Nadegowda - Member
Tissue Culture Division,
National Chemical Laboratory, Pune.

Dr.P.R.Mahajan - Member
Ex-Associate Director of Research,
MPKV., Jain Irrigation, Jalgaon.

Shri Maniram Singh Guruji
- Member
CPI Office, Bhagalpur, Bihar.

Shri Baba Saheb Thube
- Member
Ex-MLA, At & PO: Kauneer Pathar,
Taluka Barner, Dist.: Ahmednagar,(M.S.)

Dr.S.Uma
- Member Secretary
Scientist(SS), NRCB., Trichy.

***RAC Members Visits Virology net house***

The Second Research Advisory Committee meeting of the Institute was held on 19.07.97 during which the chairman and members appreciated the research programme prioritization of the institute.

**13.2 : Institute Management Committee**

**Members**

Dr.H.P.Singh, Director - Chairman
NRC on Banana, Trichy (upto 15.12.97)

Dr.P.Sundararaju, Director I/c. - Chairman
NRC on Banana, Trichy (16.12.97 onwards)

Asst.Director General (Hort.)
ICAR, New Delhi. - Member

Mr.Vasudevan, IAS.
Dir.of Hort.& Plantation crops,
State Govt.of Tamil Nadu, Chennai. - Member

Director of Horticulture
State Govt.of Karnataka, Bangalore. - Member

Dean-Horticultural College &
Research Institute,
Periyakulam, Tamil Nadu. - Member

Shri Maniram Singh Guruji
CPI Office, Bhagalpur, Bihar. - Member

Shri Baba Saheb Thube
Ex-MLA, At & PO: Kauneer Pathar,
Taluka Barner, Dist.: Ahmednagar,(M.S.) - Member

Dr.S.D.Shikhamani
NRC for Onion and Garlic, Pune - Member

Dr.B.M.C.Reddy
Principal Scientist, IIHR., Bangalore. - Member

Dr.R.D.Rawal
Principal Scientist, IIHR., Bangalore. - Member

Dr.S.Uma
Scientist (SS), NRCB, Trichy. - Member

Finance & Accounts Officer
Sugarcane Breeding Institute,
Coimbatore. - Member

Mr.N.Viswambharan
A.A.O., NRCB, Trichy. - Member Secretary

The meetings were held on 18.07.97 and 1.12.97 at NRC on Banana, Trichy.

**Significant decision taken in the meeting**

The following decisions were taken in the meeting held on 18.7.97

1. Re-appropriation of fund amounting to Rs.1,67,258/- from the Sub-head "Other Charges" to the Sub-head "Establishment Charges" (Rs.14,229/-) and "Works" Rs,1,53,029/- for the year 1996-97 was approved.

2. Purchase of spill over equipments approved in VIII Plan EFC amounting to Rs.27.80 lakh was approved.
3. Spill over items of work approved in VIII Plan EFC were approved.
4. Provision of Intercom facility at NRC on Banana for Office-cum-Lab building at 44, Ramalinganagar South Extn., Vayalur Road, Trichy-17 with 8 extensions was approved.

*Institute Management Committee members visits NRCB Farm*

5. Enhancement of the rent for the existing Office-cum-Lab building at 44, Ramalinganagar South Extn., Vayalur Road, Trichy-17 from Rs.4,999/- to Rs.8,300/- was approved.
6. Authorised Medical Attendants were appointed for the benefit of staff members.

The management committee meeting held at NRCB, Trichy on 01.12.97 has approved to import foreign equipments and opening of letter of credits including customs clearance.

**13.3 : Staff Research Council**

| | |
|---|---|
| Dr.H.P.Singh, Director<br>NRC on Banana, Trichy. | - Chairman<br>(upto 15.12.97) |
| Dr.P.Sundararaju, Director I/c.<br>NRC on Banana, Trichy. | - Chairman<br>(16.12.97 onwards) |
| Assistant Director General (Hort.)<br>ICAR., Krishi Bhawan, New Delhi. | - Member |
| Dr.N.K.Mohan<br>Chief Scientist,<br>Horticulture Research Station,<br>Kahikuchi, Guwahati. | - Member |
| Dr.K.G.Shanmugavelu<br>Ex-Dean, TNAU., Coimbatore. | - Member |
| Dr.Bala<br>Head of Plant Pathology,<br>G.A.U., Navsari - 396 360. | - Member |
| All Scietists of NRCB. | - Members |
| Dr.P.Sundararaju, Sr. Scientist<br>NRC on Banana, Trichy. | - Member Secretary |

### 13.4 : Institute Joint Staff Council

| | |
|---|---|
| Dr.H.P.Singh, Director | - Chairman (upto 15.12.97) |
| Dr.P.Sundararaju, Director I/c. | - Chairman (16.12.97 onwards) |
| Dr.S.Uma, Scientist(SS) Official side | - Member |
| Mr.N.Viswambharan, A.A.O. Official side | - Member Secretary (Official side) |
| Mr.A.Subramaniam Staff side | - Member |
| Mr.C.Thangaraj Staff side | - Member |
| Mr.M.Balu Staff side | - Member Secretary |

The Institute joint staff council meeting was held on 11th April, 1997 and 7th February, 1998.

### 13.5 : Rastra Basha Committee

| | |
|---|---|
| Dr.H.P.Singh, Director | - Chairman (upto 15.12.97) |
| Dr.P.Sundararaju, Director I/c. | - Chairman (16.12.97 onwards) |
| Dr.K.J.Jeyabhaskaran, Scientist | - Member |
| Mr.Singrey Majhi, Tech.Asst. | - Member |
| Mr.N.Viswambharan, A.A.O. | - Member Secretary |

The meeting was held on 11th April, 1997.Hindi Fortnight was celebtrated from 15-26th September, 1997. A special talk on 'Bharathia Maithri' linquistic harmony was delivered by Shri Chandramouli, Rtd., General Secretary, Dhakshin Bharathi Hindi Prachar Sabha, Trichy.

Staff Recreation Club has been set up on 15.08.97.

## 14. PARTICIPATION IN SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA ETC. IN INDIA AND ABROAD

### 14.1 : Conferences

Dr.R.Selvarajan, Scientist, attended the International Conference on "Integrated Plant Disease Management for sustainable agriculture on 10-15, Nov., 1997, at IARI., New Delhi, India and presented papers entitled "Occurrence, Geographical distribution and Electronmicroscopy of BBMV in India" and Geographical distribution, serodiagnosis and yield loss assessmet of BSV in India".

Mr.R.Thangavelu, Scientist, participated the Conference on "Women in Agriculture" held at Chennai, organised by M.S.Swaminathan Research Foundation on 3.12.97.

### 14.2 : Meetings

Dr.H.P.Singh, Director attended the group discussion on strategies of oilpalm production in 21st century and review meeting at NRC on Oilpalm, Elluru on 11th August, 1997.

Dr. P. Sundararaju and Mr. R. Thangavelu, R., participated and delivered lecture in the Agriculture Seminar on "Insects, Pests, Nematode diseases of banana and betelvine" organised by the Asst.Director of Horticulture, Tanjore at Thiruthanthuruthi village, Tanjore on 20th Aug., 1997.

Dr.S.Shivashankar, Sr.Scientist attended the Rural Programme Advisory Committee Meeting organised by All India Radio, Tiruchirappalli held at Sugarcane Research Station, Sirugamani on 25.09.97.

Dr.S.Shivashankar, Sr.Scientist attended the "Special Meeting" on "Processing of Horticultural Commodities" jointly organised by SIDCO, Madras and TATA Economic Consultancy Centre, Banglore held at Collectorate, Trichy on 30.9.97.

Dr.P.Sundararaju, Sr.Scientist, Mr.R.Thangavelu, Scientist attended Interface Deliberation with the Farmers of Poyyandarkottai village on 27th October, 1997 organised by IOB, Rural Credit Development Division, Thanjavur.

Dr.H.P.Singh, Director, NRC on Banana, Trichy visited Kannara, Kerala on 14.11.97 to participated in the monthly meeting of Genetic Resources of Banana.

Dr.P.Sundararaju, Sr.Scientist and R.Thangavelu, Scientist attended the Rural Programme Advisory Committee meeting organised by All India Radio Tiruchirapalli held at Horticultural Research Station, Yercaud on 6.1..98.

Dr.P.Sundararaju, Mr.V.Kumar and R.Thangavelu participated in the Banana Seminar jointly organised by FACT and Directorate of Horticulture at Alangudi on 14, Martch, 1998.

Dr.H.P.Singh, Director, attended the NATP meeting on Germplasm Research Strategies at NBPGR, New Delhi on 18.10.97.

Dr.R.Selvarajan, Scientist, attended the NATP Project Implementation Meeting at IARI., New Delhi on 7-12, Dec., 1997.

Dr.H.P.Singh, Director, Dr.S.Uma, Scientist (SS), Mr.R.Thangavelu, Scientist, attended Group discussion of AICRP for Tropical Fruits at UAS., Dharward during Nov., 27-30, 1997.

Dr.P.Sundararaju, attended the Group meeting of Nematologists of Horticultural Crops, CPCRI., Regional Station, Kayangulam on 16-18, January, 1998.

### 14.3 : Symposia

Dr.K.J.Jeyabaskaran, Scientist, attended and presented a research paper in the National Seminar on Applications of Treated Effluents for Irrigation" on 23.03.98 at Regional Engineering College, Trichy.

Mr. R. Thangavelu, participated in the National Seminar on the Technological Empowerment of women in Agriculture held at Chennai, 3-4, December, 1997, organised by National Commission for women and M.S.Swaminathan, Research foundation.

## 15. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMERS' DAY ETC. ORGANISED AT THE INSTITUTE

### 15.1 : Workshops

Dr.P.Sundararaju, Sr.Scientist attended the IX Biennial Workshop of All India Co-ordinated Research Project (Nematodes) on 25-26th September, 1997 at Bangalore.

Dr.H.P.Singh, Director, Dr.S.Uma, Scientist(Sr.Scale) and Mr.R.Thangavelu, Scientist attended the AICRP workshop and presented papers at UAS., Dharwad from 27.11.97 to 30.11.97.

### 15.2 : Seminars, Summer Institutes, Farmers' day

Appraisal meeting for achieving the targeted production of banana was organised at NRCB on 29.11.97.

Training / Group Discussion on Banana Cultivation - Phase-I organised to the officials of state agrl.Depts. on 30.12.97

Training / Group Discussion on Banana Cultivation - Phase-II organised to the officials of state agrl.Depts. on 2.2.98

### 15.3 : Radio talk

Dr.H.P.Singh, Director, Dr.P.Sundararaju, Dr.S.Uma, Mr.V.Kumar, Mr.R.Thangavelu and Dr.K.J.Jeyabaskaran delivered radio talk on activities and achievements of NRCB and Banana Cultivation on 7-11-97.

Dr.K.J.Jeyabaskaran, Scientist, delivered a talk in All India Radio, "Nutrient deficiency in Banana and Remedial measures" in Tamil on 16.12.97.

### 15.4 : Guest Lectures

Dr.P.Sundararaju, delivered a lecture on "Nematode infection and application and application of living system" under UGC sponsored refresher course, Bharathidasan University, Trichy on 11.2.98

Dr.P.Sundararaju, delivered a lecture on "Banana cultivation technical know how and do how" in Banana Seminar jointly organised by FACT and Directorate of Horticutlure at Alangudi, Pudukottai district, on 14.3.98.

## 16. DISTINGUISHED VISITORS

| Name of the Visitor | Organisation | Date of visit |
|---|---|---|
| Dr.R.R.Kholi, ADG (Hort.)<br>ICAR New Delhi. | ICAR | 19.7.97 |
| Dr.I.Irulappan<br>Director (Operation) | Natural Synergies<br>Ltd., Chennai | 19.07.97 &<br>29.11.97 |
| Shri N.Vasudevan,I.A.S.<br>Director of Hort. | Govt.of Tamil Nadu<br>Chennai | 25.08.97 |
| Press Party (8 persons) | Manipur state | 17.10.97 |
| Mr.S.S.Mehtha<br>Progressive grower | The Fairlands<br>Yercaud | 29.11.97 |
| Mr.N.S.Sundaram | NRS Beena Nursery | 29.11.97 |
| Dr.S.P.Ghosh<br>Dy.Dir.General (Hort), | ICAR, New Delhi | 29.11.97 |
| Dr.S.Maiti<br>Project Co-ordinator (Betelvine) | IIHR.,Bangalore | 29.11.97 |
| Dr.Azhakia Manavalan<br>Dean | Hort.College and<br>Res.Instt., Periyakulam | 1.12.1997 |
| Shri V. Rajaraman, I.A.S.<br>Dist.Collector | Collectorate<br>Trichy | 4.12.1997 |
| Mr.P.Venkatesan<br>Jt.Dir.of Agril. | Dept.of Agril.,<br>Trichy,T.N. | 2.2.98 |
| Dr.S.Asokan<br>Sr.Lecturer | AVC. College,<br>Mayiladurai | 11.2.98 |
| Shri P.V.Choudhary<br>Progressive Grower &<br>Managing Director | M/s. Pralshar<br>Bio Product Ltd.,<br>Goa | |

## 17. PERSONNEL

### RESEARCH MANAGEMENT:

| | |
|---|---|
| Dr.H.P.Singh, M.Sc.(Hort.),Ph.D. | Director (upto 15.12.97) |
| Dr.P.Sundararaju, M.Sc.,Ph.D. | Director I/c. (16.12.97 onwards) |

### SCIENTIFIC:

| | |
|---|---|
| Dr.S.Shivashankar, M.Sc.,Ph.D. | Senior Scientist (Post harvest) |
| Dr.B.Padmanaban, M.Sc.,Ph.D. | Scientist (SS)(Ent.) (w.e.f. 29.12.97) |
| Dr.S.Uma, M.Sc.(Hort.), Ph.D. | Scientist (SS)(Hort.) |
| Mr.V.Kumar, M.Sc.(Hort.) | Scientist (Hort.) |
| Mr.R.Thangavelu, M.Sc.(Ag.) | Scientist (Pl.Path.) |
| Dr.R.H.Laxman, M.Sc.(Ag.),Ph.D. | Scientist (Pl.Physiol.) (w.e.f. 05.12.97) |
| Dr.R.Selvarajan, M.Sc.(Ag.), Ph.D. | Scientist (Pl.Path.) |
| Dr.V.Balasubramani,M.Sc.(Ag.), Ph.D. | Scientist (Ent.) (upto 15.7.97) |
| Dr.K.J.Jeyabhaskaran,M.Sc.(Ag.),Ph.D. | Scientist (Soil Sci.) |
| Mr.S.Vincent, M.Sc.(Ag.) | Scientist (Pl.Physiol.) (upto 15.7.97) |
| Mr. B.Shyam,M.Sc.(Ag.) | Scientist (Biotechnology) (w.e.f. 05.12.97) |

### TECHNICAL

| | |
|---|---|
| Mr. Raghuraman | Junior Garden Supdt. |

### ADMINISTRATION

| | |
|---|---|
| Mr.N.Viswambharan | Asst.Admn.Officer |

### AUDIT AND ACCOUNTS

| | |
|---|---|
| Mr.C.J.Stephen | Asst.Fin.&Accts.Officer (w.e.f. 24.11.97) |

## 18. ANYOTHER RELEVANT INFORMATION SUCH AS SPECIAL INFRASTRUCTURAL DEVELOPMENT

**Meteorological Data**

| Month/Year | Temperature°C | | Relative Humidity(%) | Rainfall (mm) |
|---|---|---|---|---|
| | Minimum | Maximum | | |
| April-1997 | 24.3 | 35.1 | 63.8 | |
| May | 26.3 | 36.1 | 81.5 | |
| June | 25.9 | 35.9 | 57.9 | |
| July | 26.3 | 35.2 | 54.25 | |
| August | 26.3 | 34.9 | 53.4 | |
| September | 24.6 | 34.3 | 63.75 | 135.5(9) |
| October | 23.8 | 31.5 | 75.2 | 123.2(12) |
| November | 23.5 | 29.5 | 84.8 | 244.0(21) |
| December | 22.96 | 29.6 | 84.5 | 54.0(10) |
| January-1998 | 19.0 | 32.0 | 90.0 | |
| February | 18.5 | 36.5 | 82.0 | |
| March | 18.0 | 37.5 | 73.7 | |

**PERCENTAGE OF SC, ST AND WOMEN EMPLOYEES AT NRCB**

| Class of posts | Total no. of posts sanctioned | Total no. of posts filled | % of SC employees | %of ST employees | % of Woman employees |
|---|---|---|---|---|---|
| 1. Research Management | 1 | 1 | - | - | vacant w.e.f. 16.12.97 |
| 2. Scientific | 15 | 10 | 20.00 | - | 10.00 |
| 3. Technical | 15 | 15 | 33.00 | 13.00 | 7.00 |
| 4. Administration | 9 | 9 | 33.00 | - | 11.00 |
| 5. Supporting Staff | 7 | 7 | 57.14 | 14.29 | - |
| Total | 47 | 41 | 34.14 | 7.31 | 4.87 |

**Work progress for the period 1997-98**

1. Electrification for packing house and lab building completed.
2. Compound wall at the office-cum-lab building area is completed together with a security out-post.
3. Construction of quarantine house of an estimated amount of Rs.21 lakhs has started for which Boomi Pooja was done by DDG.(Hort.) and work is in progress.

*Dr. H.P. Singh unveils the foundation stone of overhead water tank*

4. Construction of over head water tank of an estimated amount of Rs.43 lakhs and work is progress.
5. All round fencing for two acres land, the land which was handed over by the Tamil Nadu State Government to NRCB for starting a laision office, work on fencing has been completed.

# कार्यकारी सारांश

देश मे केले की बढ़ती हुई महत्त एवं अनुसंधान की जटीलता को ध्यान मे रखते हुए राष्ट्रीय केला अनुसंधान केन्द्र की स्थापना दिनांक 21 अगस्त 1993 को भारतीय कृषि अनुसंधान परिषद द्वारा टास्क फोर्स की अनुशंसा से हुई और यह केन्द्र 1 अप्रेल 1994 से आधारभूत विकास एवं अनुसंधान कार्य मे पूर्ण रूप से कार्यरत है । इस केन्द्र का मुख्य उद्देश्य – मूलभूत तथा योजनाबद्ध अनुसंधान द्वारा केले का उत्पादन एवं उत्पादकता मे वृद्धि लाना है । आनुवांशिक संसाधनों का उपयोग, अन्नत किस्मों का विकास, जैव तकनीकी का उपयोग, उत्कृष्ट उत्पादन तकनीकी, पादप स्वास्थ व्यवस्था एवं सस्योत्तर प्रबंधन द्वारा केले का उत्पादन एवं उत्पादकता मे वृद्धि, अनुसंधान केन्द्र का मुख्य लक्ष्य है । पिछले चार वर्षो मे केन्द्र के आधारभूत ठॉचे और अनुसंधान कार्यो मे सराहनीय प्रयोग हुई है ।

**अनुसंधान उपलब्धियाँ :**

दूरदर्शी योजना एवं अनुसंधान सलाहकार समिति के परामर्श मे इस केन्द्र का अनुसंधान कार्यक्रम चार मूलभूत परियोजनाओं के अन्तर्गत प्रारम्भ किया गया है । आनुवांशिक विकास, उन्नत उत्पादन तकनीकी, केले का स्वास्थ व्यवस्था एवं सस्योत्तर प्रबंधन, इस केन्द्र का मुख्य कार्यक्रम है । अन्तरराष्ट्रीय केला परीक्षण कार्यक्रम के अन्तर्गत परीक्षण चला रहा है । वर्ष 1996 में कुछ ही वैज्ञानिक पद पर कार्यरत थे फिर भी इस केन्द्र पर आनुवांशिक विकास, उत्पादन तकनीकी एवं पादप स्वास्थ व्यवस्था मे सराहनीय प्रगति हुई है ।

भारत केले की विविधताओं का केन्द्र है जिसमे आनुवांशिक सम्पदा का विशेष स्थान है । केरल के दक्षिणी भाग और तामिलनाडू क्षेत्र के खोज मे 27 विषाणु प्रतिरोधक प्रजातियाँ को संग्रहकर केला जननद्रव्य मे संग्रहीत किया गया है और यह नई पूवन (AB) रसथाली (AAB - रेशम) नेन्द्रन (प्लानटन – AAB) एम. बालविसियेना (BB/BBB) आदि मे समूहीत होते है । शेवरय पर्वत, येर्काड और तिरुपथी क्षेत्रो के खोज से बीज रहित वन्य AA डीप्लोइड एवं वन्य बीजरीत एम. बालविसियेना नमूने पाये गये है । बीज अंकुरण परीक्षण के द्वारा नर जनन को पहचाना गया है । हाथीदॉत और कनाईवंशी के निषेचन द्वारा नर जनन के साथ साथ जेनोमिक वर्ग और उपवर्ग भी पाया गया है और निषेचन द्वारा कनाईवंशी के उपेक्षा हाथीदॉत मे बीज की उत्पत्ति अधिक पाया गया ।

पिसांग अवाक के निषेचन से संकर बीज, अंकुरण की क्षमता पौधाशाला मे उत्तम पाया गया है । स्ट्रेप्टोसाइकलीन (0.1 प्रतिशत) + साइट्रीमाइड (0.1 प्रतिशत) में 5 मिनट, मारकयूरीक कलोराइड (0.1 प्रतिशत) मे 3 मिनट रखकर गर्म पानी से धोने पर प्रतिरोधक क्षमता अधिक पाया गया ।

कालिवर रोबस्टा एवं करपुरवल्ली प्रजाति को $T_1$ (1/2 MS + Fe + Vit + एस्कोरबिक अम्ल + एक्टीवेटेड चारकोल (0.25 ग्राम प्रति लीटर) एवं $T_3$ (1/2 MS + Fe + Vit + एस्कोरबिक अम्ल + NAA (2µm) के प्रयोग से अंकुरण की क्षमता अर्थात जड़ो की संख्या, जड़ो की लम्बाई, मोटाई और रवेती के लिए उत्तम पाया गया है।

विदेशी नमूने (नमूने – 0697) जो ब्लुगो उपवर्ग मे समूहीत है, उपज और लवण सहनशीलता भारतीय जलवायू मे उत्तम सिद्ध हुआ है । नमूने – 0692 जो लम्बाई 3.2 से 3.5 मी. मोटाई – 75.80 सेमी. उपज – 35 से 38 किलोग्रम, 12 से 14 गुच्छे और कुल 330 से 345 दिनों में फल देता है । यह दुसरे प्रजाति के उपेक्षा सब्जी के लिए भी और 6 दिनो तक हरा रखा जा सकता है और शराब बनाने के लिए भी उपयूक्त पाया गया है। निषेचनो की मुल्याकंन से मादा जनन भी उत्तम पाया गया है ।

केन्द्र ने जननद्रव्य के ऑकड़ो को सुरक्षित एवं मुल्यांकन के लिए एक साफ्टवेयर का उपलब्ध कराया गया है जिसमे 50 से अधिक वन्य एवं खेती की जा रही प्रजातियो का ऑकड़ा तैयार किया गया है । वर्णसंकरीकरण पर कोशिश और प्रतिफल से विभिन्न डीप्लोइड जैसे – हाथीदाँत, अमरीत सागर जो एक्युमिनोटा वर्ग और तिरुबनन्तपुरम (AAB) पराग जनन के लिए उत्कृष्ट साबित हुआ है ।

पत्ती विकास अवधि (फीलाक्रोन) 5.84 से 11.88 दिनो के अन्दर और तापमान एवं आद्रता बढ़ने से पत्ती का विकास अवधि भी अधिक होता है ।

केले का खेती मे अधिक जैविक पोषक तत्व डालने पर पैधा मे वृद्धि, कम दिनों मे फल, अधिक उपज और टी.एस.एस. सभी प्रजातियों मे अधिक पाया गया जबकि 100 प्रतिशत नेत्रजन अजौविक पोषक तत्व के रूप मे डालने से अधिक दिनों के बाद फल देने का परिणाम मिला है और नेमाटोड की आवादी भी अधिक पाया गया।

खरपतवार की कुप्रभाव को पता लगाने हेतु किये गये परिक्षण से ज्ञात हुआकि प्रथम छ : महीना खरपतवार से मुकत रखने पर पौधो की लम्बाई मे बृद्धि, उपज मे बड़ोत्तरी और कम समय पर फल देता है जबकि खरपतवार न हटाने पर 33.15 प्रतिशत खांदी (बान्च) को वजन मे कमी और चार महीना तक अधिक समय लगता है।

परीक्षण से ज्ञात हुआ कि पत्ती मे पोटाश और सोडियम का अनुपात सीधा एवं अर्थपूर्ण सम्बन्ध ($r = 0.2131$) है और केले का पत्ता मे पोटाश और सोडियम का अनुपात उचित उपज के लिए एक से अधिक होना चाहिए ।

जड़ एवं पत्ती का पोटास एवं सोडियम का अनुपात, अध्ययन के आधार पर ज्ञात हुआ कि साबा प्रजाति मे जड़ के सतह पर सोडियम को बाहर करता है और पोटाश अधिक मात्रा मे सोखता है तथा इस प्रजाति के क्षारीय एवं क्षारीय सोडियम रहीत मिट्टी के जड़ एवं पत्ती मे अधिक पोटाश, एवं सोडियम का अनुपात रहता है।

तामिलनाडू एवं पाण्डिचेरी क्षेत्र के खोज से पता चला कि 12 तरह के नेमाटोड केला के स्वास्थ को हानि पहुँचाता है जिसमे से प्राटिलेंकस कॅाफिये, मेलिडोगाइनी इनकोगनिठा, हेलिकोटीलेंकस मलटिसिंकटस प्रमुख है । जबकि ए.के.अ.के. तिरूची के प्रक्षेत्र की मिट्टी एवं जड मे 15 तरह के नेमाटोड पाये गये जिसमे आर. सिमिलस, पी. काफिए, एच. मलटिसिंकटस, एवं एम. इनकोगनिटा प्रमुख है ।

नेमाटोड के आवादी अस्थिरता के अध्ययन से ज्ञात हुआ कि आर सिमिलस, की आवादी जनवरी से अप्रेल माह तक बडोतरी हुई जबकि मई से अक्टुबर माह के बीच कमी पाया गया और फिर नवम्बर ढिसम्बर मे इसकी आवादी नियमित बढता गया ।

परीक्षण से यह भी ज्ञात हुआ कि नीम की खल्ली, नेत्रजन के मुख्य स्रोत के रूप मे डालने से नेमाटोड कम पायी गयी जबकि पी. काफिया नेमाटोड, करपुरावल्ली, रोबास्टा के उपेक्षा नेन्द्रन प्रजाति मे अधिक पाया गया ।

ए.के.अ.के. तिरुची के जनन द्रव्य मे उपलब्ध नमूने के प्रारम्भिक अध्ययन से मुख्य नेमाटोड जैसे – आर. सिमीलस, पी. काफिया, एम. इंकोगनिटा और एच. मलटिसिंकटस के प्रतिरोधक तथा सहनशीलता के लिए पाया गया है । जनन द्रव्य के 567 नमूने के अध्ययन से ज्ञत हुआ कि 45 प्रजातियाँ पी. काफिया, तथा 6 प्रजातियाँ आर. सिमिलससे, 41 प्रजातियाँ एम. इंकोगनिटा से और 4 प्रजातियॉ एच. माल्टिसिंकटस प्रजातियों से संवेदनशील पाया गया।

तामिलनाडू क्षेत्र के अध्ययन से ज्ञात हुआ कि पत्ती दाग (सिगाटका) बिमारी का प्रकोप सभी प्रजातियों मे पाया गया । सबसे अधिक प्रकोप (80 प्रतिशत से ज्यादा) रोबास्टा पूवन एवं मोनथन प्रजातियो पर तथा सबसे कम प्रकोप फल पकने के समय करपूरावल्ली प्रजातियो मे पाया गया । फल पकने के समय हरी पत्ती 13 से अधिक करपूरावल्ली प्रजातियो मे और रोबास्टा एवं रसयाली मे कम देखा गया ।

मुर्झा रोग (फयुजेरियम वील्ट) का प्रकोप रसथाली, मनथन प्रजातियों मे सबसे अधिक और करपूरावल्ली मे सबसे कम पाया गया ।

नीर वाषै का प्रकोप (10 पौधेप्रति एकड़) नेन्द्रन के बगीये मे देखा गया ।

प्रक्षेत्र मे मुर्झा रोग और पत्ती दाग (सिगाटका) बिमारी का जनन द्रव्य मे मुल्यांकन किया गया । मुल्यांकन से ज्ञात हुआ कि पिसांग अवाग, मनथन एवं ब्लुगो वर्ग जो मुसा बाल्विसिलेना मे समूहित है और बी. जेनोम के अर्न्तगत आता है पत्ती दाग बिमारी का सहनशीलता कम था, जबकि जेनोम के अर्न्तगत आने वाले सभी ने बिमारी का प्रकोप कम, अधिक पिलपन और हरी पती कम पाया गया ।

क्षेत्रीय पेयन (ABB) ईना बेनियन (AAB), तिरूवनन्तपुरम (AAB) कालिबो (AAB), पेटाइट नाइन (AAA), वडक्कन कदली (AA), पिसांग राजा (ABB) प्रजातियो मे पत्ती दाग (सीगाटका) बिल्कुल नही पया गया ।

संकर पी.ए.–03–22 (ई.एम.बी.–404), फीया–03 एवं प्रकृतिक जननद्रव्य जैसे – काल्टिवर रोज, यगंमबी किमी–5, पिसांग जारी बाया और पिसांग लिलिन पत्ती दाग (सिगाटका) बिमारीयें के प्रतिरोधक जबकि संकर फीया–23, ई.एम.वि–402, जी.सी.टी.सी.वी–119, जी.सी.टी.सी.वी–215, और ब्युरो सेमसा, साबा, ब्लुगो एवं विलियम प्रजातियाँ पत्ती दाग (सिगाटका) बिमारी से संवेदनशील पाया गया ।

PMEC

अन्तरराष्ट्रीय केला परीक्षण कार्यक्रम के अन्तर्गत पत्ती दाग बिमारी का प्रकोप जानने के लिए मुल्यांकन किया गया जिसमे एस.एच–343669, साबा, पिसांग सिलांग और क्षेत्रीय रोबास्टा प्रजाति को संवेदनशील पाया गया और पी.वी–03644, पी.ए.–03622, पिसांग लिलिन, पिसांग बारलिन, नियारमा यीक, पत्ती दाग (सिगाटका) प्रतिरोधक पाया गया ।

रोग विकासकी अवधि 34–193 दिन पाया गया और यह साबा प्रजाति मे सबसे अधिक था ।

तामिलनाडू एवं केरल क्षेत्र के खोज से बी.बी.एं.वी. बीमारी का प्रकोप 60 प्रतिशत से अधिक नेन्द्रन प्रजाति मे और बी.बी.एंवी. का प्रकोप 24 प्रतिशत से अधिक पूवन प्रजाति में देखा गया विद्युत सुक्ष्मदर्शी द्वारा पचा बोनया बायिसा के पुंखड़ी (ब्रेक्त) एवं फल मे बी.बी.एम.वी. एवं बी.एस.वी.के रोगाणु पाये गये ।

जननद्रव्य मे 36 नमूने बी.बी.एम.वी. से ग्रस्थ और 15 नमूने के पुंखड़ी, पत्ती एवं तना मे लक्षण देखा गया और यह पुत्तल मे भी पाया गया सात नमूने मे बीमारी का लक्षण सिर्फ पुत्तल मे देखा गया और यह पूंखड़ी पत्ती एवं तना मे नही देखा गया ।

तापमान और आद्रता का प्रभाव सभी संवेदनशील प्रजातियों मे देखा गया जबकि इसका प्रभाव का दर विभिन्न प्रजातियो मे मिल पया गया । यह 1 डिग्री तापमान बढ़ने से रोग विकास की अवधि 6 से 14 दिन अधिक और 1 प्रतिशत आद्रता बढ़ने से 1.5 से 5 दिनो. तक कम लगता है ।

तामिलनाडू क्षेत्र के कुछ जिलों के खोज से पता चला कि टॉबेको कटरपिलर, स्पोडोपटरा लिटयुरा (एफ.) लीफ थ्रीप्स, हेलिनोथ्रीप्स कदालिफिलस आर. एवं एम. फ्लोवर थ्रीप्स, थ्रीप्स हवाइनसीस (मोरगन), बेग वार्म कॉफिनो क्युप्रि एम. और बानाना मिली बाग, स्युडोककस जाति के कीड़े पाये गये । तिरूची क्षेत्र मे लीफ थ्रीप्स, बेग वर्म, जबकि पेरियोकुलम और कयुमवाटोर क्षेत्र मे स्युडोस्टेम बोरर एवं राइजम कीभील बोरर का प्रकोप बहुत अधिक पाया गया । स्पोडोपटरा लिटयुरा (एफ.) द्वारा पत्ी की क्षति मनथन मे सबसे अधिक और पच्चनाडन मे कम देखा गया ।

फल के गुणवता अध्ययन से ज्ञात हुआ कि केला पाँच दिन तक 10° तापमान पर रखने से अधिक क्षति होती है जबकि यह केल्सियम कलोराइड एवं ए.ए. मे डालने से क्षति कम होती है ।

. करपूरावल्ली प्रजाति के परिक्षण मे ज्ञात हुआ कि केले को एक घंटा पानी मे डूबाकर और कमरे के तापमान पर रखने से 4 दिन से अधिक से 8 दिन तक उसकी हरी अवधि (ग्रीन लाईफ) बढ़ती है ।

पॉच विभिन्न वर्ग – AA, AAA, AAB, ABB, और BBB के 69 नमुने के अध्ययन से प्राप्त हुआ कि फल को 75, 90 और 100 दिन पर (फूल निकलने के बाद) काटकर 25°C ± 2°C तापमान और प्लासटिक भैला मे रखने से उसकी हरी अवधि फल के पकने की अवस्था के विपरीत होता है । सबसे लम्बी हरी अवधि नमूने – 0097 मे और सबसे लम्बी पीला अवधि नमूने – 0122 मे पाया गया ।