NATIONAL RESEARCH CENTRE FOR BANANA

TIRUCHIRAPALLI

ANNUAL REPORT 1999-2000

NATIONAL RESEARCH CENTRE FOR BANANA
(Indian Council of Agricultural Research)
#17 Ramalinga Nagar South Extension,
Vayalur Road, Tiruchirapalli – 620 017
TAMIL NADU.

भाकृ अनुप
ICAR

वार्षिक प्रतिवेदन
ANNUAL REPORT
1999 - 2000

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ICAR

राष्ट्रीय केला अनुसंधान केन्द्र
(भारतीय कृषि अनुसंधान परिषद)
त्रिची - 620 017 तमिलनाडू

NATIONAL RESEARCH CENTRE FOR BANANA
#17 Ramalinga Nagar South Extension, Vayalur Road,
Tiruchirapalli – 620 017, Tamil Nadu.

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#17, Ramalinga Nagar South Extension,
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Front Cover Page : Logo of NRC for Banana

Back Cover Page : Various banana by products developed at NRCB

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PREFACE

Bananas and plantains make a crucial contribution to Earth's food supply. Together with rice, wheat and maize, bananas are among the four most important crops in the developing world in terms of gross value of production. Under polyclonal and peasant farming system of bananas existing in India, many different cultivars constitute staple food in different regions of the country. Thus bananas and plantations lend support towards food and nutritional security of the nation.

From time to time, banana cultivation is being threatened by many pests and diseases, changing market situation and consumers' demand.National Research Centre for Banana with its sixth year of dedicated service, has been on the lookout for the occurrence of various maladies and production constraints in different parts of India. Since the recent past, banana stem weevil and two new leaf spot diseases, viz., Black Sigatoka *(Mycosphaerella fijiensis)* and Septoria leaf spot *(M.eumusae)* have been identified to be causing serious crop loss to bananas and plantains. Scientists of NRCB have been making concerted efforts with long term vision to meet such challenges facing banana production. Identification of new sources of resistance for such pests and diseases through systematic screening of vast collection of germplasm, improvement of cultivars through conventional and biotech breeding approaches, development of appropriate production technologies with emphasis on reducing production costs through optimization of resources, formulation of integrated pest management, standardization of post-harvest handling and packaging and development of technologies for value addition and utilizing banana wastes like banana sheath which is a potential source of saline tolerant fibre useful for making a range of commercial products, are some of the activities of NRCB. The Annual Report 1999-2000 reflects the activities and achievements towards this direction.

I sincerely thank the Editorial Board, all the Scientists and other staff members for compiling and editing the Annual Report with appreciable quality and elegance.

S.SATHIAMOORTHY

Director

EXCUTIVE SUMMARY

CROP IMPROVEMENT

NRCB genebank has a total of 907 indigenous and exotic accessions. Among them, 193 accessions were collected during this year which includes 181 INIBAP accessions from NBPGR, New Delhi and four accessions during exploration of Western ghats, seven accessions from Andaman and Nicobar islands, one accession from Tamil Nadu. Eighteen accesions have been identified for commercial exploitation based on five seasons of evaluation. Protocol has been standardised for *in-vitro* conservation of selected germplasm. Embryo culture has been successfully standardised for ABB cultivars. Standardised the regeneration of meristematic clumps in Silk group by optimising BAP concentration to permit proliferation of viable shoots. Molecular characterisation has been done for 14 field accessions with a view to study the phylogeny of accessions through dendrogram.

A database has been developed for 545 germplasm accessions for 121 characters based on INIBAP/IPGRI descriptor. Evaluation of IMTP accessions for their resistance to *Fusarium* wilt and Sigatoka leaf spot at two locations have resulted in the identification of six tolerant accessions to Sigatoka leaf spot disease.

Under *Musa* Germplasm Information System (MGIS), passport data for 809 accessions while complete evaluation and characterisation have been updated for 100 accessions.

PRODUCTION AND POST-HARVEST TECHNOLOGY

Studies on the effect of irrigation, fertigation and planting systems on growth, yield and quality of Poovan and Nendran were conducted. The paired row planting and 80% replenishment of evaporation loss with 100% N level have recorded the favourable growth parameters in respect of plant height, number of leaves and fruits as compared to control (normal planting with 80% Eo and 80% N level). Paired row planting delayed flowering as compared to normal planting. Paired row planting in general showed less chlorophyll a, b and total, due to the shading of the leaves. The leaf K content decreased with increasing levels of irrigation and normal planting recorded higher leaf K than the paired row planting. Highest TSS was recorded in paired row planting and acidity decreased with increasing levels of irrigation and N application.

Among different soil amendments, application of 2 kg gypsum and 15 kg FYM along with 120% of recommended K (360g K_2O) plant^{-1} recorded no salt injury and had the highest leaf K, K/Na ratio and lowest Na concentrations and higher exchangeable Ca contents in the soil. Application of gypsum, FYM with 120% K (360 g) recorded the highest constant rate K (CR-K), K concentration in soil solution (AR_c^k) and increased the potential buffering capacity (PBC^k) of the soil there by, has a better reclamation ability for the sodic soils. The highest bunch weight in Nendran cultivar was also obtained in this treatment.

Among the different organic manures, 15 Kg poultry manure plant^{-1} recorded the highest growth parameters at 80% of NPK levels. This treatment recorded the highest bunch weight with maximum soil K, Ca and minimum soil Mg and Na contents. Application of 15 Kg poultry manure could supplement 20% of recommended NPK requirements of Nendran banana.

Studies on different cooking oils on the quality of Nendran chips indicated that maximum chips recovery was obtained in coconut oil with better storage and edible quality. Sunflower oil was not suitable as a medium since it developed a bitter taste during storage. For the preparation of banana jam, the final product with 40% pulp, 70% total sugars and 0.6% acid produced an ideal jam. For the Poovan banana jam preparation, 0.25% pectin based on the final weight was optimum for proper setting while for Karpuravalli and Ney Poovan bananas, there was no need of additional pectin. A tasty, storable and acceptable banana fruit bar was prepared using Karpuravalli, Pachanadan and Poovan, mixed pulp, pectin, acid and KMS. Papads prepared by mixing rice flour with Monthan banana flour has a good storage life with acceptable quality. Poovan shelf life was extended by 4% calcium chloride infiltration at 760 mm Hg by 8 days under ambient temperature. Ethrel at 500 ppm as dip at 52+1°C as dip significantly improved the ripening of Pachanadan and Rasthali with better fruit quality and excellent fruit color.

CROP PROTECTION

Severe incidence of banana pseudostem borer and rhizome weevil was recorded in Karur and Coimbatore districts respectively. Out of 309 accessions evaluated against the pseudostem borer under field conditions, 66 accession belonging to AAB and ABB genomes were the most preferred host by the borer. Scanning electron microscopic studies indicated that substantial layer of variously shaped sensilla in the antennal tip, antennal segement proboscis and elytra are being used as sensory receptors. The pseudostem borer showed high degree of host preference for Nendran cultivars. *Spodoptera litura* mortality was the highest in Azarec and Nimbicidine. Commercially available sex pheromone 'Basslure' for *S.litura* evaluted under field conditions revealed that maximum male moth catch was recorded during 14 - 15th standard week.

The root- lesion nematode was predominant in Nendran followed by root-knot nematode in Rasthali. The burrowing nematode was recorded in cvs. Rasthali, Karpuravalli, Red banana, Rasakadali and Virupakshi. Application of Carbofuran @ 50g / plant, applied in two splits were very effective in reducing *P.coffeae* population and significantly increased the bunch weight by 50 per cent in Nendran. In Nendran, *P.coffeae* maximum damage was noticed in red soil and the least in alluvial soil.

Panama disease was recorded in cv. Poovan for the first time in India. The biocontrol agents like *Trichoderma viride* and *Pseudomonas fluroescence* were found to inhibit the wilt pathogen in dual culture. Occurrence of Black Sigatoka and Septoria leaf spots were recorded. Tilt (Propicanazole) or Anvil (Hexacanazole) @ 0.1% was found to be effective in the control of black Sigatoka and Septoria leaf spot diseases.

CROP PHYSIOLOGY AND BIOCHEMISTRY

Among the germplasm, Pisang Seribu (AAB) had the highest number of leaves and leaf area at the time of flowering which was also earlier as compared to Pacha Bondha Batheesa and Thiruvananthapuram. Dehanding of first one to three hands did not have any effect on fruit filling. The physiological evaluation of accessions revealed that 'B' genome contributed more for the higher performance of banana for the growth parameters.

TRANSFER OF TECHNOLOGY

On-farm advice, farmers meeting and lectures were given to popularize the propagation methods, identification of virus diseases affected suckers, improved production technologies for reducing the cost of cultivation, improved protection technologies for the control of new pseudostem borer and new leaf spot diseases. Farmers were educated about the Integrated nutrients, pests and diseases management, fertigation, post-harvest technology, value added products, quality improvement for domestic and export markets.

Training programme on processing of banana products were conducted for six months duration to two women entrepreneurs to develop their entrepreneural skills, sponsored by the district industries centre, Trichy.

HUMAN RESOURCE DEVELOPMENT

Six Scientists were deputed for short term trainings within the country to upgrade their skills in their respective area of specialization. Dr. P. Sundararaju, deputed as a RISBAP co-ordinator to Phitsanuloke, Thailand.

A consultancy project on the evaluation of Round up and two consultancy projects on the control of leaf spot diseases were carried out during this year.

Scientists of this centre also acted as research adviser in guiding students from Srimathi Indira Gandhi College, Trichy for their M. Phil. degree programme.

INTRODUCTION

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

BUDGET

NRCB Budget and Expenditure Details For 1999-2000 (Rupees in lakhs)

Head of Account	Budget for 1999-2000		Expenditure 1999- 2000	
	Plan	**Non-Plan**	**Plan**	**Non-Plan**
Estt. Charges	17.00	39.80	17.13	37.54
Travelling expense	2.00	0.75	1.82	0.75
Other charges	36.00	9.45	31.69	8.77
Major works	85.00	—	84.85	—
Petty work (Maintn)	—	3.00	—	0.73
Petty works (original)	—	—	3.38	—

METEOROLOGICAL DATA

Month/Year	Temperature (^{0}C)		Rainfall (mm)
	Minimum	Maximum	
April 1999	22.2	36.7	102.9
May 1999	25.1	36.8	148.2
June 1999	25.8	35.7	3.35
July 1999	21.9	36.4	18.0
Aug 1999	25.1	34.5	52.1
Sept 1999	24.4	34.2	39.8
Oct 1999	23.6	30.9	254.2
Nov 1999	22.3	29.5	249.9
Dec 1999	21.2	29.5	40.5
Jan 2000	20.2	29.4	—
Feb 2000	22.0	33.0	26.5
Mar 2000	22.1	33.8	—

2.1.3 Studies on soil amendments on Nendran banana under Saline sodic soil (K.J.Jeyabaskaran and S.D.Pandey)

The Nendran banana is highly sensitive to salinity and sodicity of the soil by showing leaf injury symptoms and 30 per cent yield loss. This type of leaf injury was mainly due to excessive Na accumulation in the leaves. Amendments like FarmYard Manure (FYM) and gypsum along with graded level of K were tried in Nendran banana. Among the amendment combinations, gypsum + FYM recorded the highest K concentration and K/Na ratio and lowest Na concentration in the leaf samples. Within the amendment combinations, the leaf K concentration and K/Na ratio increased and Na concentration decreased with increasing K levels (**Table- 8**). A similar trend was observed in the soil samples also (**Table-8**). The soil recorded higher exchangeable Ca contents wherever gypsum was applied. The soil Ca/Na ratio increased with increasing levels of K application (**Table-9**). The treatment gypsum @ 2 kg/plant + FYM @ 15 kg/plant +120 % recommended K recorded no sodic injury symptoms with the highest bunch weight (10.33 kg/plant) hence, it was found to be the best among the treatment combinations (**Table-10**).

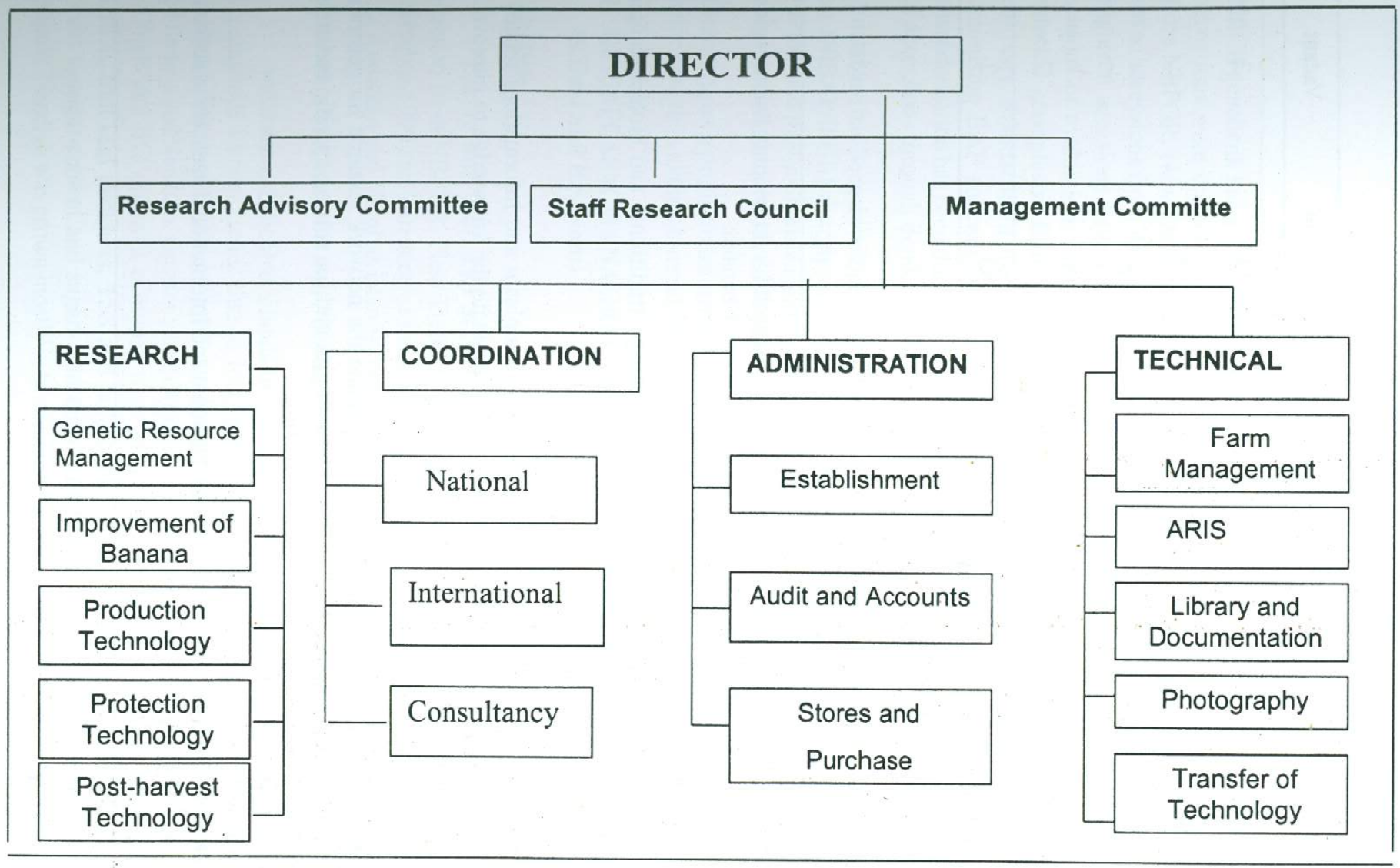
Table-8: Effect of soil amendments and potassium on leaf and soil K/Na ratio of Nendran banana

Treatment Sub	Leaf K/Na at					Soil K/Na at				
Main	K_{90}	K_{100}	K_{110}	K_{120}	Mean	K_{90}	K_{100}	K_{110}	K_{120}	Mean
Control	2.06	3.67	5.00	6.32	4.26	0.23	0.50	0.65	1.02	0.60
FYM	6.40	7.91	9.35	11.20	8.72	0.60	0.75	0.93	1.03	0.83
Gypsum	9.57	10.08	18.82	25.98	16.11	0.96	0.73	1.12	1.74	1.14
FYM+Gypsum	20.33	18.30	25.82	24.38	22.21	1.20	1.25	1.68	2.25	1.60
Mean	9.59	9.99	14.75	16.97		0.75	0.81	1.10	1.51	
		M	S	MxS			M	S	MxS	
CD(P=0.05)		4.448	3.752	7.503			0.234	0.198	0.395	

Table-9: Effect of amendments and potassium on soil Ca and Ca/Na ratio

Treatment Sub	Soil Ca (ppm) at					Soil Ca/ Na at				
Main	K_{90}	K_{100}	K_{110}	K_{120}	Mean	K_{90}	K_{100}	K_{110}	K_{120}	Mean
Control	2133	1777	2126	2423	2115	4.33	4.27	5.56	7.46	5.40
FYM	2387	2410	2368	2631	2449	7.06	6.99	7.38	8.10	7.38
Gypsum	4175	4605	4565	4921	4566	16.34	19.63	17.09	22.08	18.78
FYM+Gypsum	5231	5422	5589	6130	5593	20.13	20.95	22.65	29.68	23.36
Mean	3482	3553	3662	4026		11.97	12.96	13.17	16.82	
		M	S	MxS			M	S	MxS	
CD(P=0.05)		361.2	304.6	609.3			2.206	1.861	3.722	

ORGANOGRAM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ARIS
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Photography
Transfer of Technology

MANPOWER

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

MANDATE

- To undertake the basic and strategic research for developing technologies to enhance the productivity and utilization of banana.
- To develop improved cultivars through traditional and biotechnological methods and conserve *Musa* 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, technologies and for solving specific constraints on banana and plantain production.
- To collaborate with relevant National and International agencies in achieving the above objectives.

RESEARCH ACHIEVEMENTS

1. CROP IMPROVEMENT
General Leader : Dr.S.Sathiamoorthy

NRCB genebank has a total of 907 indigenous and exotic accessions. Among this, 193 accessions were collected during this year which includes 181 INIBAP collections from NBPGR, New Delhi and four accessions during exploration of Western ghats, seven accessions from Andaman and Nicobar islands, one accession from Tamil Nadu. Eighteen accesions have been identified for commercial exploitation based on five seasons of evaluation. Protocol has been standardised for *in-vitro* conservation of selected germplasm. Embryo culture has been successfully standardised for ABB cultivars. Standardised the regeneration of meristematic clumps in Silk group by optimising BAP concentration to permit proliferation of viable shoots. Molecular characterisation has been done for 14 field accessions with a view to study the phylogeny of accessions through dendrogram.

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Under *Musa* Germplasm Information System (MGIS), passport data for 809 accessions while complete evaluation and characterisation have been updated for 100 accessions.

1.1 GERMPLASM MANAGEMENT
(S.Uma and B.Shyam)

Collection

During this year, 193 accession were collected, which includes 181 INIBAP collection from NBPGR, New Delhi as a replacement of accessions lost during floods in November, 1999 and four accessions during exploration of Western ghats, seven accessions from Andaman and Nicobar islands, one accession from Tamil Nadu (**Table-1**).

Exploration in Andaman and Nicobar Islands

Andaman and Nicobar islands in general have a good natural variability with respect to commercial banana clones due to long periods of domestication under isolated tropical conditions. The commercial cultivars are Pisang Awak, Dwarf Cavendish, Robusta, Poovan, Red Banana and Nendran. Greater variability has been observed in Pisang Awak locally known as Chinia and five different ecotypes were identified with respect to plant height, stature, duration, fruit skin thickness, TSS and pulp colour. Poovan also exhibited variability with respect to sugar content and sugar: acid ratio. Red banana and its green mutant were very common. Nendran was grown mostly in homestead gardens especially in areas where inhabited

by Keralites. Thiruvananthapuram cultivar was noticed in one of the homestead gardens.

Present exploration in the tropical forests of South Andaman revealed the presence of a unique *Musa balbisiana* and *Musa acuminata* the subspecies status of which need to be ascertained. *Musa acuminata* was a major species under *Musa* seen in large areas and is also supposed to be an active breeding ground due to their female fertility where the possibilities of intermediate hybrids are expected to occur in natural habitat. The forest areas surveyed were Chouldhari reserve forest, Wandoor forest and Ferrargunj forest. The co-occurrence of natural wild bananas both belonging to *Musa acuminata* and *Musa balbisiana* was observed.

Table-1: New accessions collected during 1999-2000

Source	Accession collected / Genome
Khasiranga Hill, N-E. region	Wild - IV (AA)
Monobhog, N-E. region	Athiakol (BB/BB)
Assam, NBPGR	GP-39, NIC-2046, GP-39, NIC-23506, NIC-23453. Black Bhimkol (BB/BB)
Trichy, Tamil Nadu	Black Rasthali (AAB), French Plantain (Koppu)
Western ghat, Karnataka	Saldhaththi (AB), Pachaladan (AAB), Sullia(AB), Ney Poovan (AB)
Blooms Dale forest	*M.balbisiana* (BB), *acuminata-balbisiana* (ABB)
Chouldhari forest	*M.balbisiana wild* (BB), *M.acuminata wild* (AA)
Nicobar island	*M.balbisiana andamanica* (BB), *M. balbisiana wild* (ABB/BB)
CARI, Port Blair, Andaman	Rajavazhai (AAB)
INIBAP, NBPGR, New Delhi	Njombe-N2 PC 12-05, IRFA-905, SH-3436-6, Guineo, Ambiri, Adina, Kawaputa, *Calcutta-4(M.ac.ssp.burmaniccoides, Musa ac.ssp.malaccensis t, Musa.ac.ssp.microcarpa ty,* Cocos, *M.maclayi.ssp.macalayi va,* Tani *M.balbisiana, M.acuminata ssp. Zebrina,* TMB x 5295-1, Lep Chang Kut, Cachacko, Ney Poovan, Vudi Wai Wai, Cemsa 3/4, Long Tavoy, Cemeron, Honduras, Banksii, UPLB, Truncata, Malaccensis, Pa (Musore) no. 3 x, Pa (Songkla) x, Pa (Songkla) x, Pisang Cici Alas, Waigu, Banksii, Schizocarpa, Hawain 3, Japaraka no.1, Pahang, Schizocarpa no. 1, Mushu, Hawain 2, Hawain 3, Banksii, *M.a. ssp.banksii x M.sch, Balbisiana,* Khae (Phrae)

x, Adina, Kawaputa, Fougamou 1, Pisang Masak Hijau, Lidi, Kluai Namwa khom, Kluai Lep Mu Nang, Bata Bata, *M.a.ssp.malaccensis type,* TMBX 5295-1, Vietnam no.5, Tien (Than Hua), Kunnan, Amas (South Johnstone), *Musa maclayi,* Imbogo, God Mun, Wain, *Musa maclayi ssp.maclayi,* Skal, *Musa peekelii ssp. peekel, Musa maclayi ssp. Maclayi, Musa lolodensis Musa asupina,* Long Tavoy, Singapuri, Banksii, *M.acuminata ssp. truncata,* Pa (Musare) no. 3 x, Pa (Songkla) x, Pisang Cici Alas, Walgu, Hawain 3, *M.ac.ssp.malaccensis type,* Schizocarpa no.1, Hawain 2, Hawain 3, Vudu Vudu, *Musa coccinea,* Dwarf Cavendish, Robusta, Pisang Nangka, Pisang Nangka, Malaccensis, Dwarf French Plantain, Improved Lady Finger, Silk, Williams, Green Red, Chinese Cavendish, Robusta, Lady Finger, Schizocarpa, *Musa schizocarpa,* Schizocarpa, *M.a.ssp.banksii x M.schi,* Sabra, *M.ac.ssp.Banksii x M.schi,* Msinyore, Pisang Kra.

Exploration in South India

Explorations were undertaken in Tamil Nadu and Western Ghats of Karnataka, Southern Karnataka and Northern Kerala to collect *Musa* diversity (**Table -2**). The explorations and survey resulted in the collection of nine cultivated and three wild accessions.

Table –2: Areas covered during the explorations

States	Areas covered
1 Western Ghats of Karnataka	Virarajpet, Madikeri, Mangalore, Puttur, Kudremukh, Sullia, Vittal.
2. Southern Karnataka, N-E of Tamil Nadu	Mysore, Nanjangud, Mandya, Chamrajpet, Satyamangalam, Karur, Bhavani, Gudalur,Chamraj Nagar.
3. Northern Kerala	Kasaragod, Payyanur, Kannur, Mahe, Kozhikode, Shornur, Malappuram, Malampuzha, Palakkad.
4. Andaman & Nicobar Islands	Chouldhari forest, Ferrargunj, Bloom dale, Port Blair, Rutland.

Conservation

All the accessions collected during the explorations and surveys were brought as

suckers or as bits and were planted in the NRCB field genebank under wet land conditions. Some of the N-E collections collected from higher altitudes and few collected from Andaman and Nicobar islands could not establish in the field due to the change in the growing conditions and efforts are being made to collect the same through other contact persons and institutions.

NRCB had developed moderate facilities for the *in-vitro* conservation of germplasm and multiplication of accessions. This involved multiplication of INIBAP accessions received as proliferating tubes through NBPGR. A total of 72 exotic and 58 indigenous accessions were maintained in the *in-vitro*.

Characterisation

Fruit characterisation

M.acuminata, diploid was collected from Kazhiranga forest. Fruits were small in size with full of seeds, tip was pointed, seeds were small, brownish black in colour, irregular in shape but flat, outer surface was rough. Chalazal end was distinctly white.

Musa ornata (Pink streak) was collected from Arunachal Pradesh. Fruits were small to medium in size with a blunt tip, seeds were small with irregular shape. Hundred seeds weight (fresh) and dry weight were recorded on 3rd day after drying at room temperature (32°C). Embryos were checked for viability in tetrazolium solution, 60 per cent absorbed colour, indicating viability but they did not germinate on medium.

Orange/Pink was collected from Arunachal Pradesh. They were characterised by their erect flowers. Fruits were angular with pedicel being not very distinct. Tip of the fruit was blunt. Seeds were big, black in colour and irregular in shape with a white chalazal end. But 50% of the seeds in a fruit were white. Sixty per cent of the embryos showed pink colour with tetrazolium solution but germination was not observed on embryoculture medium.

GP-9 was collected from NBPGR. Fruits were very immature, pedicel was not distinct and seeds were also very immature to the size of Mustard.

Table- 3: Fruit characters of wild accessions from N-E India.

	Fruit length (cm)	Fruit circum ference (cm)	Pedicel length (cm)	Pedicel circum ference (cm)	Thickness of peel (mm)	Fruit wt. (g)	Pulp wt. (g)	Skin wt. (g)	100 seed wt (fresh) (g)	Seeds/ fruit (No)	Wt. of 100 seeds (dry)(g)
1. *Acuminata* diploid	8.5	7.0	1.0	2.53	2.5	22.29	14.04	8.46	5.34	115	33.77
2. Pink streak	8.96	9.6	2.7	2.8	3.0	40.89	23.68	15.28	7.21	165	3.45
3. Orange/pink	6.26	8.4	1.23	2.65	4.0	18.57	25.73	12.68	10.23	33	6.42
4. G.P- 9	6.9	6.76	1.33	1.56	3.2	56.7	22.9	13.3	11.4	45	7.54

Morpho-taxonomic characterisation

Multivariate analysis of morphological variation among the *Musa* accessions was done to classify the accessions into identifiable clone sets. A total of 18 quantitative parameters that were found to differ among the accessions were selected. The traits were colour of the pseudostem, colour of the upper surface of the leaves, nature of leaves, peduncle, position of the bunch, appearance of the bunch rachis, colour of the male bract, colour of the compound tepal, colour of the free tepal, position of the stamen, colour of pollen sac, position of fruits, length of finger, colour of the peel and nature of fruit apex. 48 accessions belonging to Pisang Awak subgroup was studied using morphotaxonomic characterisation of Simmond and Shepherd's score card. The characters most responsible for the variation pattern and the extent of similarity and dissimilarity were worked out for 48 accessions and are presented in the phenogram.(Table-4)

The cluster analysis of the matrix of distance co-efficients was done. Two distinct groups were clear involving Bhurke-1, Karpuravalli-1 and 2,Jammulapalem collection and Chinia. The group involving Octoman, Bhoodhi bale-1, 2, and 3, Bhurkel, Mas, Vellapalayankodan, Enikompan and Amrithapani. Of all the collections, accessions Shahil Kela, Chinia-1, Poombidiyan and Kechulepa had distinct independent clustering. In many cases, the names and the plants were different due to wrong labelling at the secondary centres from where they were collected.

Table 4 : Molecular Divergence (Isozymes) in Banana

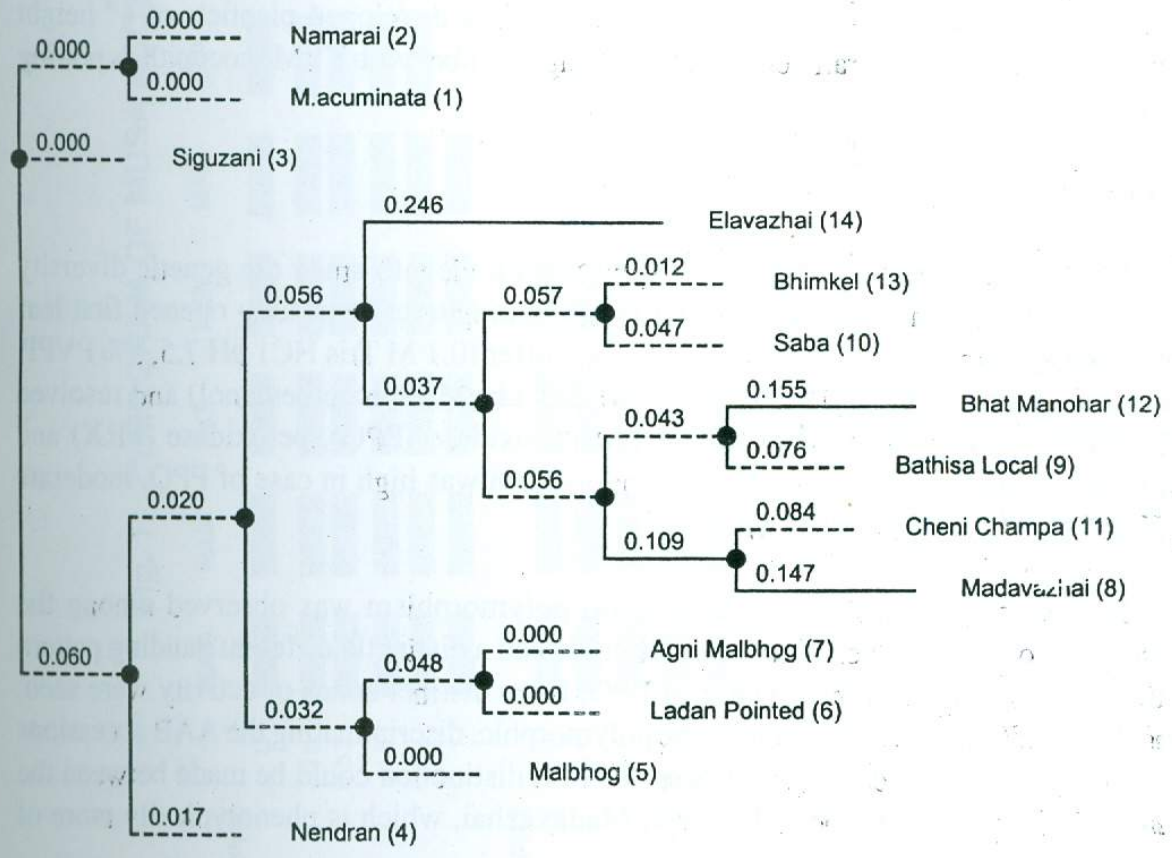


Fig. 8. Effect of Gypsum and FYM with 120% Recommended K on Q/I Parameters of Soil K at Different Growth Stages of Nendran

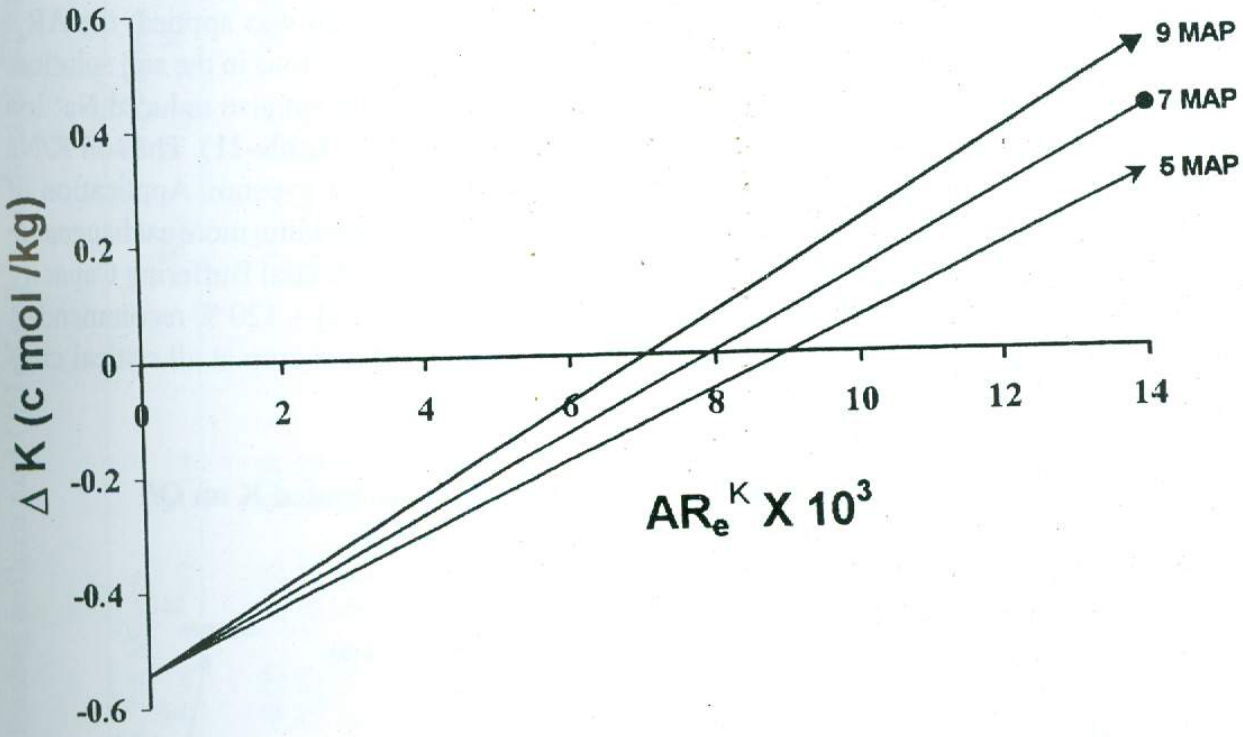


Table - 10: Effect of amendments and potassium on salt injury and yield of Nendran banana

Treatment Sub	Salt injury (%) at					Yield (Bunch weight kg/plant)				
Main	K_{90}	K_{100}	K_{110}	K_{120}	Mean	K_{90}	K_{100}	K_{110}	K_{120}	Mean
Control	55.58	33.87	16.87	5.56	27.97	5.93	5.90	5.93	6.77	6.13
FYM	19.70	12.66	3.19	1.84	9.35	6.17	6.13	6.43	7.17	6.48
Gypsum	15.09	12.40	4.66	0.00	8.04	6.23	6.40	7.47	8.17	7.07
FYM+Gypsum	7.33	4.23	2.93	0.00	3.62	7.53	7.87	9.73	10.33	8.87
Mean	24.43	15.79	6.91	1.85		6.47	6.58	7.39	8.11	
		M	S	MxS			M	S	MxS	
CD(P=0.05)		4.465	3.766	7.532			0.533	0.449	0.899	

The K concentrations and K/Na ratios in soil and plant tissues showed positive and significant correlation with yield of Nendran banana. The soil Ca concentration and Ca/Na were also positively and significantly correlated with yield of Nendran banana. The K/Na ratios of soil and plant tissues had negative and significant correlation with sodic injury of banana leaves. The soil Ca/Na ratio had positive effect on yield and negative effect on sodic injury of leaves of banana.

Increasing K application increased slightly the constant rate K (CR-K) at different crop growth stages. The amendment combinations had significant influence on the CR-K.

Evaluation of Germplasm

Germplasm was evaluated for various morphological, quantitative and qualitative traits for the fifth generation. This was helpful in evaluating the accessions for stability of desirable characters over generations and its further multilocation evaluation. Further study was carried out to know the extent of variability existing for various quantitative characters and effectiveness of exercising selection based on these characters.

1.2. Improvement of banana through biotechnological approaches (B.Shyam and S.Uma)

In vitro embryo germination and regeneration of *Musa* genomes

Embryos were extracted from mature seeds of Calcutta-4, Bhat Manohar, *Musa acuminata* and Athiakol. The seeds were surface sterilised in silver nitrate 0.1% and embryos were excised under sterile conditions in a laminar airflow chamber. The embryos were placed upright on the semi-solid media with the micropylar end in contact with the medium.

Media with various combinations of BAP, IAA or IBA were used with sucrose and incubated in darkness at 25^{oC}. The composition with MS+Vitamins 100 mg/1 meso-inositol 10mg/ascorbate with 3% sucrose and 0.2% gelrite, without hormones was found to be best. Gelrite was found to be better than Agar in increasing the hydration of embryos and hence better survival of embryos was noted.

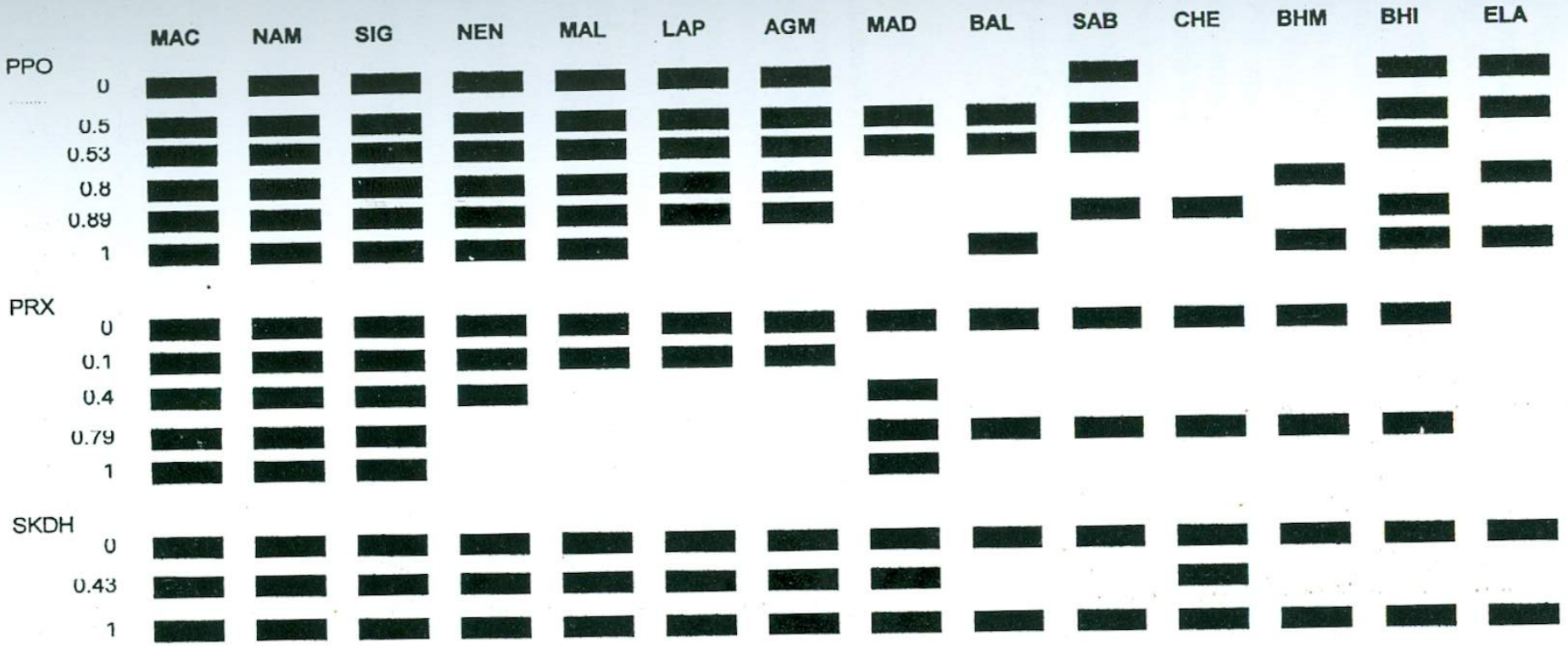
The germination and rooting occured after four weeks. The plants were transferred to illuminated racks (10W/m^2, 12hr photoperiod). Fully developed plantlets of 4" height were grown to maturity and transferred to hardening chamber with FYM+cocopith as potting mixture.

Molecular characterization

Profiling of banana varieties was done with a view to study the genetic diversity among fourteen indigenous accessions. Crude protein extract from fully opened first leaf was obtained by grinding the tissue in extraction buffer (0.1 M Tris HC1 pH 7.5, 5% PVPP, 10% sucrose, 10mM DTT, 0.1% Triton x-100 and 14mM Mercaptoethanol) and resolved on 8% PAGE. Staining was done for polyphenol oxidase (PPO), peroxidase (PRX) and shikimic acid dehydrogenase (SKDH). Polymorphism was high in case of PPO, moderate in PRX and poor in SKDH. **(Fig. 1)**

In case of PPO, PRX and SKDH, no polymorphism was observed among the *acuminata* diploids. However, *acuminata* diploids had a distinctly different banding pattern from the rest of the accessions. In case of PPO, three distinct zones of activity were seen. Among them, Rf 0.8 – 0.89 was found to be polymorphic, discriminating the AAB accessions from the ABB and BB accessions. In case of PRX, distinction could be made between the *acuminata* and *balbisiana* types. However, Madavazhai, which is phenotypically more of

Fig. 1. ZYMOGRAM OF MUSA ACCESSIONS



MAC-Musa acuminata, NAM-Namarai, SIG-Siguzani, NEN-Nendran, Mal-Malbhog, LAP-Ladan Pointed, AGM-Agni Malbhog, MAD-Madavazhai, BAL-Bathisa Local, SAB-Saba, Che-Cheni Champa, Bhm-Bhat Manohar, BHI-Bhimkol, ELA-Elavazhai

balbisiana type, was found to have similarity with *acuminata* as for as PRX is concerned. In case of SKDH, a distinct band at Rf 0.43 was found to be present among the *acuminata* accessions while it was absent in most *balbisiana* types. Using SKDH, little distinction could be made within the genomic groups.

The scoring of isozyme marker bands was done for their presence/absence and data on 14 accessions was analysed using NTSYS software. The qualitative molecular marker differences were converted into measures of similarity/dissimilarity by correlation matrices and further clustered using un-weighted paired group arithmetic average (UPGMA) method into dendrograms (Fig. 1). Among the fourteen accessions with preponderance of A or B genome in general clustered separately with varieties in between them. Further, some varieties considered to be distinctly of the B type (ABB), like Madavazhai were found to gravitate towards A. Ladan Pointed (AAB) was found to cluster with distinctly B genomic groups for the markers studied. This points to varying degrees of introgression than that observed phenotypically. Molecular probing using DNA markers would give a better understanding of evolutionary divergence in banana.

Somatic embryogenesis in *Musa*

Somatic embryo incubation was attempted in the cultivars Nendran, Rasthali and Pachanadan. Male flower buds were used. The outer bracts were removed under aseptic conditions and florets from the 7-15th position from the inner most were excised. The florets were inoculated into semisolid MS as well as liquid medium with varying concentrations of Dicamba, Pichloram, 2,4 -D and 2,4,5-T. Dicamba and 2,4,5-T were found to be the most promising for induction of embryos after 5 months in culture. Initial culture in liquid medium followed by culture in semisolid medium in darkness was helpful in induction. Subsequent proliferation and maturation in the medium with lower concentration of auxin was found helpful. The embryos progressed through distinct heart shape, torpedo shape and finally matured into a mushroom shaped structure resembling zygotic embryos. Gelrite was found to be better than agar in inducing embryos. Rasthali as well as Pachanadan were more responsive than Nendran. Use of PVP to prevent browning interfered with embryogenesis, Citric acid (100mg/1) and ascorbic acid (150mg/1) were used instead. Standardisation of auxin concentration and media constitution to increase the number of embryos was done.

2. PRODUCTION AND POST HARVEST TECHNOLOGY

General Leader: Dr. M. M. Mustaffa

Studies on irrigation, fertigation and planting systems on the growth, yield and quality parameters of Poovan and Nendran were conducted. The paired row planting and 80% replenishment of evaporation loss with 100% N level has recorded the maximum growth parameters like plant height, number of leaves and fruits than the control (normal planting with 80% Eo and 80% N level). Paired row planting delayed flowering as compared to normal planting. Paired row planting in general showed less chlorophyll a, b and total, due to the shading of the leaves. The leaf K content decreased with increasing levels of irrigation and normal planting recorded higher leaf K than the paired row planting. Highest TSS was recorded in paired row planting and acidity decreased with increasing levels of irrigation and N application.

Among different soil amendments, application of 2 kg gypsum and 15 kg FYM along with 120% of recommended K (360g K_2O) $plant^{-1}$ recorded no salt injury with highest leaf K, K/Na ratio and lowest Na concentrations and higher exchangeable Ca contents in the soil. Application of gypsum, FYM with 120% K (360 g) recorded the highest constant rate K (CR-K), K concentration in soil solution (AR_e^K) and increased the potential buffering capacity (PBC^K) of the soil there by, has a better reclamation ability for the sodic soils with highest bunch weight in Nendran banana.

Among the different organic manures, 15 kg poultry manure $plant^{-1}$ recorded the highest growth parameters at 80% of NPK levels. This treatment recorded the highest bunch weight with maximum soil K, Ca and minimum soil Mg and Na contents. Application of 15 kg poultry manure could supplement 20% of recommended NPK requirements of Poovan banana.

Studies on different cooking oils on the quality of Nendran chips indicated that maximum chips recovery was obtained in coconut oil with better storage and edible quality. Sunflower oil was not suitable as a medium since it developed a bitter taste during storage. For the preparation of banana jam, the final product with 40% pulp, 70% total sugars and 0.6% acid produced an ideal jam. For the Poovan banana jam preparation, 0.25% pectin based on the final weight was optimum for proper setting while for Karpuravalli and Ney Poovan bananas, there was no need of additional pectin. A tasty, storable and acceptable banana fruit bar was prepared using Karpuravalli, Pachanadan and Poovan, mixed pulp, pectin, acid and KMS. Papads prepared by mixing rice flour with Monthan banana flour has a good storage life with acceptable quality. Poovan shelf life was extended by 4% calcium chloride infiltration at 760 mm Hg by 8 days under ambient temperature. Ethrel at 500 ppm as dip at 52+1°C as dip significantly improved the ripening of Pachanadan and Rasthali with better fruit quality and excellent fruit color.

2.1. PRODUCTION TECHNOLOGY

2.1.1. Effect of irrigation, fertigation and planting systems on Poovan banana (S.D.Pandey and K.J.Jayabaskaran)

Plant height and number of leaves showed significant differences among the treatments. At 9th month stage, treatment P2I1F2 (paired row, 80% Eo and 100% N level)

recorded maximum height (322.16cm) where as P1I3F1 (conventional planting 120% Eo and 80% N level) recorded the minimum plant height (256.58 cm). Maximum number of leaves were recorded in P2I2F2 treatment (paired row, 100% Eo and 100% N level) while the lowest was observed in P2I1F1 treatment. Other growth parameters showed non-significant differences at different stages of observation. **(Table- 5) (Fig 2,3,4,5,6).**

Table -5 : Effect of irrigation, fertigation and planting system on growth parameters of banana cv. Poovan

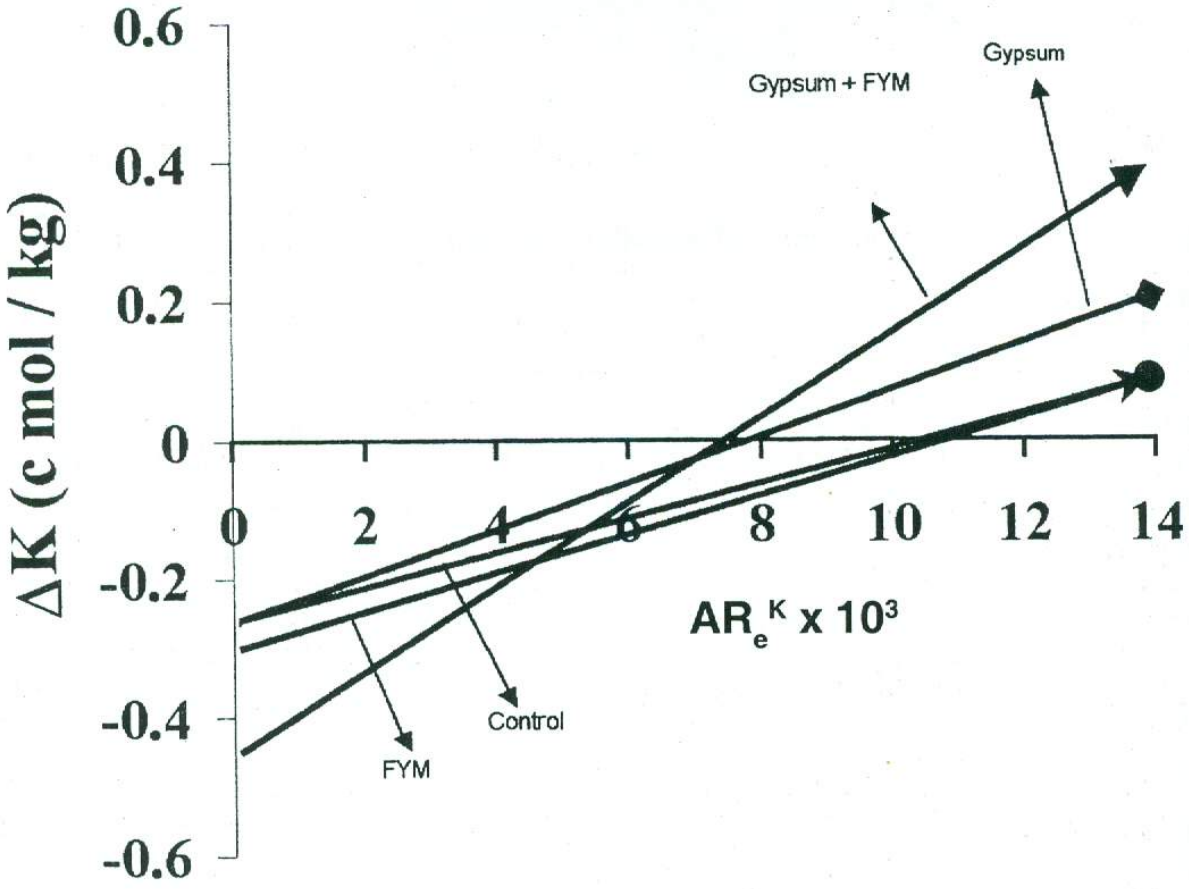
Treatment	Plant Height (cm)	Days taken for shooting	Leaves (Nos)	Fruits (Nos)
P1I1F1	308.95	309.75	21.91	179.62
P1I2F1	291.87	313.50	21.49	177.86
P1I3F1	256.58	320.25	22.62	169.96
P1I1F2	261.29	311.00	20.53	177.42
P1I2F2	260.08	290.00	20.37	189.73
P1I3F2	259.49	311.50	21.50	188.19
P1I1F3	280.37	302.00	19.95	177.06
P1I2F3	274.40	293.50	20.62	185.31
P1I3F3	272.41	285.50	22.33	201.00
P2I1F1	297.62	310.00	18.90	174.19
P2I2F1	303.18	315.50	22.10	172.70
P2I3F1	294.16	313.00	21.24	169.44
P2I1F2	322.16	316.50	22.73	165.85
P2I2F2	313.82	319.50	23.44	166.99
P2I3F2	301.82	321.75	21.99	169.41
P2I1F3	282.41	316.00	21.66	170.21
P2I2F3	284.91	317.00	22.12	173.94
P2I3F3	286.33	317.25	22.83	181.34
CDat 5%	52.75	5.15	2.65	19.78

Observation recorded on phyllochron revealed significant differences at all stages of observations. Treatment combination P1I2F3 and P1I3F3 (conventional planting 100% E0 with 125% N level and conventional planting 120% E0 with 125% N level) respectively took minimum number of days for successive leaf emergence. In general, leaf emergence was faster in conventional planting as compared to paired row system of planting **(Table-5).** Data on days to flowering showed significant response to different treatment combinations and P1I3F3 (conventional planting 120% Eo and 125% N level) recorded earliest flowering (285.50 days) followed by P1I2F3 treatment. Paired row system of planting in combination of nitrogen and irrigation levels produced delayed flowering in comparison to the conventional system of planting in combination of nitrogen and irrigation levels.

There were significant differences in chlorophyll 'a' content among the treatments. In general, in the paired planting system the chlorophyll 'a' content was less as compared to conventional planting system. Total chlorophyll content showed significant differences among

The higher CR-K was observed in the combination, gypsum+FYM at all the growth stages and at all K levels. The increasing levels of K increased the K concentration in the soil solution (AR_e^K) but the AR_e^K decreased with increasing duration of crop **(Fig. 8)**. It was also noted that in the amendment combinations wherever gypsum was applied, the AR_e^K was lowered and K was increased due to increase in activity of Ca^{++} ions in the soil solution. The Ca^{++} added through gypsum not only enhanced the K values but also reduced Na^+ ion concentration in the ion exchangeable site by cationic exchange **(Table-11)**. The soil K/Na ratio at exchangeable site was increased due to the application of gypsum. Application of FYM along with gypsum facilitated this reclamation process by providing more exchangeable sites due to the formation of humus in the soil. The increased Potential Buffering Capacity (PBC^K) of soil for K at the treatment combination, gypsum + FYM + 120 % recommended K facilitated the soil to supply K adequately and timely to banana crop at all critical crop growth stages. **(Fig 9)**

Fig. 9. Effect of Amendments with 120% Recommended K on Q/I Parameters of Soil K at 9 MAP of Nendran



2.1.4 Effect of soil amendments on Rasthali Banana under saline sodic soils (K.J.Jeyabaskaran, S.D.Pandey and R.H.Laxman,)

The results showed that the amendments, FYM and gypsum alone and in combination, increased the chlorophyll a, b and total chlorophyll contents in the leaf as

Fig. 2. Effect of moisture regimes and fertigation levels in two planting systems on plant height of banana

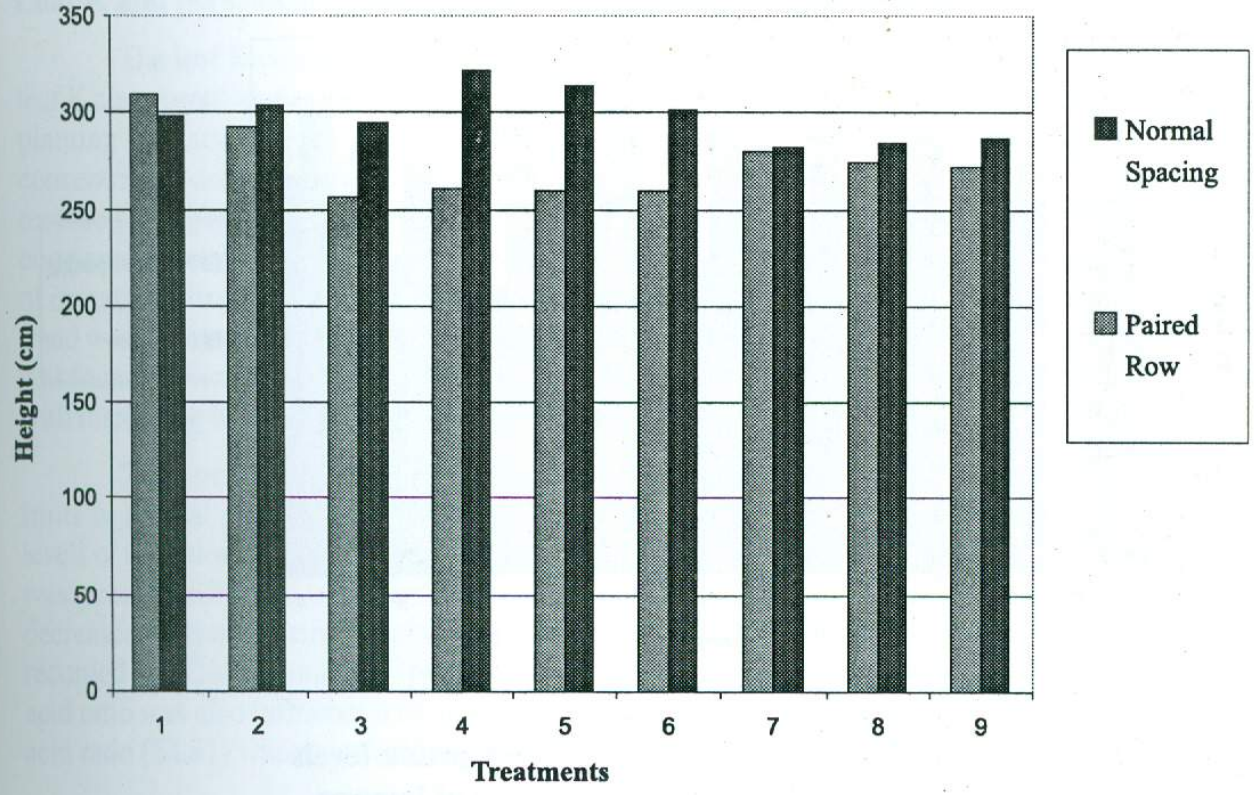


Fig. 3. Effect of moisture regimes and fertigation levels in two planting systems on pseudostem girth of banana

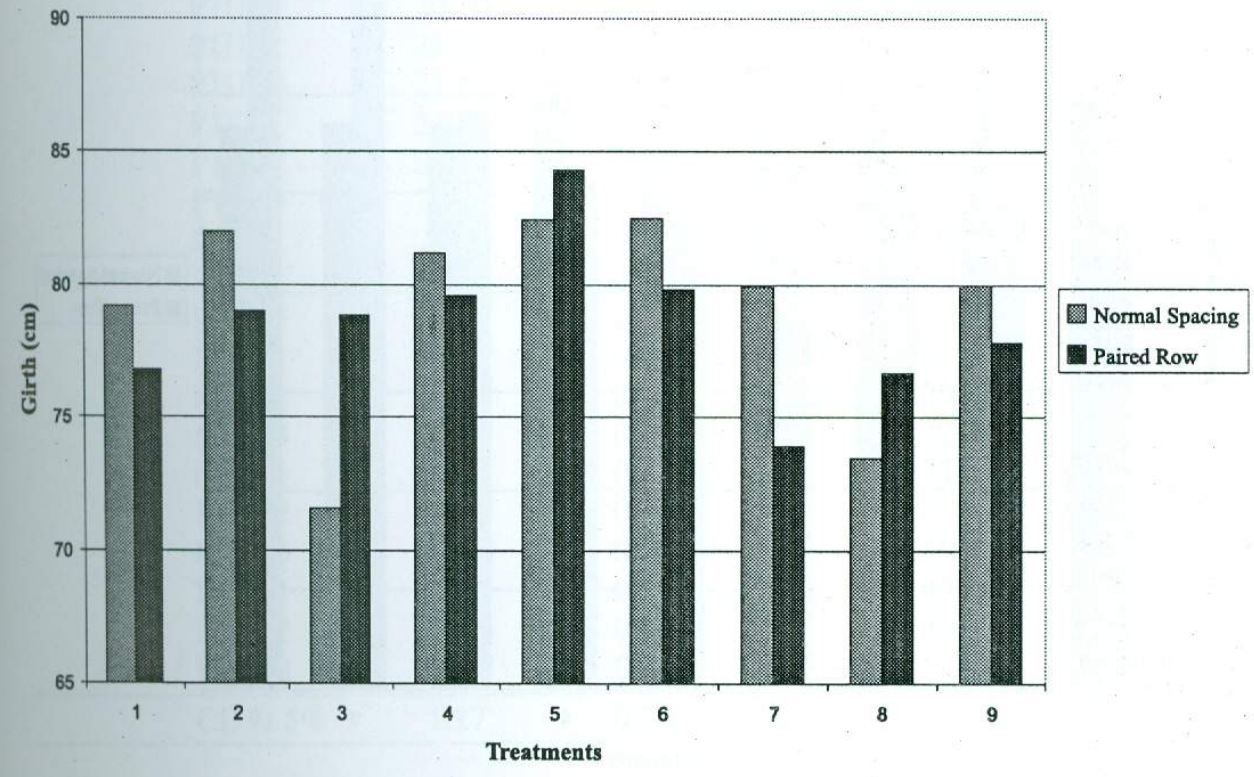


Fig. 4. Effect of moisture regimes and fertigation in two planting systems on bunch weight of banana

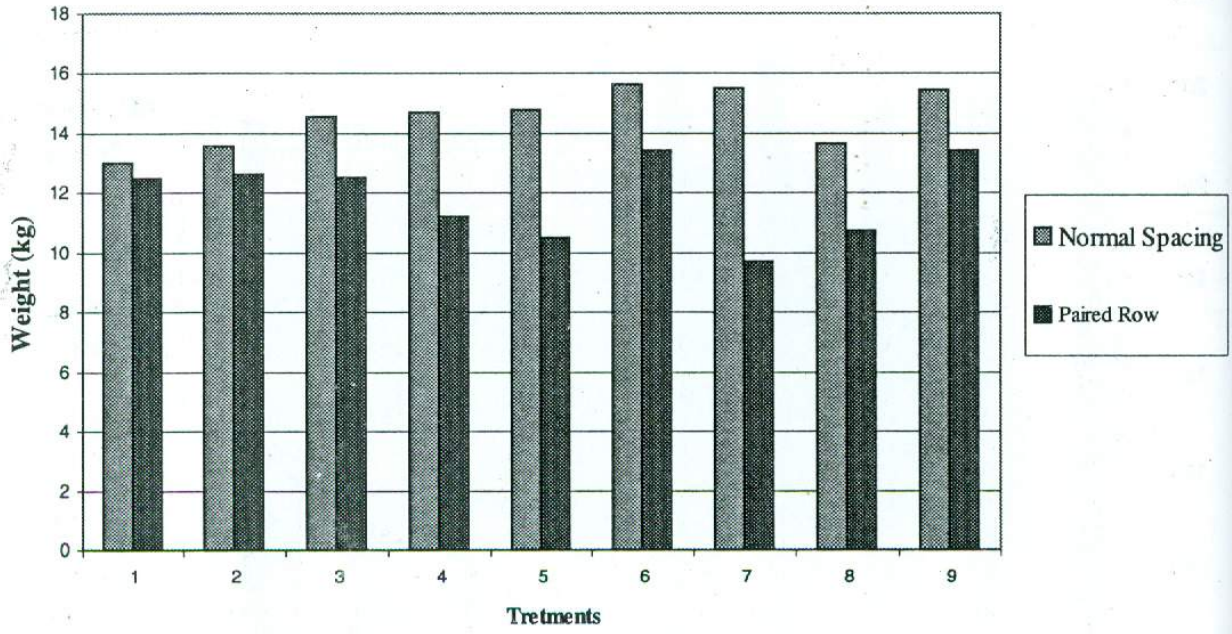
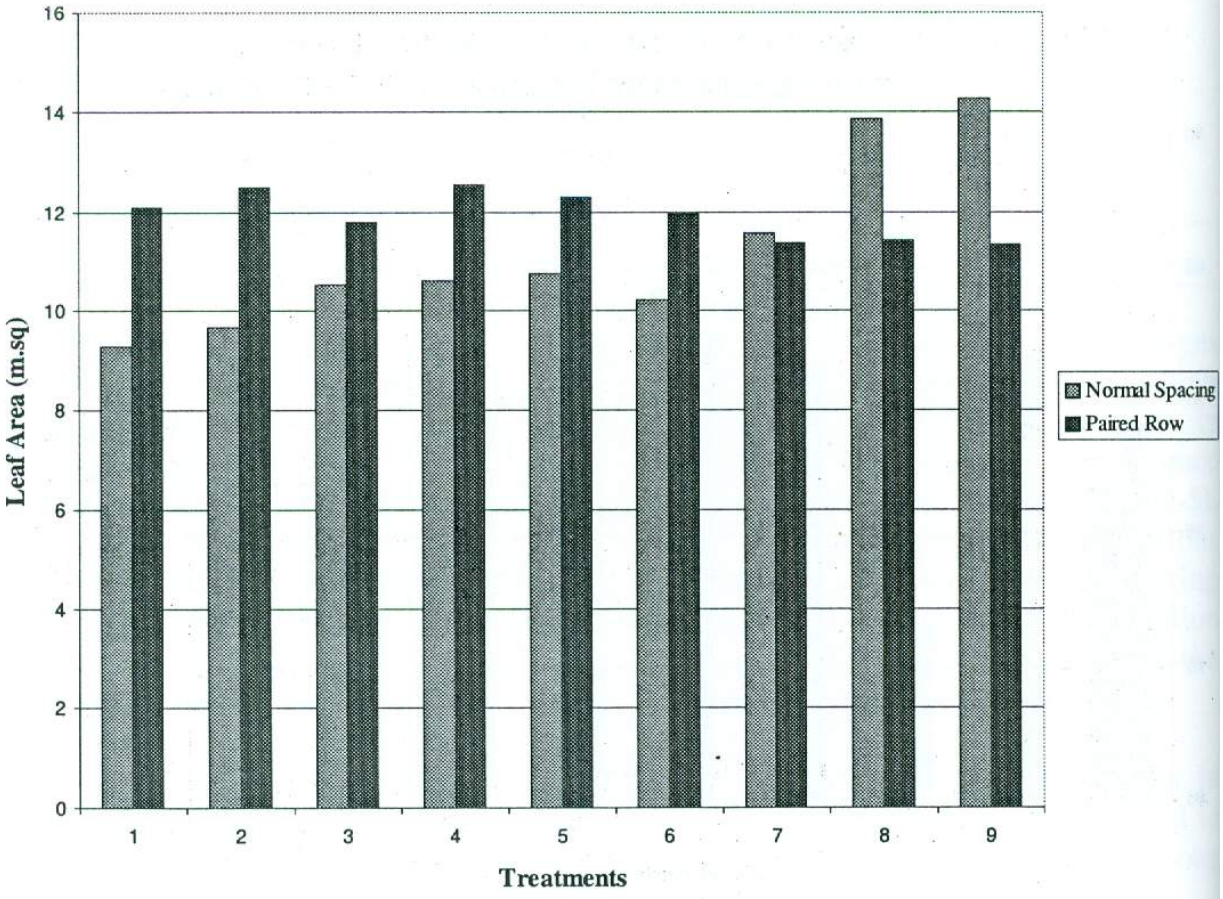


Fig. 5. Effect of moisture regimes and fertigation levels in two planting systems on leaf area of banana



the treatments and highest total chlorophyll content was recorded in treatment P1I3F2. In general, paired planting system showed less total chlorophyll content than the conventional planting system.

Leaf K and Na concentrations and K/Na ratio of banana

The leaf K concentration varied from 2.60 to 3.90 per cent. No significant variations in leaf K concentration due to plant geometry, irrigation and fertilizer levels were observed. Normal planting was superior to paired row planting, regarding leaf K concentration. The leaf K concentration decreased with increasing levels of irrigation. Higher leaf K concentration was recorded at higher fertilizer levels. Leaf Na concentration was less in paired row planting as compared to normal planting. A gradual decrease in leaf Na concentration with increasing levels of irrigation was observed. This may be due to leaching of Na salts from the rhizosphere. Similar trend was observed between leaf Na concentration and levels of fertilizer. The K/Na ratio of leaf was found higher in the normal planting than in the paired planting. The leaf K/Na ratios increased with increasing levels of both irrigation and fertilizer.

The number of fruits / bunch recorded significant differences with maximum number fruits in normal planting with higher levels of irrigation and N fertigation (P1I3F3). Different levels of irrigation and N fertigation significantly influenced the fruit quality. Highest TSS (23.57°) was recorded in P2I3F3 treatment followed by P2I3F2, P2I3F1 and P1I3F3. The acidity percentage decreased with increasing levels of irrigation and N fertigation. Minimum (0.43%) acidity was recorded in P2I3F3 treatment (paired row, 120 % Eo and 125 % N fertigation). Similarly, TSS / acid ratio was also influenced by higher level of irrigation and fertigation and a maximum TSS / acid ratio (54.81) was recorded in P2I3F3 followed by P2I2F2 and P1I3F3. **(Fig. 7)**

Table-6: Effect of irrigation, fertigation and planting systems on quality of Poovan Banana.

Treatments	TSS (Brix)	Acidity	Sugar :Acid ratio
P1I1F1	20.20	0.70	28.86
P1I1F2	21.43	0.67	31.98
P1I1F3	21.60	0.67	32.23
P1I2F1	21.30	0.57	37.36
P1I2F2	21.83	0.50	43.66
P1I2F3	22.87	0.57	40.12
P1I3F1	22.53	0.50	45.06
P1I3F2	22.93	0.57	40.22
P1I3F3	23.17	0.47	49.29
P2I1F1	20.23	0.70	28.90
P2I1F2	20.63	0.67	30.79
P2I1F3	21.67	0.67	32.34
P2I2F1	21.23	0.67	31.68
P2I2F2	22.47	0.60	37.45
P2I2F3	22.90	0.57	40.18
P2I3F1	23.17	0.53	43.72
P2I3F2	23.43	0.47	49.85
P2I3F3	23.57	0.43	54.81
CD at 5%	1.27	0.10	12.70

Fig. 6. Effect of moisture regimes and fertigation levels in two planting systems on days to shooting of banana

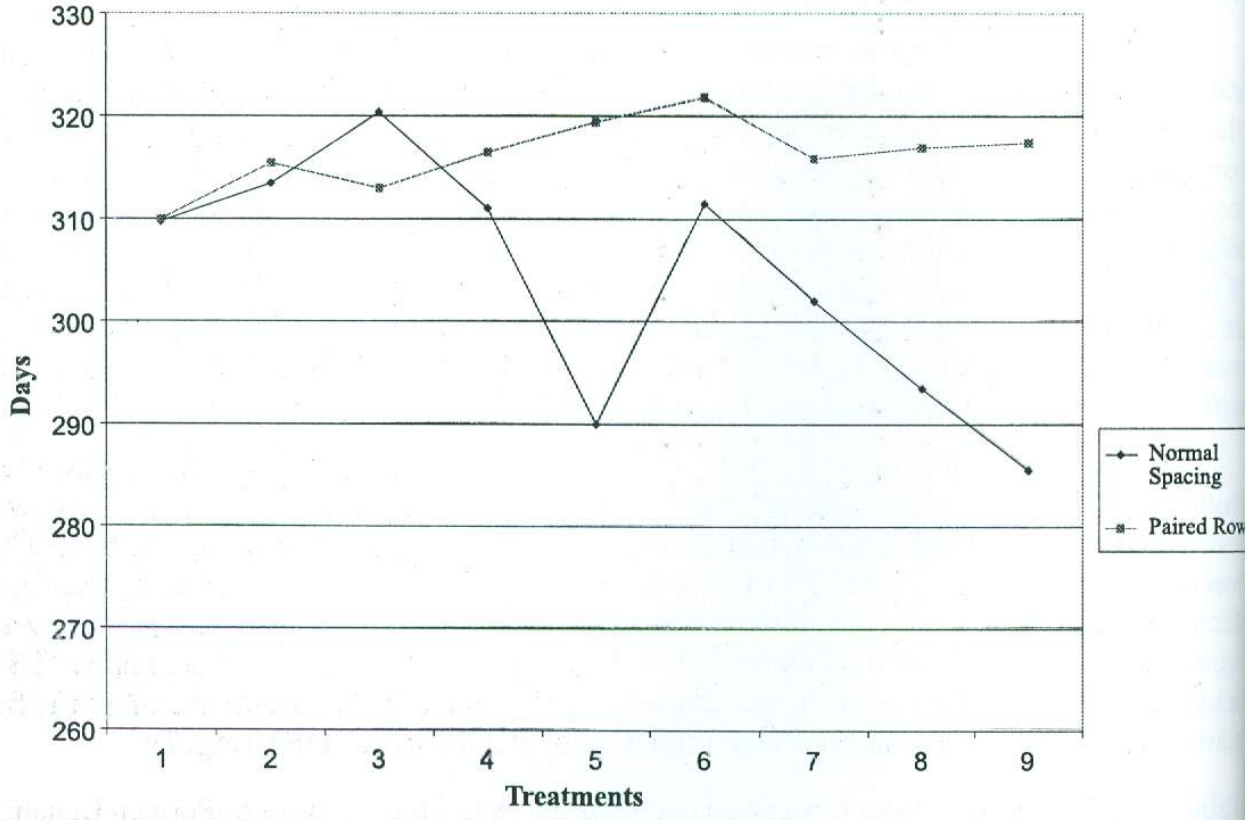


Fig. 7. Effect of moisture regimes and fertigation levels in two planting system on T.S.S/acid ratio of banana

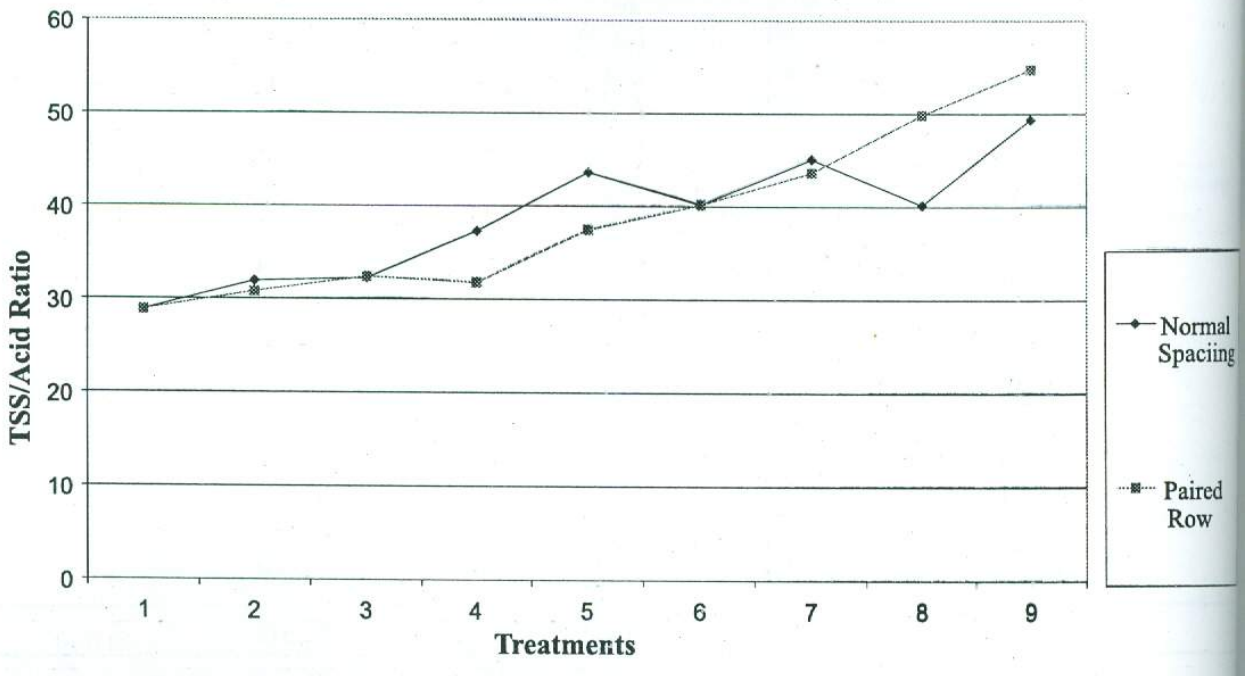


Table- 11: Effect of amendments and potassium on the releasing pattern and Q/ I of soil potassium at different growth stages of Nendran banana

Amendments & Parameters	5th Month				7th Month				9th Month			
	K_{90}	K_{100}	K_{110}	K_{120}	K_{90}	K_{100}	K_{110}	K_{120}	K_{90}	K_{100}	K_{110}	K_{120}
Control												
CR-K	0.03	0.03	0.03	0.03	0.05	0.05	0.05	0.04	0.03	0.03	0.05	0.03
Stet-K	0.32	0.49	0.62	0.65	0.18	0.32	0.48	0.52	0.22	0.32	0.44	0.57
-△K	0.20	0.32	0.32	0.32	0.10	0.19	0.29	0.30	0.09	0.10	0.21	0.27
$AR_e^K X10^3$	9.70	10.9	11.9	12.3	9.0	10.0	10.6	11.9	8.5	9.7	10.0	11.3
PBC^K	16.5	18.3	26.9	26.0	11.1	19.0	27.4	25.2	10.6	10.3	21.0	23.9
FYM												
CR-K	0.09	0.09	0.10	0.10	0.09	0.09	0.05	0.05	0.09	0.05	0.03	0.05
Step-K	0.51	0.57	0.74	0.83	0.40	0.46	0.71	0.69	0.32	0.47	0.69	0.62
-△K	0.17	0.24	0.34	0.39	0.12	0.19	0.39	0.45	0.10	0.13	0.28	0.34
$AR_e^K X10^3$	9.2	10.9	11.2	11.9	8.5	9.5	9.9	11.0	8.2	8.9	9.6	11.0
PBC^K	18.1	22.4	30.5	32.4	4.0	20.4	39.3	41.2	12.0	14.7	29.3	30.9
Gypsum												
CR-K	0.02	0.08	0.08	0.09	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Step-K	0.58	0.37	0.48	0.47	0.35	0.43	0.51	0.60	0.34	0.42	0.47	0.70
-△K	0.19	0.26	0.37	0.40	0.12	0.22	0.39	0.47	0.10	0.12	0.25	0.31
$AR_e^K X10^3$	9.0	9.8	10.1	10.8	7.2	8.1	8.6	9.3	6.3	7.1	7.9	8.0
PBC^K	21.1	26.5	36.6	37.0	16.7	27.2	45.3	50.5	15.9	16.9	31.6	38.8
Gypsum + FYM												
CR-K	0.10	0.12	0.10	0.13	0.05	0.05	0.09	0.10	0.05	0.09	0.10	0.10
Step-K	0.64	0.77	0.85	1.04	0.69	0.85	0.66	0.94	0.65	0.62	0.66	0.99
-△K	0.27	0.36	0.41	0.54	0.15	0.32	0.43	0.53	0.16	0.29	0.44	0.53
$AR_e^K X10^3$	8.6	9.2	9.8	9.9	7.0	7.9	8.6	8.9	6.5	7.0	7.5	7.8
PBC^K	31.8	39.0	42.3	54.6	21.3	39.9	50.1	59.3	25.0	41.4	59.0	67.8

*CR-K, Step-K & △ K in cmol kg^{-1}; AR_e^K in $(M/l)^{0.5}$; PBC^K in cmol $kg^{-1}.(M/l)^{-0.5}$

2.1.2. Effect of irrigation, fertigation and planting systems on banana cv. Nendran (S.D.Pandey, R.H.Laxman and K.J.Jayabhaskaran)

The leaf area showed significant response to different treatment combinations of irrigation and N fertigation in early stages of observation **(Table-7)**. At 5th month stage, maximum leaf area (0.33 m^2) was recorded in P1I1F3 while P2I1F3 recorded maximum (0.43m^2) at 7th month whereas no significant response was observed at 9th month. Phyllochron revealed significant differences during August-September and January and non-significant response during October-November and December months. Higher N fertigation took more days for successive leaf emergence. Higher fertigation and irrigation levels induced early shooting and treatments P1I2F2 and P2I2F2 recorded the earliest flowering (217.75 days) followed by P1I1F3.Shooting to harvest time recorded minimum (97.25 days) in P1I2F3 followed by 99.25 and 99.50 days in P2I2F2 and P2I1F3 respectively. Delayed maturity was observed in P2I1F2, P2I1F1 and P1I1F1 treatment combinations where less irrigation was applied. There was a significant difference in relative water content between irrigation levels and maximum RWC (91.38%) was recorded in the treatment P2I2F1 followed by P2I2F2 and P1I2F2. Maximum bunch weight (9.82 kg) was recorded in P1I2F2 treatment followed by P2I1F3 and P1I1F3 treatments. Minimum (7.5 kg) bunch weight was recorded in P1I1F1 (normal planting, 80 % Eo and 75 % N fertigation). The concentration of leaf nutrients showed non-significant differences, however, leaf nutrient concentrations increased with increasing levels of irrigation.

Table-7 Effect of irrigation, fertigation and planting systems on growth and yield parameters of Nendran Banana

Treatments	Height (cm)	Girth (cm)	Leaf area (m^2)	RWC (%)	Days for shooting	Shooting to harvest(days)	Bunch weight (Kg)
P1I1F1	203.61	50.58	0.32	76.05	247.75	119.00	7.54
P1I1F2	197.54	51.88	0.33	76.05	247.75	119.00	7.54
P1I1F3	238.89	56.08	0.36	81.04	223.00	05.50	9.01
P1I2F1	237.08	52.87	0.33	86.08	228.00	100.50	8.28
P1I2F2	214.08	61.04	0.29	88.57	217.75	97.25	9.82
P2I1F1	208.43	51.27	0.38	81.48	267.25	120.25	7.08
P2I1F2	217.45	48.32	0.33	85.84	243.75	121.00	8.06
P2I1F3	231.54	54.47	0.43	86.83	229.00	99.50	9.69
P2I2F1	211.04	54.51	0.39	91.38	234.00	103.25	8.34
P2I2F2	191.58	57.48	0.36	90.11	217.75	99.25	8.79
CD at 5%	16.48	4.87	0.03	5.388	14.822	5.30	30.999

compared to control. The increase in potassium level also increased the content of chlorophyl a, b and total chlorophyll.The treatment combination FYM+gypsum at 120% K level recorde the highest chlorophyll a, b and total chlorophyll contents indicating that the amendment and higher K levels helped in reversing the adverse effect of salinity on photosynthetic pigments. Similarly, the amendments and potassium levels increased the total sugar conten in the leaf as compared to control. The highest total sugar content was reorded in the treatmen combination of FYM+gypsum at 120% K indicating that the adverse effect of salinity o carbohydrate metabolism was neutralized by amendments with higher K level.

2.1.5. Effect of different organic manures with graded levels of NPK on Banana (K.J.Jeyabaskaran and S.D.Pandey)

The plant height varied significantly due to the different treatment combinations Among the organic manures, the poultry manure recorded the maximum height (214.7 cm and rice mill ash recorded lowest height (198.4 cm) irrespective of mineral fertiliser levels The pseudostem girth of Poovan banana varied significantly from 43 cm to 56 cm in differen treatment combinations. Press mud recorded the maximum pseudostem girth (53.5 cm) an the minimum at control (48.7 cm). A gradual increase was observed for plant height an pseudostem girth with increasing levels of mineral fertilisers from 40 % to 80 % o recommended NPK with different organic manure. But a negative trend was observed fro 80 % to 120 % of recommended NPK levels. This has clearly indicated that using organi manure could save 20 % of recommended NPK.

The bunch weight of Poovan banana varied significantly among the differen treatment combinations (**Table-12).** Irrespective of mineral fertiliser levels, the poultry manure recorded the highest average yield while the control recorded the lowest yield Application of 15 kg poultry manure + 80 % of recommended NPK recorded the highes yield. The highest soil organic carbon content was at FYM application (1.44 %) and lowes at control (0.97 %) was observed **(Table-13).** The poultry manure recorded highest soil K (618 ppm) and the rice mill ash recorded the lowest soil K (550 ppm).

Table 12: Effect of different organic manures with graded levels of NPK on bunch weigh of Poovan banana.

Organic Manures	Bunch weight(kg) at the NPK level of					Mean
	40 %	60 %	80%	100%	120%	
Press mud	6.6	7.1	8.4	8.4	6.7	7.4
Poultry manure	7.8	6.5	10.7	7.3	7.0	7.9
Rice mill ash	5.1	8.5	6.0	6.8	5.5	6.4
Farm yard manure	5.7	7.2	6.2	6.0	6.0	6.4
Control	6.1	6.6	5.7	6.1	5.3	5.3
Mean	6.3	7.2	7.4	6.9	6.3	

Table- 13: Effect of different organic manures on chemical properties of soil

Organic Manures	Soil nutrients content				
	Organic Carbon (%)	K (ppm)	Na (ppm)	Ca (%)	Mg (%)
Pressmud	1.33	558	528	0.59	0.18
Poultry manure	1.11	618	570	0.71	0.10
Rice mill ash	1.14	550	620	0.55	0.21
Farm yard manure	1.44	555	568	0.52	0.21
Control	0.97	568	612	0.57	0.19

The organic manures used were very efficient in lowering down the Na content of soil. The lowest soil Na was observed at pressmud application (528 ppm) and the highest at control (612 ppm). The poultry manure recorded highest soil Ca and lowest soil Mg contents. Poultry manure is highly suitable to banana when compared to other organic manures. Application of poultry manure @ 15 kg/plant could supplement 20 % of requriements of banana.

2.2. POST-HARVEST TECHNOLOGY

2.2.1. Post-harvest management, evaluation and processing of banana (S.Shivashankar and C.K.Narayana)

Post-harvest evaluation of germplasm

Evaluation of germplasm for post-harvest characters in 46 more accessions showed marked differences in green life, yellow life, physiological loss of weight and pulp/peel characters.

Effect of pre-harvest bunch sprays on post-harvest fruit quality

The effect of spraying micronutrients and growth regulators on the bunch during the initial phase of bunch development was assessed in two varieties viz., Poovan and Neypoovan. The spray was given at 30 and 60 days after shooting. Fruit yield and quality parameters were assessed after harvest. K_2SO_4 and urea spray on Poovan significantly improved the fruit yield. GA_3 application on Neypoovan also showed a marked improvement in fruit yield. There were no significant differences in fruit quality parameters among the various treatments **(Table 14)**.

Table:14. Effect of pre-havest bunch sprays on maturation time and bunch weight

Treatments	Ney Poovan		Poovan	
	Days taken for maturity	Bunch weight (Kg)	Days taken for maturity	Bunch weight (Kg)
Control	127	9.5	107	9.65
2,4 –D, 25ppm	121	8.0	107	9.75
2,4 –D, 50ppm	123	10.5	107	10.7
GA, 10ppm	128.6	12.1	109	9.2
GA, 25ppm	122.5	12.6	111	9.25
NAA, 25ppm	122.3	9.2	98.3	9.73
NAA, 50ppm	126.7	9.25	100	9.90
Urea 1%	119.3	9.3	107.6	14.3
Urea 2%	122.5	9.2	107.6	14.5
K_2SO_4 0.5%	117.6	8.0	109	13.8
K_2SO_4 1%	118.5	8.5	109	13.0
$ZnSO_4$ 0.5%	122	8.3	100	11.3
$ZnSO_4$ 1.0%	116	9.8	100	7.2
Ca(NO_3)2 0.5%	114	10.2	108	11.5
Ca(NO_3)2 0.5%	122.4	9.3	98	9.4
Borax 0.5%	125.5	9.5	102	7.9
Borax 1.0 %	117	8.0	99	10.0

Chilling injury as a function of variety

Eight varieties of freshly harvested bananas stored at 8°C upto 18 days were assessed for their ripening behaviour, shelf life and fruit quality components. The dessert varieties showed a higher degree of susceptibility to cold than the cooking types. The peel color, monitored by changes in chlorophyll and carotenoid pigments showed a rapid fall in the cold-stored fruits. The degree of pigment destruction was proportional to the duration of storage in cold. The amount of epicuticular waxes in the peel was related to the degree of chilling injury.

2.2.2. Studies on process and product development, value addition and waste utilization (C.K.Narayana and S.Shivashankar)

An experiment was conducted to study the effect of different cooking oils on the quality of Nendran banana chips(Plate 1). The results indicated that in general, the pulp percentage ranged between 57 to 62 percent. Maximum chip output was obtained where palm oil, groundnut oil and sunflower were used (32.5 percent based of fruit weight; 57.8 percent based on pulp weight) followed coconut oil. Every kilogram of chips produced consumed 0.615 Kg of coconut oil or 0.682 Kg of sunflower oil or 0.583 Kg of palm oil or 0.500 Kg of groundnut oil (**Table-15**). Organoleptic evaluation showed that chips made from coconut oil were superior followed by palm oil. Sunflower oil was least preferred as a medium of frying (**Table-16**). The storage life of chips was maximum (30 days) using coconut oil while others had developed a bitter taste after 20 days of storage. The cost of production of Nendran banana chips in coconut oil under lab conditions was found to be Rs.60/- per Kg.

Table- 15: Effect of different types of oil on the chips yeild and oil consumption

Type of oil	Chips Yield		Kg oil consumed / Kg chips
	Based on fruit wt. %	Based on pulp wt. %	
Sunflower	25.28	44.00	0.682
Ground Nut	27.50	47.83	0.500
Coconut	32.50	57.78	0.615
Palm oil	30.00	51.06	0.583

Table-16: Effect of different types of oil on the organoleptic quality of chips

Type of oil	Colour	Crispness	Flavour	Taste	Over all
	(out of 25)	(out of 25)	(out of 25)	(out of 25)	(out of 100)
Sun flower	19.05	19.15	15.45	17.85	71.50
Ground nut	17.20	21.40	15.35	18.05	72.00
Coconut	20.75	20.40	20.00	20.45	81.60
Palm oil	20.95	20.05	17.60	18.90	77.50

Suitability of alternate varieties of banana for making chips was tried using cvs. Nendran, Zanzibar and Bainsa. The results indicated that the chips output were 42.85, 45 and 57.8 percent on pulp weight basis respectively and the oil consumption per kilogram chips was 0.888, 0.667, 0.615Kg respectively. (**Table-17**). Organoleptic evaluation showed that Nendran was superior in overall quality followed by Zanzibar and Bainsa (**Table-18**).

Various by-products of banana.

1. Banana baby food
2. Banana powder
3. Banana wine
4. Banana biscuit
5. Banana fruit bar
6. Banana health drink
7. Banana juice
8. Banana jam
9. Banana dehydrated fig

The storage studies showed that the quality rundown was slower in Nendran as compared to Zanzibar and Bainsa.

Table-17: Fruit and Chips yield of plantains varieties

	Chips Yield			
Variety	Pulp %	Based on fruit wt. %	Based on pulp wt. %	Kg oil consumed/Kg chips
Nendran	57.50	32.50	57.78	0.615
Zanzibar	56.01	23.99	42.85	0.888
Bainsa	54.29	24.43	45.00	0.667

Table –18: Organoleptic quality of chips of plantain varieties

Variety	Colour (out of 25)	Crispness (out of 5)	Flavour (out of 25	Taste (out of 25)	Over all (out of 100)
Nendran	20.75	20.40	20.00	20.45	81.60
Zanzibar	19.81	20.00	18.06	19.06	76.93
Bainsa	15.31	19.25	15.75	16.94	67.25

Standardised the process for preparation of Jam using different combinations of pectin, sugar and acid. The results indicated that 0.25% pectin based on final weight of the product was ideal for proper setting of jam for Poovan banana, while for Karpooravalli and Ney Poovan, there was no need of additional pectin. Out of various combinations tried, 40% pulp, 70% total sugars and 0.6% acid in the final product was the best combination for an ideal jam (**Table - 19**).

Table-19: Standardization of pectin content for Poovan jam (with acid adjustment)

Pectin %	Acidity (%)	Reducing sugar(%)	Total sugar (%)
0	0.077	11.82	81.25
0.1%	0.077	14.46	81.25
0.25%	0.165	18.14	86.66
0.5%	0.099	16.67	81.25

Poovan and Ney Poovan banana puree was preserved in different packages and stored under different storage conditions. The results indicated that the samples stored in glass and PVC bottles with 2000 ppm KMS, under room temperature stored for 3 months and under refrigeration for 5 months. After storage though there was no visible spoilage, the serum got separated from the pulp hence it was terminated. The jam prepared from the stored pulp had an acceptable quality. Banana biscuits were prepared using Poovan banana puree but the texture of biscuits were slightly hard for which the process needs to be refined.

The process of fig preparation was studied to improve the quality of figs using different treatments. The results indicated that the moisture percent of figs ranged between 26-30%. Acidity was least in 1% KMS dip treatment and maximum in blanched sample. Sugars were maximum in ascorbic acid treated sample and least in blanched (both with and without KMS dip) samples. Blanching followed by 0.1% KMS dip treatment reduced the NEB units considerably (**Table-20**). However, the shelf life was only 15 days at room temperature. Rest of the samples was acceptable upto 35 days without spoilage.

Table-20: Chemical composition of figs

Parameter	Treatments				
	T1	T2	T3	T4	T5
Moisture (%)	27.0	26.0	30.0	28.0	29.0
Acidity (%)	0.495	1.650	0.561	1.320	1.360
Red. Sugar (%)	45.40	40.63	40.63	43.33	50.00
Total sugar (%)	54.17	52.00	46.43	52.00	59.00
NEB (OD units)	0.281	0.256	0.155	0.376	0.248

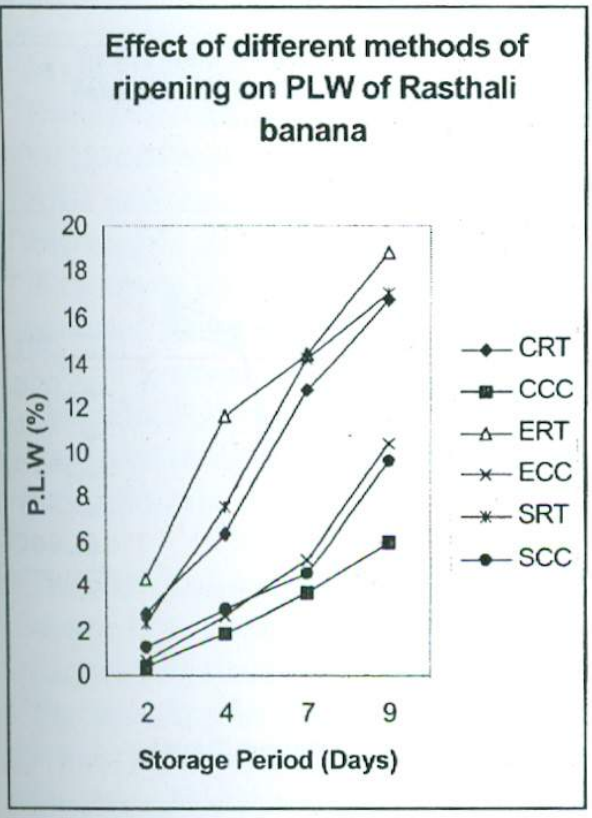
The process of banana bar preparation was studied using mixed pulps o Karpooravalli, Pachanadan and Poovan. The results indicated that a tasty, storable an acceptable banana fruit bar could be prepared using fruit pulp, pectin, acid and KMS.

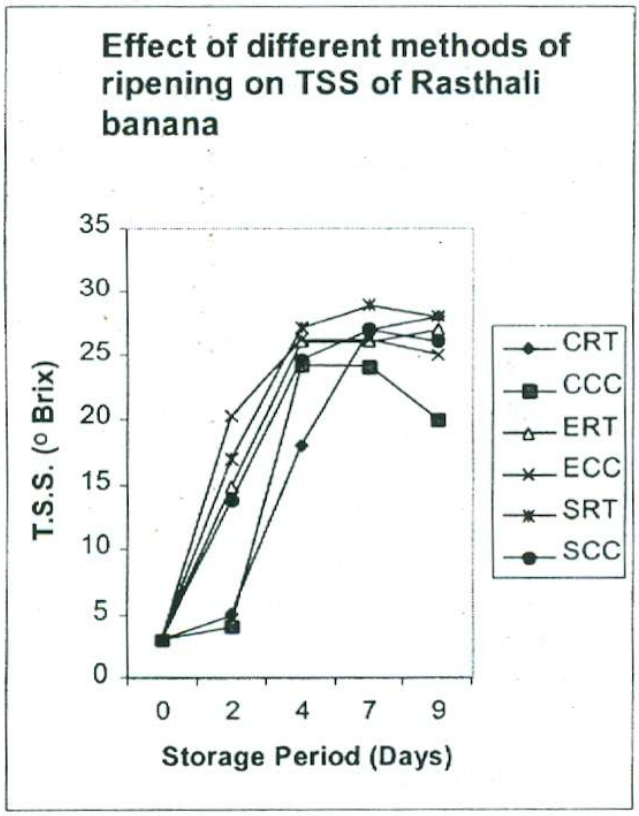
Powder from Monthan and Nendran banana was prepared and stored as a bas material for other products. Papads were prepared by mixing rice flour with Monthan banan flour and it had a good storage life.

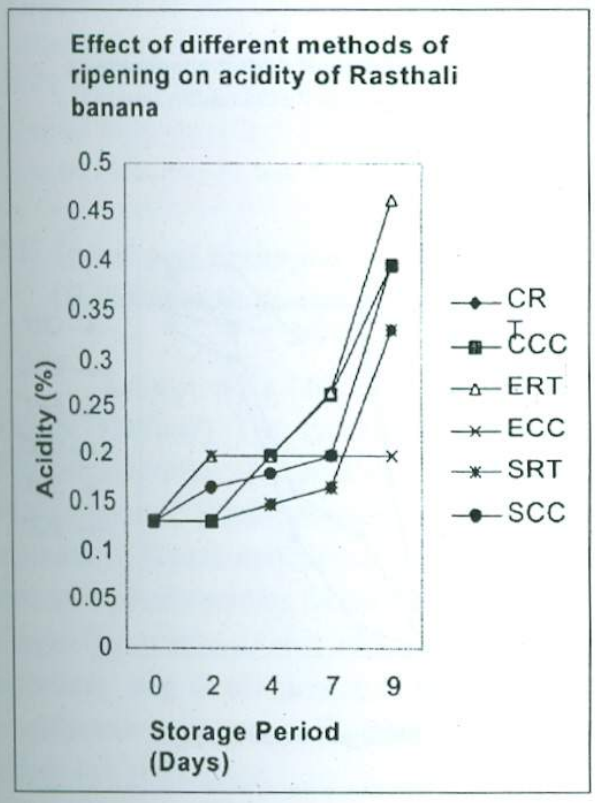
Calcium chloride at 2, 4 and 6% were applied to Poovan banana as dip, as well a infiltrated at 760 mm Hg and stored at room temperature for studying its effect on shelf life spoilage and ripening behaviour. The results showed that 4% calcium chloride infiltrated a 760 mm Hg reduced the spoilage and extended the shelf life (both green and yellow) upto days under room temperature. The ripening was slowed by 2 days with this treatment.

A study was undertaken to evaluate the efficacy of Ethrel on ripening as compare to smoking in cvs. Pachanadan and Rasthali. The results showed that Ethrel at 500 ppm applied at 52 $\pm 1^{\circ}$ C as dip significantly improved the ripening with excellent colou development as compared to smoking and control. The fruits ripened within 72 hours afte the treatment and had better quality as compared to control and smoking. **(Fig. 10 & 11)**

Fig. 10. Effect of different methods of ripening on quality of Rasthali fruits







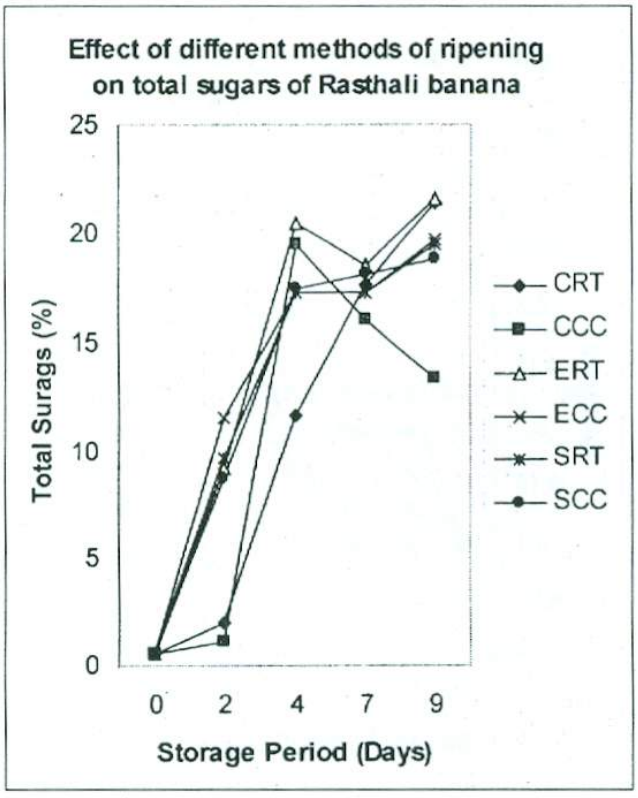
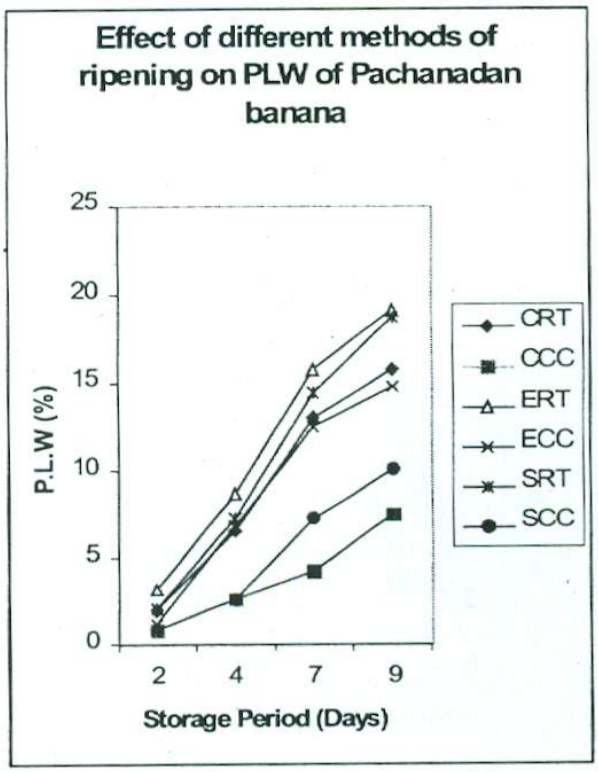
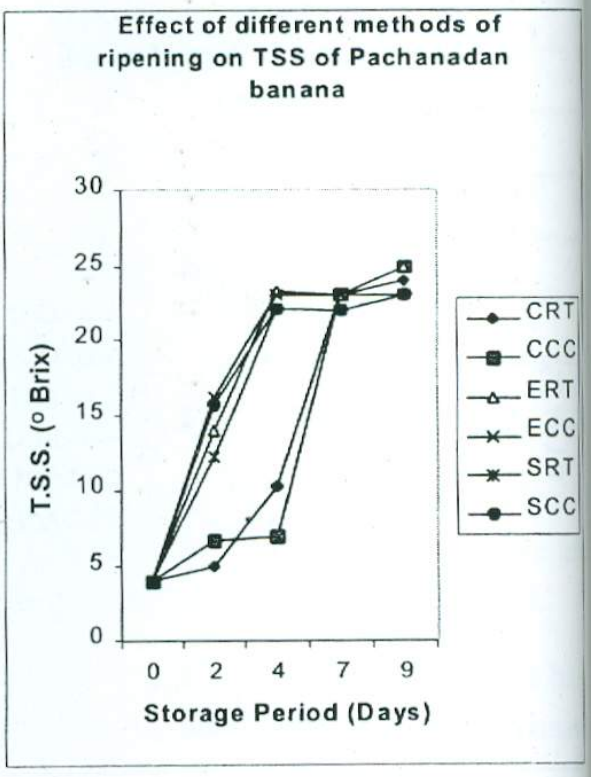
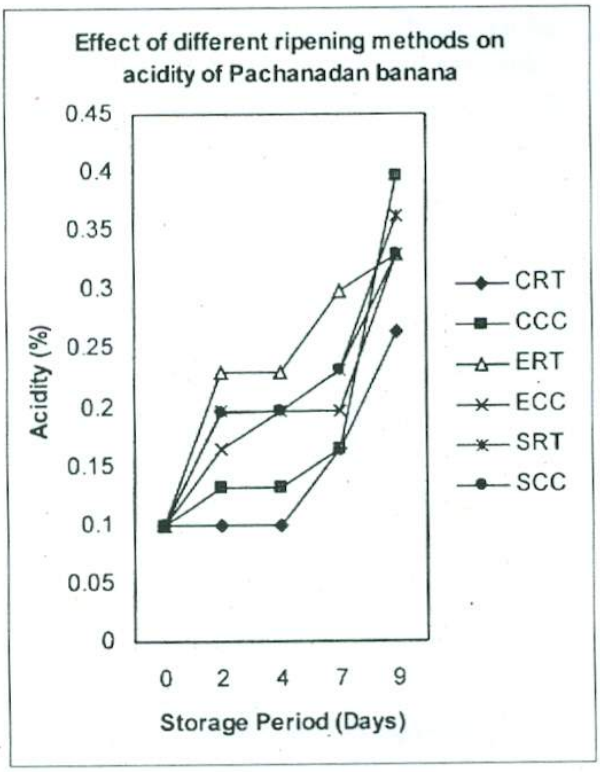
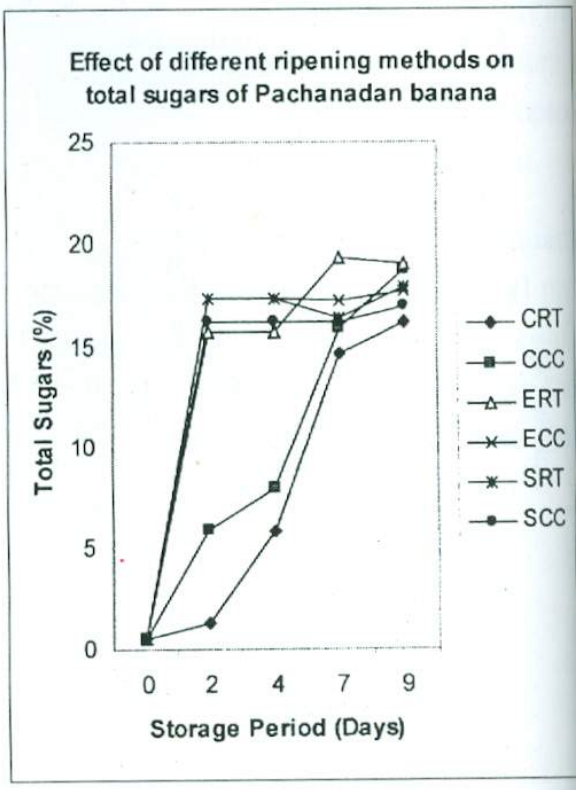


Fig. 11. Effect of different methods of ripening on quality of Pachanadan fruits









3. CROP PROTECTION

General Leader: Dr. P.Sundararaju

Severe incidence of banana pseudostem borer and rhizome weevil was recorded in Karur and Coimbatore districts respectively. Out of 309 accessions evaluated against the pseudostem borer under field conditions, 66 accessions belonging to AAB and ABB genomes were the most preferred host by the borer. Scanning electron microscopic studies indicated that substantial layer of variously shaped sensilla in the antennal tip, antennal segement proboscis and elytra are being used as sensory receptors. The pseudostem borer showed a high degree of host preference for Nendran banana. *Spodoptera litura* mortality was the highest in Azarec and Nimbicidine. Commercially available sex pheromone 'Basslure' for *S.litura* evaluted under field conditions revealed that maximum male moth catch was recorded during 14 - 15th standard week.

The root- lesion nematode was predominant in Nendran followed by root-knot nematode in Rasthali. The burrowing nematode was recorded in cvs. Rasthali, Karpuravalli, Red banana, Rasa kadali and Virupakshi. Application of Carbofuran @ 50g / plant, applied in two splits after planting at 3 months intervals were very effective in reducing *P.coffeae* population and significantly increased the bunch weight by 50 per cent in Nendran. In Nendran, maximum damage due to *P.coffeae* was noticed in red soil and the least in alluvial soil.

Panama disease was recorded in cv. Poovan for the first time in India. The biocontrol agents like *Trichoderma viride* and *Pseudomonas fluroescence* were found to inhibit the wilt pathogen in dual culture. Occurrence of Black Sigatoka and Septoria leaf spots were recorded. Tilt (Propicanazole) or Anvil (Hexacanazole) @ 0.1% was found to be effective in the control of black Sigatoka and Septoria leaf spot diseases.

3.1. Insect pest management in banana (B.Padmanaban and P.Sundararaju)

Surveys were conducted in Tamil Nadu (Karur, Cumbum and Coimbatore) and Kerala (Thrissur). The incidence of banana pseudostem weavil, *Odoiporus longicollis* in Mahadhanapuram (Karur district) and banana rhizome weevil, *Cosmopolites sordidus* in Madhampatty, Teethipalayam of Coimbatore were recorded. Vedivazhai and Anaikkai maladies in Erasakanaickenur of Cumbum area were found on cultivar Robusta. Vedivazhai acts as a pre-disposing factor for the infestation of banana pseudostem borer, *Odoiporus longicollis*, where as rhizome weevil infestation on Robusta plants resulted in 'peduncle curvature' and development of small fingers. Peduncle also found infested with banana pseudostem borer on cv.Red banana. Rhizome weevil damage was recorded to a greater extent in Coimbatore.

Neem based commercial formulations like Azarec, Neemazal, Neem Gold and Nimbicidine were evaluated against the third instar larvae of banana leaf eating caterpillar, *Spodoptera litura* under laboratory conditions with Monocrotophos as a standard check. Maximum mortality was recorded in the treatments viz., Azarec and Nimbecidine. Commercially available sex pheromone for banana leaf eating caterpillar, *Spodoptera litura* viz., Basslure was evaluated under field conditions indicated maximum male moth catch during 14 -17th standard week.

Field evaluation of control methods against finger thrips infestation in Pachanadan and Rasthali, indicated that infestation was comparatively less in Chlorpyrifos spraying and bagging and insecticide inpregnated bagging.

Banana germplasm at the NBPGR Regional Station, Thrissur,was evaluated against the banana pseudostem weevil, *Odoiporus longicollis*. Out of the 309 accessions, sixty-six accessions showed borer infestation. Accession nos.1, 302, 309 and 317 had infestation during previous year observation also. It was observed that more or less adjacent plants showed infestation during this year. AAB and ABB cultivars were preferred by the borer.

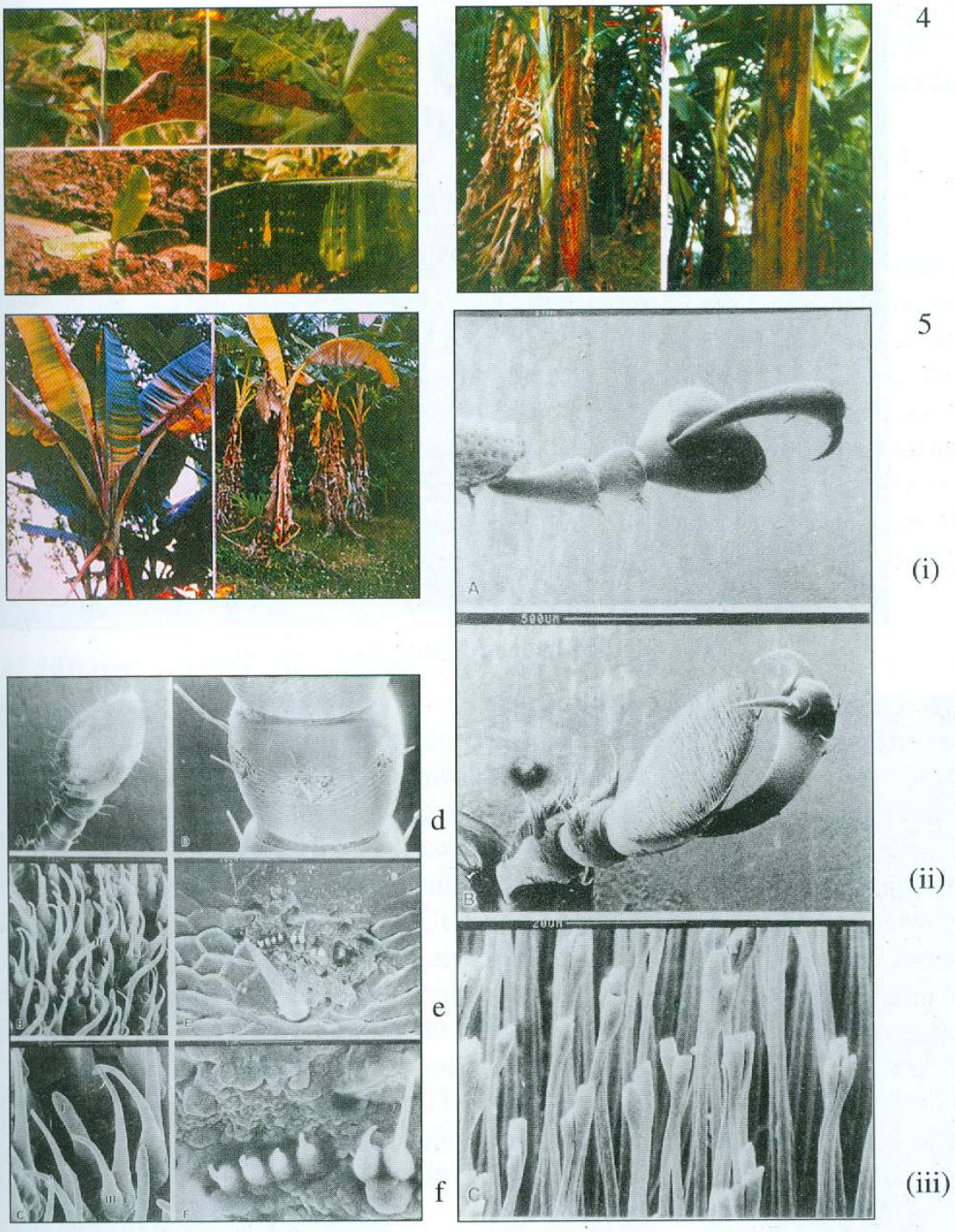
Scanning electron microscopic studies on adult weevil of banana pseudostem borer *Odoiporus longicollis* in collabration with the Institute of Evolutionary biology and Ecology, University of Bonn, Germany was carried out. The results indicated substantial layer of variously shaped sensilla in the antennal tip, antennal segment, proboscis and elytra, which were used as senory receptors of various nature such as chemomechanorecptors and thermohygroreceptors. The rostrum was blunt and short in males where as in females it was elongated and comparatively slender. In male, the sensory structures on the rostrum were flat and broad, dorsal side of the rostrum showed differences in the distribution of sensory structures. Each antennal club had two types of sensory organs (Plate 1). The weevil showed a high degree of host preference for Nendran. The ability of weevil to distinguish the host plant may be aided by the presence of sensory chemoreceptors. The third tarsal segment has elongated fastening hairs with tender distal ends and hollow openings. These hollow structures helped in walkening and climbing (Plate 1).

3.2. Nematode management in banana (P.Sundararaju and B.Padmanaban)

Survey

Surveys for plant parastitic nematodes were conducted in Tamil Nadu (Karur, Coimbatore, Madurai, Nagercoil, Cumbam and lower Palani hills) and in Kerala (Thrissur, Alleppey and Pathanamthitta). During the survey, a total of 50 each of soil and root samples were collected from 15 banana cultivars and nematode populations have been assessed. Eleven genera of plant parasitic nematodes were recorded from the rhizosphere of banana. Among them, root-lesion nematode, *Pratylenchus coffeae* was the predominant species found to occur maximum in cv. Nendran which caused extensive damage to plant growth (Plate3

Plate - 1

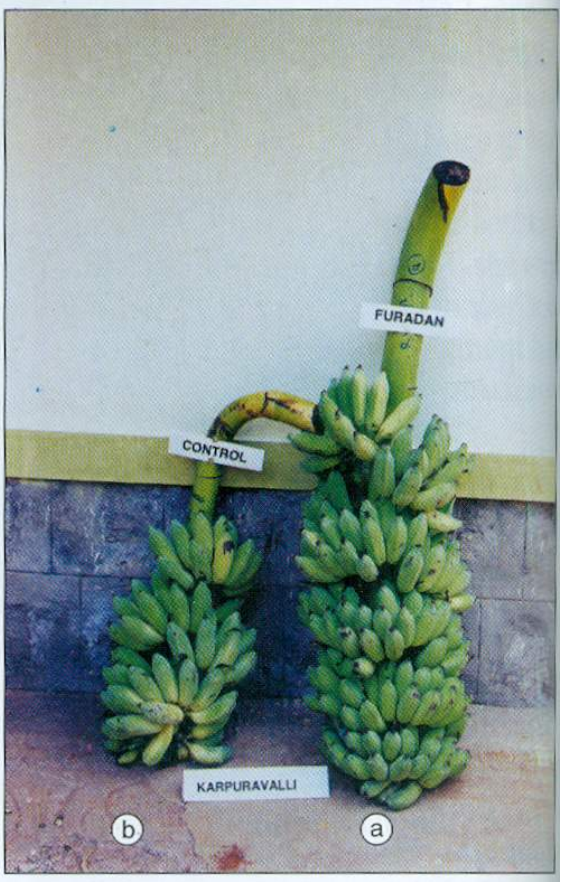


1. Banana leaf showing damage by *S. litura*
2. Leaf yellowing and stunted growth due to Banana rhizome weevil infestation.
3. SEM photograph of antenna of adult *O. longicollis*
   (a) antenna with hair sensilla (b) sensilla type I (c) sensilla type II
   (d) antennal segment with sensilla type I & II (e) antennal segment enlarged view
   (f) sensilla type II
4. Banana stem weevil infested plants
5. SEM photograph of pretarous of the leg with claw of banana stem weevil, *O. longicollis*
   (i) dorsal view (ii) ventral view and (iii) fastening hair.

Plate - 2

Root-lesion nematode infested Nendran field.

Showing the vigour of plant and root growth of Nendran. (a) Alluvial (b) Red loam



Karpooravalli bunch harvested from (a) Furadan treated plant (b) control

followed by root-knot nematode, *Meloidogyne incognita* in cv. Rasthali and spiral nematode, *Helicotylenchus multicinctus* in cv. Ney Poovan. The burrowing nematode, *Radopholus similis* was recorded from cv. Rasthali in Alleppy district, Karpuravalli in Thrissur district of Kerala, Virupakshi (Hill banana) in Perumal malai, Kodaikanal and in cvs. Rasa kadali and Red banana in Kanyakumari district of Tamil Nadu.

Control of Root-lesion nematode, *Pratylenchus coffeae* in banana

An experiment was conducted in heavily infested field with root-lesion nematode using three commercial cultivars of banana viz., Karpuravalli, Monthan and Nendran with two chemicals viz., Monocrotophos and Carbofuran. Results revealed that both chemicals applied at different periods were found to be effective in reducing the nematode population and subsequently increased the growth and yield when compared to untreated control. Among the different treatments, application of Carbofuran @ 50 g/plant one, at the time of planting in the pit or dipping the suckers with mud slurry and sprinkling with Carbofuran @ 50 g/ sucker and two applications after planting at 3 months intervals were found to be very effective in reducing the nematode population and significantly increased the bunch weight by 50 per cent (Plate **2**)

Effect of different soil types on multiplication of *Pratylenchus coffeae*

A pot experiment was conducted on banana cv. Nendran in order to find out the effect of different soil types on the plant growth and reproduction of root-lesion nematode, *Pratylenchus coffeae*. Different soils were collected from different banana growing regions in Tamil Nadu. Six types namely alluvial, sandy loam, silty clay, black soil, laterite and red soil were used in this study. Manures or fertilizers were not added to the soil. Nendran was planted in pots containing different soils. Under each soil type, root-lesion nematode was inoculated and uninoculated checks were also kept. The results revealed that significant parameters such as number shoot length, shoot weight, girth at collar, number of leaves, root length, number of roots and root weight were observed in nematode inoculated plants grown in alluvial soil followed by sandy loam soil whereas the plant growth was minimum and significantly low in red soil (Plate **2**). The reproduction factor of *Pratylenchus coffeae* based upon root lesions, final root and soil population was maximum in silty clay soil followed by sandy loam soil while it was minimum in red soil.

3.3. Fungal and Bacterial Diseases and their Management (R.Selvarajan)

New report

Wilt incidence was recorded in cultivar Poovan for the first time in India. The pathogen was isolated and pure cultured. On re-inoculation, it produced the similar symptoms suggesting that the disease was caused by *Fusarium Oxysporum f.sp. cubense*

Screening of diploids against Wilt pathogen race-1

Screening of five diploid cultivars/accessions against wilt pathogen was carried out in pot culture. The infected rhizome and pseudostem bits (3kg) per pot were applied in the pot mixture. All the five diploids did not produce any wilt symptoms and no infection was observed in cut rhizomes also. The accessions were: Pisang Lilin, Cultivar Rose, Anaikomban, Pisang Mas and Hatidat.

Studies on *Mycospherella* Leaf spot diseases and their management

Occurrence of black Sigatoka caused by *Mycospherella fijiensis* and Septoria leaf spot caused by *Septoria eumusae* in Tamil Nadu were recorded for the first time. The ascospores (*Mycospherella fijiensis*) isolated were two celled and had bipolar germination. The conidia of the black Sigatoka pathogen had typical thickened hilum and the conidiaphore had the scar. The colony morphology in PDA medium showed hemispherical and raised growth of mycelium while the hyphae were dumb-bell shaped. The conidia of *Septoria* were found in the pycnidia and the ascospore was bicelled and germinated from only one side. The morphology of the spores was similar as reported by Carlier *et al.* (2000).

The incidence and severity in various locations of Tamil Nadu and Kerala were studied (**Table 21**). The incidence varied among cultivars and locations. Locations having different altitude and seasons were selected for the survey. Under wetland cultivation, the disease incidence was very severe in four commercial cultivars and the disease spread was very rapid. In Trichy district in Nendran, the disease severity was 50.64 and the YLS was 3.12 at harvest stage. In cultivars Robusta, Pachanadan and Rasthali, the DSI and the YLS at harvest were 80.77, 87.95, 48.70 and 3.92, 1.00, 4.93 respectively. Where as in Kerala, the Disease Severity Index (DSI) was 14.14 and the YLS was 9.5 in cv. Nendran and in some orchards leaf spot was not observed while in cv. Robusta, the DSI was 49.64 and the YLS 4.9 at harvest stage. Sigatoka leaf spot was recorded at altitudes of 1500m above mean sea level in Virupakshi, Robusta and Poovan.

The DSI and YLS were the least in Mettupalayam area (near Coimbatore) and YLS above 10 was recorded in cv. Robusta and Nendran at harvest stage. DSI of 34.94 was observed in cv. Poovan was which grown for the purpose of leaf under close planting system (1m x 1m). Cultivars Nendran, Rasthali and Robusta had DSI ranging from 5.31 to 21.76, however, the YLS was high, ie 13.24 and 12.26 in Nendran and Rasthali respectively. In Karpuravalli there was no spot at vegetative stage (8 months old).

The pathogens causing various leaf spot diseases were isolated and pure cultured. *Drechslera sp, Alternaria musae, Colletotrichum musae* have been identified. Freckle leaf spot was observed in Coimbatore district in Nendran cultivar and the causal agent has to be identified. More than sigatoka, freckle leaf spot was found to cause more damage in that region. Leaf spot [sigatoka] was found to be serious in Sirumalai region in Poovan and Virupakhsi.

Isolation of ascospore

The ascospores of *Mycospherella* spp were isolated as per the protocol of Natural (1989) with little modification. Leaf sections having mature spot of *Sigatoka* were cut into 2 cm^2 pieces. They were dipped in sterile distilled water for 10-15 min. and the pieces were stapled in a sterile filter paper and placed in the lid of petridish facing 3% water agar. The plates were incubated at room temperature for a day, the release of ascospores was observed under microscope.

Released ascospores were observed under 100 x magnification. Spores had one septum and bipolar germination of ascospore (Plate 3) was observed. Ascospores picked from the plain agar media were transferred to PDA and incubated. After one month, the culture grew to 0.5 cm diameter. The colonies were raised in the centre, light grey to wilt green in color. The backside of the colony was light brown to black in color. Ascospores of *Septoria* were also isolated from cultivar Virupakshi collected from Kolli hills.

Conidia scraped from immature spots had distinct hilum at the base with 2-8 septa. Often, conidia without hilum (Plate 3) were also observed which might be of *M.musicola.* Spores pick technique as per protocol of Natural (1989) yielded only contamination. The size of ascospore and conidia were measured. Ascospores were isolated from cvs. Robusta, and Neypoovan. The leaf spot samples of Nendran, Poovan and Rasthali had numerous condia but ascospores were not observed. Pycnidia of Septoria leaf spot was observed in the cross section of affected leaf.

Among the commercial cultivars Rasthali, Robusta, Virupakshi, Pachanadan and Nendran had Septoria spores and the leaf spot symptoms were little different from that of Black Sigatoka. In cultivar Robusta, both black Sigatoka and Septoria leaf spots could be distinguishable but in cultivars Anaikomban (AA) and Galanamalu (AAA) had akin to Septoria symptoms. The leaf spots were uniformly spread over the leaf. The brown initial streaks appeared on the lower side of the leaf and the corresponding upper surface showed yellow to greenish yellow specks. The matured spots could be distinguishable from Sigatoka leaf spots. The spots were not linear, but they were broader than other Sigatoka spots. The matured spots had orange to grey centre with light to dark brown margin (Plate 4), yellow halo was bright in the initial stages of spot development and on maturation the yellow halo was less prominent. In Anaikomban (AA), the matured spots were similar to Galanamalu (AAA), but the spots were very linear. *M.musicola* spores were isolated from these spots, though the spots appeared to be of Septoria.

Pitting disease in exotic hybrid (New report)

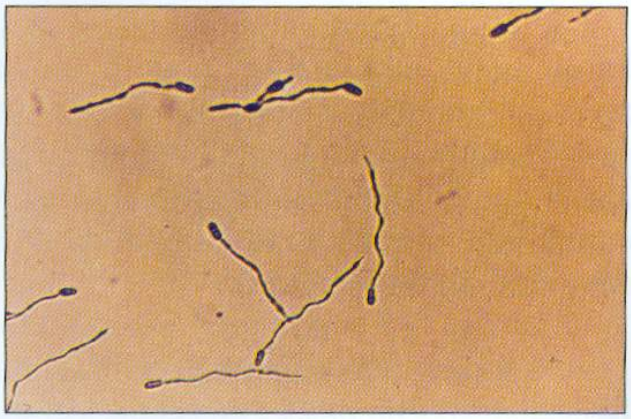
During the survey in Kerala pitting disease in a FHIA hybrid was observed. On isolation the disease was caused by *Pyricularia grisea* and this is the first report in India. The fungus produced pyriform spores in culture, typical of the pathogen.

Plate - 3

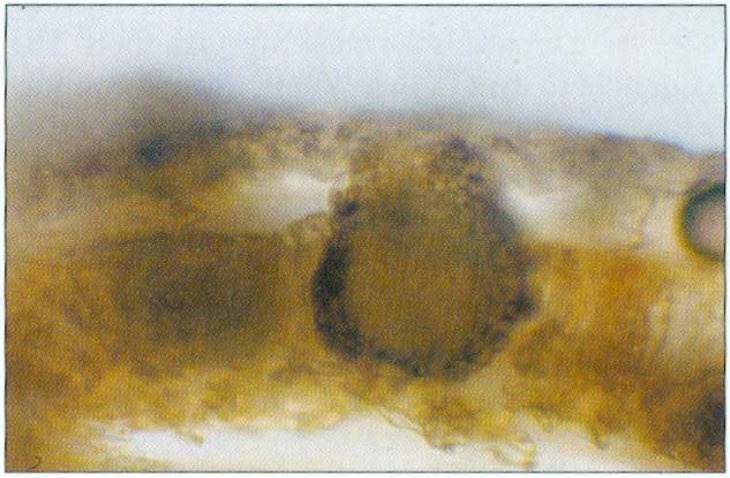
Black Sigatoka in Robusta

Septoria leaf spot in Robusta

Pycnidia of *Septoria eumusae*



Ascospore of *Septoria eumusae*



Conidia of *M. musicoea*

Conidia of *M. fijiensis*

Erwinia Head Rot

Vedivazhai locally named for *Erwinia* head rot disease in Cumbam area. The infected plants were visibly looking alike wilt affected plants. When the rhizome was cut opened yellow ooze was prominent in vascular regions. Erwinia head rot was observed in Robusta and Nendran in farmers' field. Amritsagar (AAA) an accession maintained in the field germplasm was infected with *Erwinia rot.*

Fusarium wilt incidence versus soil parameters (R.Selvarajan and K.J.Jeyabhaskaran)

A survey was conducted in the wilt-affected areas of Trichy and Karur districts. The per cent incidence and the soil pH, EC, Ca, Mg, Na, K and K/Ca ratio were recorded. Correlation analysis of percentage incidence with soil parameters was studied. There was no relationship between soil factors and disease incidence. The pH of the soil was negatively correlated however there was no significance. The resting spores, chlamydospores might play a major role in inciting the disease in new plantations.

In a survey in Kodai hills, 40% wilt incidence was recorded in cv. Virupakshi and in Trichy the incidence ranged from 1% to 50% in cultivar Rasthali and Karpuravalli.

Biocontrol of Fusarium wilt (R.Selvarajan and P.Sundararaju)

The biocontrol agents like *Trichoderma viride, T.hamatum and Pseudomonas fluorescence* was isolated from different banana growing areas of Trichy, Sirumalai, Coimbatore and Kallar for the biocontrol of *Fusarium* wilt disease on banana. The isolated antagonists were pure cultured for testing in dual culture technique. Many of the isolates showed inhibition zone against wilt pathogen (4 isolates).

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

Survey

In Coimbatore district in cv. Poovan, grown exclusively for its leaf, had ninety seven percent BBMV infection. 40% of Nendran [ratoon crop] was infected with BBMV where Banana was a mixed crop with arecanut. BBMV was recorded for the first time in Lower Pulney and Sirumalai hills in cvs. Robusta and Red Banana. Banana Streak Virus (BSV) was observed in Nendran and the symptoms were recorded. Nearly 30 percent of Red banana in Dindigul district was affected with BSV. Incidence of BSV was also noticed at lower Pulney hills in cvs. Poovan and Red Banana.

Correlation of BSV symptom expression with weather parameters

A study was conducted on symptom expression of BSV disease in relation to minimum and maximum temperature and rain fall in cultivar Poovan **(Table 21).** Fifteen

plants showing symptoms were randomly selected. Presence and absence of symptoms was recorded on fully opened leaves. The per cent leaf showing symptoms in a week was recorded from January. The correlation analysis related to minimum and maximum temperature prevailed during previous weeks [up to 4] had significant negative correlation with symptom expression. Lower the temperature higher the incidence. However, there was no corrlation in symptom expression with the corresponding temperature of the week. Even though the rainfall was positively correlated with symptom expression, the r^2 value was low. **(Fig 12b)**

Studies on the effect of abiotic stresses on BBMV and BSV

A field trial was conducted to study the effect of abiotic stress on BBMV in cv. Ney Poovan. The result showed that the parameters viz., plant height, girth, leaf area, finger length and bunch weight were significantly less as compared to healthy plants irrespective of treatments. **(Fig. 12c)** There was no significant difference among main treatments for all the parameters except the petiole length. However the duration of the crop significantly varied among the treatments.

A field trial was conducted to study the BSV symptom expression and the yield loss in cultivar Poovan. Treatments did not show any significant difference among the growth and yield parameters except the yield in the first crop. The parameters viz., height, girth, leaf area, number of hands and fingers and bunch weight recorded significant differences among the treatments. The bunch weight reduction was 21.0 per cent. The symptoms were not influenced by the nutrient stresses. However, the temperature had negative correlation with the symptom expression. Higher the temperature lowers the per cent disease incidence. **(Fig 12a)**

Transmission studies (R.Selvarajan and B.Padmanaban)

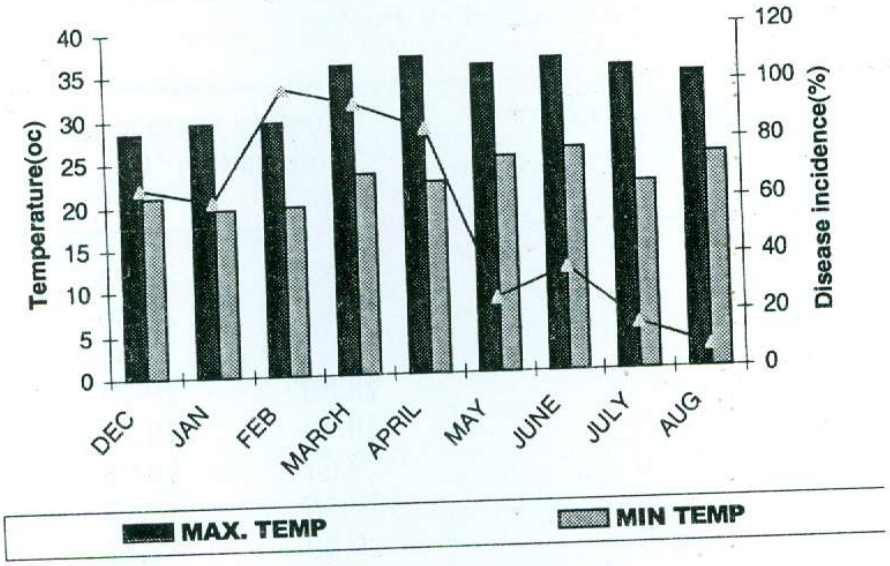
Transfer of BSV from Poovan to Pisang Ceylon using the Sugarcane mealy bug *Saccharococcus sachari* was tried. The protocol of Wang (1999) was followed. Results indicated that there was no transmission of the virus. However presence of the virus particle has to be checked through serodiagnosis and / or through ISEM technique. An experiment to transmit BBMV through banana aphid was taken up. The aphids did not transmit the virus by both the means of transmission i.e., non persistently and persistently to healthy plants.

Table 21. Effect of temperature and rainfall on symptom expression of Banana Streak virus in tissue culture plants of cv. Poovan

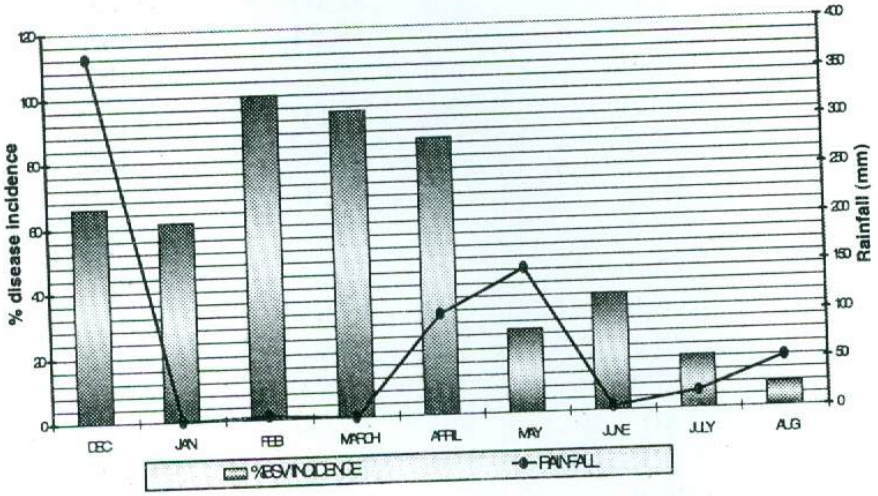
Week	Percent incidence of BSV	Monthly average temperature(°C)		Rainfall (mm)
		Max	Min	
1	-	27.29	21.93	16.2
2	-	27.93	21.36	33.74
3	-	28.71	19.64	0.0
4	-	28.50	19.93	0.143
5 January	55.5	28.79	19.71	0.0
6	75.0	29.64	19.93	0.0
7	77.8	29.36	20.07	0.0
8	85.7	29.79	18.57	0.0
9 February	100.0	30.86	18.64	0.0
10	100.0	31.79	21.14	0.0
11	100.0	31.86	22.36	0.714
12	100.0	31.60	21.79	0.486
13 March	100.0	33.64	19.86	0.0
14	92.9	35	21.79	0.0
15	100.0	35.96	22.07	0.0
16	86.7	36.96	23.04	0.0
17 April	93.3	37.8	24.07	0.0
18	93.3	36.8	23.36	3.0
19	73.3	39.24	26.53	0.0
20	78.6	35.04	24.46	7.0
21 May	28.6	35.94	24.40	4.70
22	13.3	36.53	24.43	12.98
23	40	36.64	25.07	0.071
24	20	34.46	25.07	7.214
25 June	30.8	34.51	25.57	0.786
26	13.3	36.36	26	0.114
27	33.3	35.93	25.93	0.479
28	53.8	35.81	25.59	0.0
29 July	25	36.26	26.07	0.0
30	64.4	37.90	25.54	0.0
31	23.1	36.66	25.87	2.571
32	9.1	35.29	25.79	0.0
33 August	12.5	34.40	26.19	0.0
34	22.2	34.50	26.40	0.0
35	11.1	34.79	25.93	0.0
36	12.5	35.79	25.14	5.829
37 September	0.0	34.21	24.43	1.464
38	0.0	34.29	25.15	0.143
39	0.0	34.61	25.57	0.0

Fig. 12

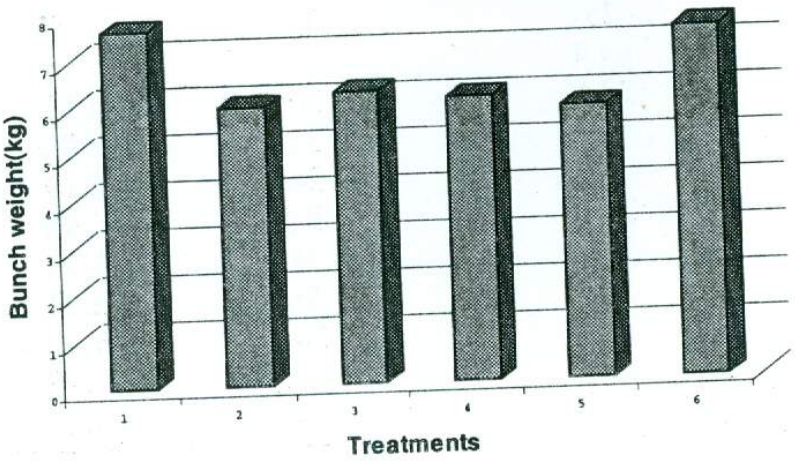
a. Temperature and BSV incidence



b. Rainfall and BSV incidence



c. Effect of BSV on bunch weight



Yield loss assessment due to BBMV (R.Selvarajan and K.J.Jeyabhaskaran)

A fixed plot survey was conducted in four different orchards in Trichy district **(Table 22).** The soil and fertility status of the orchard was recorded. Randomly selected disease free plants were tagged and BBMV infected plants as control was randomly selected based on its symptoms in pseudostem. The two factor RBD was adapted. The result revealed that the average yield reduction was 30 per cent. The reduction in bunch weight over healthy plants was 15.8, 24.1, 21.4 and 58.9 per cent at different locations .The yield loss due to BBMV vary from place to place depending on soil fertility.

Table 22 Sigatoka leaf spot incidence in different cultivars

Location	Cultivar	Date of observation	Disease severity	Y.L.S	Stage of the crop
Koppu (89)	Nendran@	8/12	13.45	10.6	V
		6/1	21.29	8.72	S
		8/2	40.54	6.02	S
		8/3	47.41	3.4	H
Ayillapettai (89)	Nendran	10/12	8.99	10.2	V
		10/1	19.69	7.9	S
		10/2	28.78	5.7	S
		10/3	50.64	3.12	H
Pallakadu (89)	Rasthali@	15/11	14.28	10.89	S
		20/1	42.11	4.5	H
Koundapatti (89)	Rasthali@	19/12	22.31	9.4	V
		7/1	22.79	101	V
		9/2	33.32	8.1	V
		9/3	34.53	7.9	S
		7/4	48.69	4.3	S
Podhavur (89)	Rasthali@	10/12	41.5	6.56	V
		5/1	50.33	7.32	V
		10/2	65.93	5.32	S
		7/3	66.08	4.21	S
		6/4	80.77	3.92	H
	Pachandan@	10/2	53.47	3.25	S
		6/4	87.95	1.0	H
Vayalur-I (89)	Robusta@	6/12	29.43	6.62	V
		7/1	27.61	7.40	S
		6/2	37.02	7.6	S
		9/3	40.06	4.54	H

Vayalur-II (89)	Robusta@	6/12	30.31	7.16	V
		11/1	34.05	7.30	S
		7/2	41.94	7.12	S
		9/3	48.70	4.93	H
Kannara,# (45)	Robusta*	26/6	49.64	4.9	H
	Nendran*	"	14.14	9.5	V
	Nendran*	7/4	0.0	13.0	V
KAU,# Mannuthy(45)	Nendran*	"	10.1	9.89	BMS
	Nendran*	26/6	4.78	10.5	V
Thottiam (90)	Nendran@	29/1	56.4	3.1	H
	Rasthali@	29/1	90.0	2.0	H
	Rasthali*	29/1	50.7	4.4	H
	Rasthali*	29/1	25.3	8.9	V
	Poovan*	29/1	54.1	3.1	H
Coimbatore (400)	Nendran*	17/12/99	5.31	13.24	H
	Poovan*	17/12/99	34.94	6.32	V
	Rasthali*	17/12/99	10.25	12.26	S
	Karpuravally*	17/12/99	0.0	18.1	V
	Robusta*	17/12/99	15.62	9.4	H
	Robusta*	17/12/99	21.76	8.0	S
Mettupalayam (450)	Nendran*	17/12/99	0.31	10.25	H
	Robusta*	17/12/99	1.56	10.13	H
Kambam (300)	Robusta*	2/3	40.5	5.6	H
	Robusta*	2/3	10.5	10.1	S
Kodaikanal (1500)	Virupakshi	3/3	0.0	11.5	H
Sirumalai (1000)	Virupakshi	7/2000	negligible	10.5	H
	Robusta	"	10.5	12.4	V
	Poovan	"	26.3	9.8	S
Kolli Hill (1200)	Namaran (Pome)	-	41.2	5.6	H

Figures in the parenthesis are altitude of the location in metre
*-Gardenland cultivation; @-Wet land Banana; **-Grown for leaf purpose
H-Harvesting stage; S-Shooting stage; V-Vegetative stage
BMS-Bunch maturity stage KAU- Kerala Agricultural University.

Table.23 Effect of BBMV on growth and yield parameters in cv Nendran at different locations

Field No.	Leaf area(cm^2)			Girth(cm)			Height(cm)			No. of hands/ bunch			Bunch weight (kg)		
	D	H	M	D	H	M	D	H	M	D	H	M	D	H	M
L1	7711	10024	8867.2	56.2	58.2	57.2	256.3	286.9	271.6	5.2	6.25	5.73	4.96	7.37	6.16
L2	8949	10226	9587.3	55.1	62.9	59.1	249.7	299.4	274.5	5.5	5.85	5.68	5.08	10.97	8.02
L3	7472	7991	7731.4	54.1	52.8	53.5	250.5	259.2	254.8	5.45	5.95	5.7	4.85	6.99	5.92
L4	6831	8337	7583.7	51.5	54.8	53.2	247.8	264.4	256.1	5.5	5.95	5.73	3.89	5.47	4.68
M	7741	9144		54.3	57.2		251.1	277.5		5.41	6.00		4.69	7.70	
CD at 5%	M	S	M*S	M	S	M*S	M	S	M*S	M	S	M*S	M	S	M*S
	644.7	455.83	911.67	3.51	2.48	4.96	16.03	11.33	22.66	NS	0.237	0.47	0.54	0.38	1.00

D: diseased; H: healthy; M: mean; L1 to L4: locations

4. POST-HARVEST TECHNOLOGY AND PHYSIOLOGY
General Leader Dr. S. Shivashankar

Among the germplasm, Pisang Seribu (AAB) had higher number of leaves and leaf area at the time of flowering which was also earlier as compared to Pacha Bondha Batheesa and Thiruvananthapuram. Dehanding of first one to three hands did not have any effect on fruit filling. The physiological evaluation of accessions revealed that 'B' genome contributed more for the higher performance of banana for the growth parameters.

4.1. Studies on flowering behaviour and its regulation in Banana (R.H.Laxman and S. Uma)

The observations on growth parameters and on the proportion of female and male flowers, number of hands and male flowers per bunch and bunch weight were recorded. Among the germplasm, Pisang Seribu had higher number of leaves and leaf area at the time of flower emergence and flowering was also earlier as compared to Pacha Bontha Batheesa and Thiruvananthapuram. Pacha Bontha Batheesa recorded 100.8 completely filled fruits in11.8 hands. After the female phase, there were few male flowers and again there were 35 partially filled female flowers from 3.8 hands. Subsequently there were only male flowers. Dehanding of first one to three hands did not have any effect on the number and fruit filling of the subsequent female flowers which emerged after a stint of male phase. This showed

that the sex of the flowers was predetermined before emergence and fruit filling was governed by factors other than the availability of photosynthates alone. Pisang Seribu had only female and no male phase. Among female flowers, while 429 were filled 370.6 were partially filled and persistent on the peduncle. Thiruvananthapuram on the other hand had short female phase with only 38.6 fruits in 4.33 hands and subsequently had only male flowers with an average of 92 male hands.

4.2. Physiological evaluation of germplasm accessions (R.H.Laxman)

The germplasm accessions belonging to AB, BB, AAB, ABB genomes were evaluated for the growth parameters like plant height, pseudostem girth, number of leaves, leaf area and leaf emergence rate at different stages of growth. The analysis of the data suggested that the accessions under AB group had the minimum plant height and girth at 6th, 8th and 10th months followed by AAB. And maximum height was recorded in BB group at all the stages. The number of leaves was minimum in AAB whereas, maximum was recorded in AB group at 6th month followed by BB. But at 8th and 10th month stages, BB recorded maximum number of leaves followed by AB. ABB group followed by BB at all the stages recorded the highest leaf area. The leaf emergence rate (LER) was highest during 7th month and it gradually decreased in all the groups during the later stages and AAB recorded the lowest LER at all the stages. Highest LER was recorded in BB followed by ABB at 10 th month stage. It was observed that contribution of 'B' genome was more for higher performance of banana for the growth parameters evaluated. **(Fig. 13)**

5. TECHNOLOGY ASSESED AND TRANSFERRED

The technology developed by the centre on 'High Tech Banana Cultivation' is being explained to Mr. N. Athimolam, I.A.S., Secretary, Agriculture, Government of Tamil Nadu, Chennai, who visited the NRCB Farm on 19-8-1999.

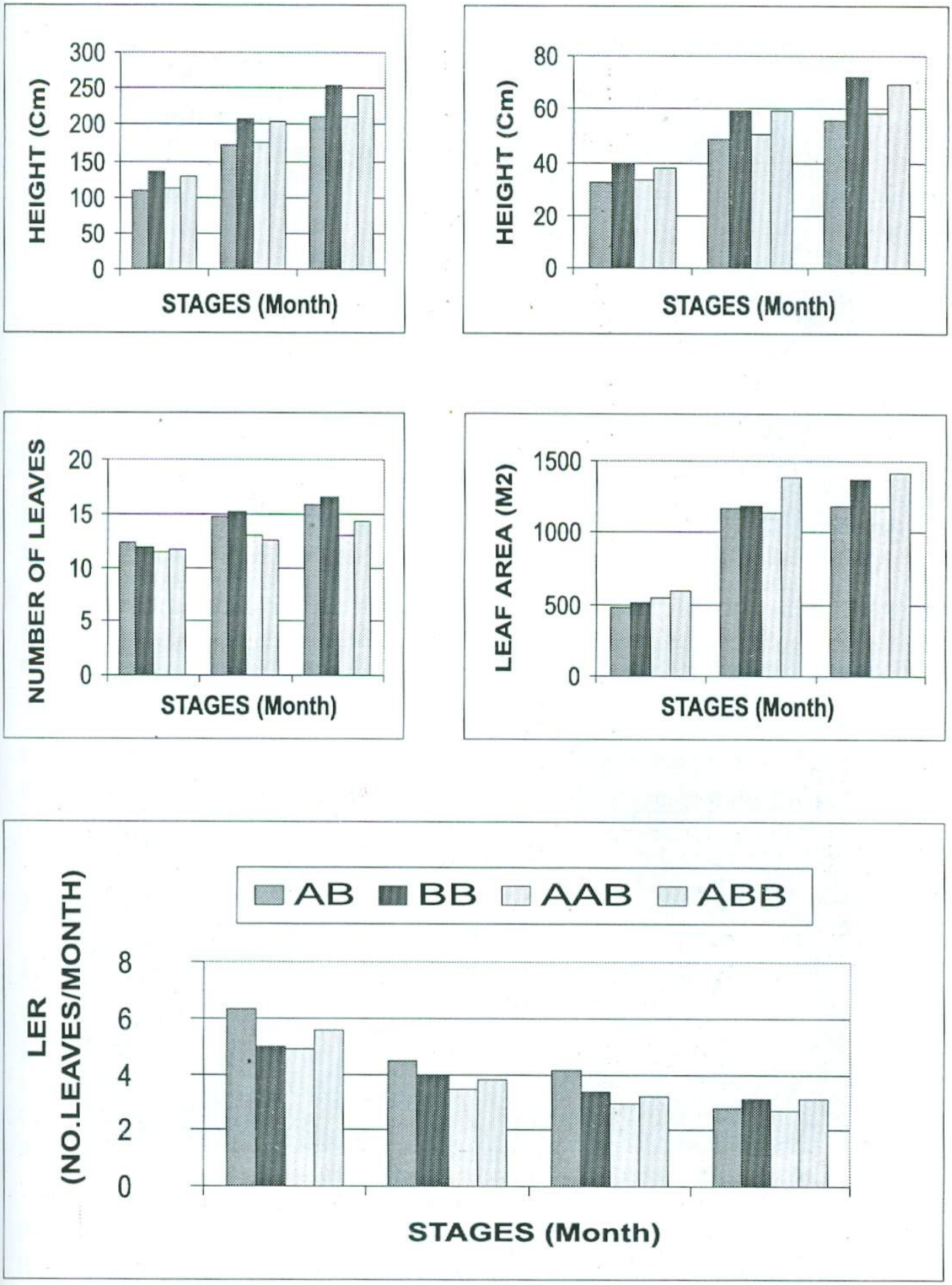


Fig. 13. The performance of germplasm accessions at different growth stages AB, BB, ABB Genomes of banana.

Dr.S.Sathiamoorthy, Director, NRC for Banana delivering a talk on "Recent trends in banana cultivation" to the farmers mela organised by M/S. Rajashree sugars at Madurai.

Dr. M.M.Mustaffa, Principal Scientist, Dr. P.Sundararaju, Dr. B. Padmanaban and Dr.R.Selverajan, participated in the 'Banana Seminar' organised by SPIC at Anaimalaiyanpatti near Cumbum. They spoke on different topics on banana cultivation such as Integrated Nutritient management, Integrated management of Nematodes, Insect pests and diseases. The scientists interacted with the banana growers, clarified their doubts and informed the banana farmers about the improved production and protection technologies on banana cultivation.

6. EDUCATION AND TRAINING

NRCB is actively involved in educating the local farming community either at institutes farm level or at farmer's filed

Dr. P.Sundararaju as research advisor, guided Miss R.Leela Devi, student of Srimathi Indira Gandhi College, Trichy, for her dissertation work entitled "Analysis of best treatment and variety based on nematode population on Banana using artificial neural networks" for her partial fulfilment of M.Phil. Degree submitted to Bharathidasan University.

Dr. B.Padmanaban as research advisor, guided Ms.C.Sripria, student of Srimathi Indira Gandhi College, Trichy, for her dissertation work entitled "Evaluation of banana gerplasm against insect pests of banana using artificial neural network" for her partial fulfilment of M.Phil. Degree submitted to Bharathidasan University.

Dr. R.Selvarajan, as a research advisor, guided Ms. Sumathi student of Srimathi Indira Gandhi College, Trichy, for her dissertation work entitled "Prediction of Sigatoka leaf spot disease incidence based on weather parameters using artificial neural networks" for partial fulfilment of M.Phil. degree submitted to Bharathidasan University.

Dr. S. Shivashankar conducted a training programme for two women entreprenures, Ms. M.Bhuvaneswari and Ms. M. Mahmootha Begum, sponsered by the District Industris Centre, Trichy on "Processing of banana products" from February 2000 – July 2000.

Dr. S. Uma as a research advisor, guided Ms. S.Ambi, student of Srimathi Indira Gandhi College, Trichy, for her dissertation work entitled "Yield stability analysis in banana germplasm using artificial neural networks" for partial fulfilment of M.Phil. Degree submitted to Bharathidasan University.

7. LINKAGES AND COLLABORATION IN INDIA AND ABROAD

International collaboration:

NRCB has collaboration with International Network for the Improvement of Banana and Plantain (INIBAP) in the field of Research and Development of Banana and Germplasm exchange. Under this collaborative work, INIBAP has funded a project entitled "Collection, Characterisation of Banana and Plantain in North-Eastern India"with a budget of Rs 13,20,00 is being under under operation at NRCB since September 1998.

During the 1st phase of exploration to North-Eastern states viz., Assam, Arunachal Pradesh and Meghalaya states were undertaken and collected Section Eumusa -wild, Section Eumusa-cultivated and Section Rhodochlamys. The collected accessions during 1st phase exploration were planted in the NRCB field genebank. Evaluation has been completed for 18 accessions for their growth, yield and post harvest quality parameters for two seasons.

15 accessions were lost due to poor acclimatization by the germplasm. Efforts were being made to collect the lost accessions in the forthcoming exploration to North-Eastern states.

Under the germplasm exchange programme 48 accessions were initiated and supplied to NBPGR, New Delhi for onward transmission to ITC Belgium as per the MoU.

Musa Germplasm Information System (MGIS) is the global germplasm Information Network among the collaborating centres at global level. INIBAP, France has centralises the information which is supplied by the collaborating centres. NRCB has sent the passport data for 809 accessions and complete evaluation data for 100 accessions for MGIS networking.

National level collaboration:

In collaboration with National Horticultural Board, Gurgaon, a funded the project entitled " In-vitro propagation of banana for higher productivity" was in operation. Under this project, survey was undertaken in Tamilnadu, Kerala and Karnataka to identify and collect disease free mother plants of Cavendish clones along with other local commercial cultivars. Protocol for reducing culture contamination during initiation over transportation time lag. Use of liquid culture for early proliferation has been standardised. Tissue cultured plantlets of Cavendish have been multiplied, hardened and supplied to BRS, Kannara for evaluation under multilocation trials.

In collaboration with National Bureau of Plant Genetic Resources (NBPGR), New Delhi, a project entilted "Plant Bio-diversity" under NATP is being operated at NRCB. Under this programme during the project reporting period from September 1999 - March 2000 an exploration was untertaken during December 1999 to Andaman and Nicobar islands and 7 accessions were collected of which wild and one commercial cultivars. The details of exploration are given in text. During this exploration, a detailed survey of the varietal situation of Andaman and Nicobar Islands was made and a note on the indigenous, introduced and indigenously domesticated has been made. Variability within Pisang Awak cultivars was noted in 3 other islands and collected for the NRCB genebank. A preliminary data collection on other islands where wild musa species are expected to occur has been collected for a more detailed survey in the next exploration.

International *Musa* Testing Programe (IMTP)

IMTP on wilt was taken up in a farmer's field at Thottiam. The selected field was already a sick soil for wilt, hence no artificial inoculation was done. The results revealed that only Gross Michael (AAA) was affected with wilt. The Sigatoka leaf spot incidence was recorded at 7th month after planting. The accessions viz., Cultivar Rose, Yangambi, PA-03-22, and FHIA-3 did not show any leaf spot symptoms. The other accessions showed various levels of infection index. PV 03-44 had some other leaf spot disease but was not

typical to symptoms of Sigatoka. Pisang Mas, FHIA-01 and Pisang Nanga showed 15.84, 9.0 and 12.11 infection indices respectively. All other accessions had infection index of above 21.0.

8. AICRP/COORDINATION UNIT/NATIONAL CENTRES

Two NRCB selections 0079 and 0652 which have proved their superiority in our evaluation trials have been multiplied and supplied to two research institutes, (one in humid tropics and other in subtropics) and to farmers field for multi location evaluation. (BRS, Kannara, Kerala; BRS, Kovvur, Andhra Pradesh; State Horticulture Department. Agartala, Tripura and local farmers in Tamilnadu). These were found to be superior due to of their improved characters like suitability for marginal lands, high yielding potential, better salt tolerant, excellent fruit quality, better transport and keeping quality and tolerance to Sigatoka leaf spot.

9. PUBLICATIONS

Papers Published in Journals

Anitha Karun,K., Sajini, K. and Shivashankar, S. 1999. Embryo culture of coconut: the CPCRI protocol. *Indian Journal of Horticulture*, 56(4): 348-353.

Padmanaban,B. and Sundararaju,P. 1999. Occurrence of Banana Weevil borers (*Curculionidae: Coleoptera*) in Tamil Nadu. *Insect Environment*, 5: (3): 135.

Shivashankar,S. 1999. Post harvest evaluation of banana accessions for shelf life and quality parameters. *Indian Journal of Horticulture,* 56 (2): 11 – 166.

Shivashankar,S. and Kumar,V 1999. Pattern of fruit development in six banana varieties. *Indian Journal of Plant Physiology,* 4(4) 286-288.

Thangavelu,R., Padmanaban, B. and Sundararaju, P. (1999). Peduncle rot in India. *Infomusa*, 8 (1) 35.

Uma, S., Singh, H.P., Dayarani, M. and Shyam, B. (2000). Variety evaluation for response to edaphic factors on yield and Physico-chemical characterisation of commercial banana cultivars. *Indian. Journal of Horticulture* 56(1-4): 104-08.

Uma,S., Singh,H.P. and Dayarani,M. 1999. A study on male bud mutations and reversions in *Musa* accessions. *Indian. Journal of Horticulture,* 56(3):201-205

Papers presented in Seminar/Workshop/Symposium

Jayabaskaran, K.J., Laxman, R.H.and Pandey,S.D. 1999. Effect of soil amendments and potassium on banana(cv. Nendran) in saline sodic soil. Paper presented in National Seminar on Plant Physiology at Interface on Agri-Horticulture and Industry, held at Rajasthan College of Agriculture, Udaipur from 30th Dec 1999 to 1st January 2000

Jeyabaskaran, K.J., Pandey, S.D. and Laxman,R.H. 2000. Studies on Reclamation of saline sodic soil for banana (cv. Nendran). Paper presented in the International Conference on Managing Natural Resources for Sustainable Agricultural production in the 21st century, held at IARI, New Delhi from Feb 14-18, 2000.

Laxman, R.H., Jeyabaskaran, K.J. and Pandey, S.D., 2000. Effect of amendments and potassium levels on chlorophyll content and sugar levels in banana under saline sodic conditions. Paper presented in National Seminar on Recent Advances in Plant Biology, held at CPCRI, Kasaragod from 3-5, Feb 2000.

Narayana, C.K. 2000. Use of Ethel and smoking for ripening of banana: a comparative study. Paper presented in 'National Seminar on Recent Advances in Plant Biology', held at CPCRI, Kasargod from 3rd to 5th February 2000.

Narayana, C.K. 2000. Effect of maturity on shelf life, ripening and quality of banana. Paper presented in 'National Seminar on Recent Advances in Plant Biology', held at CPCRI, Kasargod from 3rd to 5th February, 2000.

Narayana C.K., Shivashakar,S. and Laxman,R.H. 1999. Post harvest handling and value addition in banana. In the proceedings of National seminar on Banana (Production, Post-harvest and Export) Pune, 15-16, Oct 1999.

Padmanaban, B., Sundararaju, P. and Sathiamoorthy, S. 1999. Review on pheromone studies of banana rhizome borer *Cosmopolites sordidus* German (Curculionidae: Coleoptera). abs : *"Innovative methods of Crop Protection"* at SPIC, Chennai 18 Dec., 1999.

Padmanaban, B., Sundararaju, P. and Sathiamoorthy, S. 2000. Evaluation of pheromone trap against the banana leaf eating caterpillar, *Spodoptera litura* FAB (Noctuidae : Lepidoptera). Paper presented in *"Symposium on Plant Protection"* at Banaras Hindu University, Varanasi 25-27, Feb., 2000.

Padmanaban, B., Sundararaju, P. and Narasimhan, S. 2000. Synthesis and Evaluation of Pheromone of Banana Rhizome Weevil, *Cosmopolites sordidus* G(curculionidae coleoptera) for the management of the pest. Paper presented in *"Indo-UK Workshop on Innovative Pest and disease management in Horticultural and Plantation Crops: Technology Improvement, validation and Transfer"* organised by British Council at SPIC, Chennai on 10-11, March, 2000, 107-108.

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Pandy, S.D., Uma,S., Sathiamoorthy ,S. and .Laxman,R.H. 1999. Technologies for quality banana production.In the proceedings of National Conference on Banana (production, postharvest technology and Export) Jalgaon, Pune, 15 - 16th Oct. 1999.

Sathiamoorthy,S., Uma,S., Singh,H.P., Shyam,B., Selvarajan,R. and Dayarani,M. 1999. Exploitation of tissue culture for enhancing the production and productivity of Banana in India. In the proceedings of National Conference on Banana (Production, Post-harvest Technology and Export) Jalgaon, Pune, 15-16 October 1999.

Sathiamoorthy, S. and Uma,S. 1999. Banana R & D in India - Status report. In the proceedings of Regional Advisory Committee Meeting (RAC) of Asia and Pacific (ASPNET/INIBAP) Guangzhou, China, 02-05 November 1999.

Selvarajan,S. and Sathiamoorty,S. 1999 Diseases of Bananas and Plantains limiting production, productivity and quality. "Banana Seminar" held at NIPHT, Pune, 15 – 16 October, 1999.

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Shivashankar,S., Narayana ,C.K.and Sathiamoorthy. 1999. Postharvest care and handling of banana for exports. In : Proc.National Seminar on Banana held at Jalgaon, Maharashtra, 15-16 October, 1999, 14-19.

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Shyam, B., Uma,S., Dayarani,M. and Sathiamoorthy,S. 2000. Numerical taxonomy studies on the molecular divergence in Banana, *'ibid'*

Shyam, B., Uma,S., Dayarani,M. and Sathiamoorthy,S. 2000. Molecular characterisation of banana using Isozymes, *'ibid'*

Singh, H.P., Uma ,S.and Dayarani,M. 1999. Musa species-under exploited ornamentals of the fruit world. In the proceedings of National Symposium on Emerging Scenario in Ormanental Horticulture in 2000 AD and Beyond held on 21-22 July 1999 at IARI, New Delhi.

Sudha,S. and Sundararaju, P. 1999. Effect of Neem Oil cake and nematicide for the control of burrowing nematode, *Radopholus similis* in the arecanut based cropping system. *In : Proc. Third International Symposium of Afro-Asian Society of Nematologists,* (TISAASN) (Ed.Usha K.Mehata, 1998-99), Sugarcane Breeding Instt., Coimbatore. 251-257.

Sundararaju, P. 2000. Biocontrol Agents of Plant parasitic nematodes in Banana. Paper presented in *"Indo-UK Workshop on Innovative Pest and disease management in Horticultural and Plantation Crops : Technology Improvement, validation and Transfer"* organized by British Council at SPIC, Chennai, 10-11, March, 2000, 58-60.

Sundararaju, P. and Uma, S. 1999. Evaluation of Promising Hybrids and Cultivars of Banana against Major Nematode Pathogens, *'Ibid'*

Sundararaju, P. and Sudha,S. 1999. Nematode management in Arecanut and Arecanut based farming system. *'Ibid' 190-192.*

Sundararaju, P., Padmanaban, B. and Sathiamoorthy, S. 1999. Control of root-lesion nematode, *Pratylenchus coffeae* in certain cultivars of banana. *Abs : "National Seminar on Nematological Research in India"* at C.S. Azad University of Agri. & Tech., Kanpur 17 Dec., 1999. 46-47.

Thangavelu, R. and Sundararaju, P. 1999. Status Report on the Fusarium Wilt diseases of Banana in India. Paper presented by in *"International Seminar and Workshop on Banana Fusarium Wilt Disease"* held at MARDI, Malaysia, 18-20, October 1999.

Uma, S., Dayarani,M., Shyam,B. and Sathiamoorthy,S. 2000. Micropropagation of Rasthali. In the proceedings of State level seminar on 'Recent trends in molecular genetics' held at Jamal Mohammaed college, Trichy, 29-30, March, 2000.

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Uma.S., Singh,H.P., Dayarani,M. and .Shyam,B. 1999. Embryo culture studies on *Musa velutina* an exotic ornamental banana. In the proceedings of National Symposium on Emerging Scenario in Ornamental Horticulture in 2000 AD and Beyond, 21 -22 July 1998, IARI, New Delhi.

Uma.S, Singh,H.P., Shyam,B. and Dayarani,M. 1999. Variability studies in the *Musa* subgroup- Mysore. In the proceedings of National Seminar on Sustainable Horticultural Production in Tribal Regions, 16-17 July 1998, Ranchi.

Uma.S, Singh,H.P., Shyam,B., Selvarajan,R. and Dayarani,M. 1999. Genetic Diversity of *Musa* in India. In the proceedings of National Seminar on Sustainable Horticulture Production in Tribal Regions, 16-17 July 1998, Ranchi.

Uma.S, Singh,H.P., Shyam,B. and Dayarani,M. 1999. Indigenous technical knowledge in Banana utilisation. In the proceedings of national seminar on "Sustainable Horticultural Production in Tribal Regions" July 16-17, Ranchi.

Chapters in Books

Shivashankar,S. and Chempakam,B. 1999 .Germination and early seedling growth. In : Advances in Plant Physiology and Biochemistry of the coconut palm. APCC Publication, Bangkok, Thailand. 1-4.

Kasturi Bai,KV. and S.Shivashankar. 1999. Flowering and fruit development. In : Advances in Plant Physiology and Biochemistry of the coconut palm. APCC Publication, Bangkok, Thailand. 15-29.

Shivashankar,S. and B.Chempakam. 1999. Biochemical responses to water stress. In : Advances in Plant Physiology and Biochemistry of the coconut palm. APCC Publication, Bangkok, Thailand. 73-79.

Popular Articles

Jeyabaskaran, K.J. and Sundararaju. P. 1999."Vazhaikku Nunnutta Chattu" (Micronutrients in Banana) in *"Valarum Velanmai"* (Tamil), 8: 43 – 45.

Jeyabaskaran, K.J. and Sundararaju, P. 1999. Vazhaiyil Boron matrum Thamira chathukalin Avasiyam (Tamil). *"Valarum Velanmai"* (in press).

Padmanaban, B., and Sundararaju, P. 1999. Vazhayil Orunginaintha Poochi Niruvagam (Tamil), *"Valarum Velanmai"* 25(12) : 45-48.

Sundararaju, P., Padmanaban, B. and Thangavelu, R. 1999. Banana Plant - A plant of heaven. *Kisan World,* 26(6) : 35.

Shivashankar,S. 2000. Multiple uses of banana. *Agrigold Swarna Sedyam* March, 2000, 47-48.

Shivashankar,S. 1999. Bananas for the Supermarket. *AgroIndia* May, 1999, P.9.

Shivashankar,S. 1999. Balehannu Samskarane.(Part.I) *AdikePathrike*, September.1999. p.23.

Shivashankar,S. 1999. Balehannu Samskarane. (Part.II) *Adike Pathrike*, December 1999. p.23.

Reports

Narayana ,C.K. Training manual of 'A short term training course on processing of Banana in to value added products'.

Narayana ,C.K. 'Scope for banana based Agro industries in Tiruchiraplli' – a report submited to Shri. P.R.Kumaramangalam, Hon'ble Minister for Power. Govt. of India.

Narayana ,C.K. Self employment for self help group of Trichy district- Banana based added products', A report submitted to Dist. Collector of Trichy.

10. LIST OF APPROVED ON-GOING PROJECTS

I. CROP IMPROVEMENT

Banana Crop improvement through germplasm management and enhancement
S.Uma and S.Sathiamoorthy

Crop improvement through conventional breeding of banana
S.Sathiamoorthy and S.Uma

Improving banana cultivars through biotechnological approaches for yield quality, biotic and abiotic stress resistance
B. Shyam and S.Uma

II. CROP PRODUCTION AND POST HARVEST TECHNOLOGY

Standardisation of Agrotechniques for banana production and productivity
S.D.Pandey and M.M.Mustaffa

Studies on amendment and reclamation of saline sodic soil for banana
K.J.Jeyabaskaran and S.D.Pandey

Studies on organic farming in banana
K.J.Jeyabaskaran and S.D.Pandey

Post-harvest management, evaluation and processing of banana
S.Shivashankar and C.K.Narayana

Studies on process and product development, value addition and waste utilization in banana
C.K.Narayana and M.M.Mustaffa

III. CROP PROTECTION

Insect pest management in banana
B.Padmanaban and P.Sundararaju

Studies on banana nematodes and their management
P.Sundararaju and B.Padmanaban

Studies on fungal and bacterial diseases and their management
R. Selvarajan

Bio-control of fusarium wilt of banana and nematodes in wet land production system
R. Selvarajan and P.Sundararaju

dies on viral diseases of banana and their management
R. Selvarajan

CROP PHYSIOLOGY AND BIOCHEMISTRY

dies on flowering behaviour and its regulation in Banana germplasm accession
R.H.Laxman and S.Shivashankar

CONSULTANCY, PATENTS, COMMERCIALISATION OF TECHNOLOGY

A consultancy project on the evaluation of Roundup (Product of M/S Monsanto mpany) for control of weeds and its effect on growth and productivity of banana was npleted during the year. The final report of the trial has been completed.

Two consultancy projects on sigatoka leaf spot disease control are in progress.Tilt, product of M/S Novartis company and Anvil, the product of M/s. ICI Geneca have been en for the bio-efficacy testing. As per the treatments given by the company in consultation h the NRCB, the trials are being carried out in farmers' field. The first year work has been npleted. The second year work is in progress. The total cost of the project is Rs 1.0 lakh.

PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, ORKSHOPS, SYMPOSIA ETC. IN INDIA AND ABROAD

rticipation in Symposia/ Conference/ Workshop

xman R.H. participated in the National Seminar on Plant Physiology at Interface on Agri-rticulture and Industry, held at Rajasthan Agriculture University , Udaipur, from 30th c'99 to 1st Jan' 2000.

xman R.H. participated in the National Seminar on recent advances in Plant Biology held CPCRI, Kasaragod, from 3-5, February 2000.

ayana,C.K. participated in the National seminar on "Banana (Production Postharvest hnology and Export)", NIPHT, Pune, 15th - 16th October 1999.

ayana,C.K. participated in the National seminar on 'Recent Advances in Plant Biology' at CPCRI, Kasargod 3rd to 5th February 2000.

manaban,B. participated in the seminar on problems of Hill bananas organised jointly Department of Horticulture, Government of Tamil Nadu and Tamil Nadu Agricultural versity, Periyakulam on 26.8.1999.

Pandey,S.D. attended special workshop on fifty years of official language implementation, achievements and prospects. Organazed by NAARM, Hyderabad from 29 – 30th November 1999

Selvarajan,R. attended a Banana seminar (vazhai karutharangu) organised by A.I.R Trichy on 20th october 99. Delivered a talk on 'Banana disease and their management' at Mahadhanapuram.

Selvarajan,R. attended a "Banana growers seminar organised by IFFCO and KVK of Gandhigram Deemed University, on 22nd Oct. 1999. Delivered a lecture on 'Fungal and Viral disease of banana and their identification and Management" at KVK. Gandhigram Deemed University, Dindugul.

Shivashankar,S. participated in the 'National Seminar on recent advances in plant biology' held at CPCRI, Kasaragod from 3-5, February 2000.

International:

Sundararaju,P. deputed to Phitsanuloke, Thailand as a RISBAP co-ordinator to attened theTraining cum workshop on the Regional Information System on Banana and Plantain (RISBAP) on Info/Doc databases at Naresuan University, Phisanuloke, Thailand on 14-17, September 1999.

Training courses attended

Laxman,R.H. Training course on Microsoft – Office '97 (II) at the Division of Computer Applications, IASRI, New Delhi, 20th – 25th September, 1999.

Narayana,C.K. A short term training course on "Recent advances in Biosciences for Sustainable Food Security", AAREM, HAU, Hissar, 21st September – 1st October 1999.

Padmanaban,B. Master trainers training on Integrated Pest Management, National Centre for Integrated Pest Management (NCIP), New Delhi, 13 - 17 April 1999.

Padmanaban,B. Summer school on Emerging trends in microbial control of Crop pests, 5 to 26 May 1999 the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

Pandey,S.D. Short course on statistical modeling for forecasting Biological phenomena, IARSRI, New Delhi, 10 - 19th 1999.

Shyam,B. Attended training course on "Molecular Markers for DNA fingerprinting", NRC on DNA fingerprinting, NBGR, November 28th – December 18th 1999.

Uma,S., First training programme for the Co-operator under NATP – PB from 5 – 6th November 1999, NBGR Regional station, Thirusur.

Meetings attended

Dr..M.M.Mustaffa, Dr.B.Padmanaban, Dr. P.Sundararaju, and Dr. R.Selverajan, attended a Banana farmers meeting on banana cultivation at organized by SPIC on 23.03.2000, Aanaimalaiyanpatti Cumbum.

Dr.S.D.Pandey, attended scientific advisory panel meeting (NATP) Coastal Agro- eco-system held at CMFRI, Cochin, from 29th - 30th January 2000.

Dr.C.K.Narayana, attended a Farmers meet of Vegetable FFS's at Office of Asst.Director of Agriculture Manaparai on 9th November 1999 for giving training on value added products from tomato.

Dr.B.Padmanaban, attended NATP-IPM working committee meeting held at NCIPM, New Delhi on 27-28th January 2000 and presented entomological aspects relating to project proposal.

Dr.S.Uma, attended the zonal technical co-ordination committee meeting of NATP (PB) held at NBPGR Regional station, Thrissur, 9.06.2000.

13. WORKSHOPS, SEMINARS, SUMMER INSTITUTES, FARMERS DAY ETC. ORGANISED BY THE CENTRE

Radio Talks

Dr.B.Padmanaban, Senior Scientist delivered radio talk on (I) Vazhayil orunginaindha poochi nirvagam (Broadcasted on 31.7.99).

Dr.R.Selvarajan, Scientist "Vazhayil illaipulli matrum kottaivazhai kattupaadu" delivered in Aug. 1999.

Dr.S.Uma, Scientist (SS), gave a Radio talk on Banana export industry-problems and prospects on 8th Aug. 1999.

Dr. B.Padmanaban, Senior Scientist delivered radio talk on Vazhayil Kizhangu matrum thandu thulaippanin paramarippu (broadcasted on 25.10.99).

Dr. P.Sundararaju, Senior Scientist delivered a radio talk on "Vazhayil Orunginaintha Noorpuzhukkal Nirvagam" (Tamil) in the month March, 2000.

Dr.K.J.Jeyabaskaran, Scientist "Vazhayil Orunginaintha Ura Nirvagam" (Tamil) (Integrated Fertilizer Management in Banana) Broad casted on 11.03.2000.

14. DISTINGUISHED VISITORS

Dr. Augustin B. Molina, Regional Coordinator, ASPNET/INIBAP, Philippines, visited on 16.02.2000 to review of INIBAP project.

Dr. Dolares A. Ramirez, Institute of Plant Breeding, University of Philippines, Philippines, visited along with Dr. A.B. Molina on 16.02.2000 to review of INIBAP project.

Shri. N.Athimoolam, I.A.S., Secretary, Agriculture, Government of Tamil Nadu, Chennai, visited on 19.8.1999 for Foundation stone Ceremony to the office cum laboratory building.

Dr.Jean Vincent Escalant, Genetic Resource Scientist, INIBAP, France, visited on 11.10.1999 to discuss the INIBAP collaboration programme.

Dr.Augustin B.Molina, Regional Coordinator, ASPNET/ INIBAP, Philippines, visited on 16.02.2000 to review of INIBAP project.

Dr.Dolares A. Ramirez, Institute of Plant Breeding, University of Philippines, Philippines, visited on 16.02.2000 to review of INIBAP project.

. PERSONNEL

ıri. B. Vijayakumar joined as A.A.O. w.e.f. 06.06.1999.

r.S.Sathiamoorthy, assumed the charge as Director w.e.f. 25.08.1999.

r.M.M.Mustaffa, assumed the charge as Principal Scientist, Horticulture w.e.f. 12.01.2000.

RANSFERS

hri. N.Viswambharan, A.A.O was transferred to C.M.F.R.I., Cochin on 06.06.99 as inter-stitutional transfer.

hri. Singray Mahji, T-3 Tech. Asst. was transferred to I.I.H.R.Regional station, hubaneswar, Orissa, on 30.9.1999.

ESIGNATION

ri S.Karthikeyan,T-3 Tech. Asst. was relieved on 08.02.2000.

ESEARCH MANAGEMENT

S.Sathiamoorthy	M.Sc., (Ag.) Ph.D.	**Director** (from 25-08-1999)

IENTIFIC

M.M.Mustaffa, M.Sc.,(Ag.) Ph.D.	Principal Scientist (Hort.)
P.Sundararaju, M.Sc., Ph.D.	Senior Scientist (Nema.)
S.Shivashankar, M.Sc., Ph.D.	Senior Scientist (Biochem.)
B.Padmanaban, M.Sc., Ph.D.	Senior Scientist (Ento.)
S.D.Pandey, M.Sc., (Hort.) Ph.D.	Senior Scientist (Hort.)
C.K.Narayana, M.Sc., (Hort) Ph.D.	Senior Scientist (Hort.)
S.Uma, M.Sc., (Hort) Ph.D.	Scientist(SS) (Hort.)
R.H.Laxman, M.Sc., (Ag.) Ph.D.	Scientist (Pl.Physiol.)
R.Selvarajan, M.Sc., (Ag.) Ph.D.	Scientist (Pl.Path.)
K.J.Jeyabhaskaran, M.Sc., (Ag.) Ph.D.	Scientist (Soil.)
V.Kumar, M.Sc., (Hort.).	Scientist (Hort) (on study leave)
R.Thangavelu, M.Sc., (Ag.).	Scientist (Pl.Path) (on study leave)
B.Shyam, M.Sc., (Ag.).	Scientist (Biotechnology)

CHNICAL

Raghuraman	Jr. Garden Supdt.

MINISTRATION

B.Vijayakumar	Assistant Administrative Officer

DIT and ACCOUNTS

C.J.Stephen	Assistant Finance and Accounts Officer

16. INFRASTRUCTURAL DEVELOPMENT

During the period under report the following constructions have been completed. Overhead tank work at NRCB farm and Foundation stone ceremony. The office cum main laboratory building foundation stone was laid by Shri. N. Athimoolam, I.A.S., Secretary Agriculture, Government of Tamil Nadu, Chennai, on 19.8.1999.

Fourth Staff Research Council meeting

The Fourth Staff Research Council meeting of NRCB was held on 15th March, 1999 under the Chainmanship of Dr. P.Sundararaju, Acting Director. All the scientists have participated in the meeting, Dr. P.Sundararaju in his inaugural address highlighted the institute research programmes and advised the scientists to prepare projects under the NATP for getting external funding. Subsequently all the scientists presented the salient research findings of their research project for the year 1998-99 and the technical programme for 1999-2000. The Staff Research Council meeting also approved new projects presented by Drs. C.K. Narayana, S.D. Pandey and R. Selvarajan before the meeting. The plenary session of fourth SRC was held under the Championship of Dr. S.P. Ghosh, Dy. Director General (Hort.), ICAR on 20th March 1999. The research programmes were modified as per the valuable suggestions given by DDG (Hort.)

NRCB Foundation Stone Ceremany

The office cum main laboratory building foundation stone was laid by ri.N.Athimoolam, IAS, Secretary, Agriculture, Government of Tamil Nadu, Chennai, on 08.1999 in the presence of Dr.P.Sundararaju, Acting Director, NRCB, and E. Sambandam, SE, PWD, Madurai.

NRCB Foundation Day

nual club day of Recreation club was celebrated at NRCB Farm, Podhavur on 21.8.1999. s. Dhanalakshmi, Station Director, AIR, Trichy was the chief guest. Dr. P. Sundararaju, ident of the club presided over the function. The Staff and members of their family gave ltural programme. The Chief guest distributed prizes to the winners of various cultural sport events.

कार्यकारी सारांश

फसलसुधार

राष्ट्रीय केला अनुसंधान केन्द्र, तिरुची में केले की देशी एवं विदेशी कुल जननद्रव्य संखया 907 है। इन में 193 प्रजातियां इस वर्ष एकत्रित की गई, जिसमें 181 प्रजातियां INIBAP से NBPGR नई दिल्ली द्वारा एवं 4 प्रजातियां पश्चिमी घाट से 7 अन्डमान निकोबार एवं 1 क्षेत्रीय प्रजाति शामिल है। 5 वर्ष के मूल्यांकन के आधार पर 18 प्रजातियां व्यवसायिक उत्पादन के लिए इंगित की गई हैं। कुछ चयनित जनन द्रव्यों के संरक्षण के लिए इन-विट्रो प्रोटोकाल का मानकी करण किया गया हैं। एबीबी जातियों के लिए भ्रूण संबर्धन तकनीकि का सफल मानकीकरण किया गया है। 14 नये प्रक्षेत्र प्रकारों का डेन्टोग्राम के माध्यम से मालीकुलर कैरेक्टेराइसेशन उनकी वंशावड़ी के अध्ययन लिए किया गया है।

सांख्यिकी आधार 545 जननद्रव्य प्रकारों के लिए विकसित किया गया है, जो कि INIBAP/NBPGR के डिस्क्रिपटर पर आधारित है। IMTP प्रकारों का फ्यूजेरियम विल्ट एवं लीफ स्पाट बीमारियों की प्रतिरोधता के लिए दो स्थानों पर मूल्यांकन किया गया है। जिसमें 6 प्रकार लीफ्स्पाट के लिए प्रतिरोधी पाये गये हैं।

मूसा जननद्रव्य सूचना पद्धति के अन्तर्गत 809 प्रकारों के लिए पास्पोर्ट आंकडा एवं 100 प्रकारों के लिए पूर्ण मूल्यांकन एवं कैरेक्टेराइसेशन आंकड़े तैयार किये जा चुके हैं।

उत्पादन एवं तुडाई - उपरांत तकनीकि

टपक सिंचाई, फरटमीगेशन एवं पौध लगाने के पद्धति का केले की पोधों की वृद्धि, उत्पादन एवं गुणवत्ता पर प्रभाव का अध्ययन पूवन एवं नेन्द्रन जातियों पर किया गया। इसमें द्विपंक्ति पद्धति एवं 80 % पानी की छातिपूर्ति 100 प्रतिशत नाइट्रोजन की संस्तुति मात्रा का पौधों की ऊंचाई पतियों की संख्या एवं फलों की संख्या पर प्रभाव कन्ट्रोल की अपेक्षा अच्छा पाया गया। द्वि पंक्ति पद्धति में सामान्य की अपेक्षा देरी से फूल आये और क्लोरोफिल की मात्रा भी पत्तियों में कम पाई गई। पोटेशीयम की मात्रा पत्तियों में पानी की मात्रा बढ़ाने से कम पाइ गई एवं सामान्य में पोटेशीयम पत्तियों में ज्यादा पाया गया। टी.एस.एस. की मात्रा भी ज्यादा आंकी गई एवं अम्लता पानी एवं नत्रजन की मात्रा बढाने से कम होती गई।

विभिन्न भूमि सुधारको में 2 किलोग्राम जिप्सम एवं 15 किलोग्राम गोबर की खाद एवं 120 % संस्तुत पोटैशीयम (360 ग्राम प्रति पौधा) का प्रयोग अच्छा पाया गया एवं पतियों में सोडियम से नुकसान नहीं हुआ। इन पोंधों की पत्तियों में पोटेशियम की मात्रा भी ज्यादा दर्ज की गई साथ ही साथ पोटेशियम/सोडियम अनुपात ज्यादा एवं सोडियम की मात्रा पत्तियों में कम रही। विनिमय कैल्सियम की मात्रा भूमि में ज्यादा पाई गई। जिप्सम, गोबर की खाद एवं 120 % पोटेशियम के प्रयोग से सी आर-के की मात्रा बढी एवं भूमि के पोटेशियम की सांद्रता और भूमि की पी. बी. क्षमता भी अधिक पायी गई जो की भूमि सुधार क्षमता के लिए अच्छा पाया गया जिसके कारण नैन्द्रन जाति का घेर भार ज्यादा पाया गया।

विभिन्न कार्बनिक खादों में, 15 किलोग्राम मुर्गी की खाद प्रति पौधा 80% संस्तुत के साथ पौधों की वृद्धि के लिए अच्छा पाया गया। इस प्रयोग में ज्यादा घेर भार के साथ भूमि में पोटेशियम एवं कैल्सियम की ज्यादा मात्रा एवं मैगनिशियम एवं सोडियम की कम मात्रा पायी गयी। इस प्रकार 15 किलोग्राम मुर्गी की खाद से 20% एन.पी.के. की मात्रा की प्रति पूर्ति की जा सकती है।

नेन्द्रन जाति से विभिन्न खाने वाले तेल में चिप्स तैयार किए गये जिसमें नारियल का तेल चिप्स की मात्रा, भ्रंडारण क्षमता एवं गुणवत्ता आधार पर उत्तम पाया गया। सूरजमुखी का तेल चिप्स के लिए अच्छा नही पाया गया, जिसमें भंडारण के समय चिप्स में कडुआहट पायी गयी। पूवन जाति से जैम तैयार करने के लिए 40% केले का गूदा, 70% चीनी एवं 0.6% अम्ल एवं 0.25% पेकिटन का अनुपात उत्तम रहा। करपूरवलि एवं नेपूवन जाति से जैम तैयार के लिए पेक्टिन की मात्रा आवश्यक नहीं है। करपूरवली, पच्चलाडन एवं पूवन जाति का मिश्रित गूदा, पेक्टिन, अम्ल एवं पोटेशियम मेटाबाई सलफाइट का प्रयोग करके स्वादिष्ट, अच्छी भ्रंडारण क्षमता एवं गुणवत्ता वाला केला फ्रूट बार तैयार किया गया। मोंन्दन केला पाऊडर एवं चावल आटा को मिलकर अच्छी भंडारण क्षमता एवं स्वाद वाला पापड़ बनाया गया। 500 पीपीएम इथरेल का प्रयोग 52 ± 1°C पर रस्थाली पचानाडन जाति के फलों को पकाने के लिए अच्छा पाया गया साथ ही साथ फलों की गुणवत्ता एवं रंग में भी सुधार हुआ।

फसल सुरक्षा

केला तना हेदक एवं कंद विविल का करूर एवं कोयम्बतूर जिले में केले की फसल पर अधिक प्रभाव देखा गया। जिन 309 प्रकारों का मूल्यांकन तना छेदक के लिए किया गया उनकें ए.ए.बी. एवं बीबी समूह के 66 प्रकार बना छेदक कीट द्वारा ज्यादा प्रभावित रहे। तना छेदक का सबसे ज्यादा प्रभाव नेन्द्रन जाति पर देखा गया। स्पौडोप्टेरा लीट्रा की सबसे ज्यादा मारटेलिटी एजारेक एवं निम्बीसीडीन में देखी गयी। वासालूर सेक्स फेरोमोन का मूल्यांकन एस. ली ट्रा के लिए किया गया एवं सबसे ज्यादा नर माथ 14 वे एवं 15 वे मानक सफ्ताह में पाड़े गये।

नेन्द्रन जाति में रुट लेजन सुत्रकृमि एवं रस्थाली में रूटनाट सूत्रकृमि का प्रभाव ज्यादा देखा गया। बरोइंग सूत्रकृमि का प्रभाव रस्ताली, करपूरावली एवं लाल केला पर देखा गया। कारबोफ्यूरान 50 ग्राम प्रति पौधा एकं बार पौधा लगाते समय एवं 2 बार पौधालगाने के बाद 3 महिने के अंतराल से प्रयोग करने से नेन्द्रन के घेर भार में 50% की वृद्धि पायी गई एवं पी. काफी सूत्रकृमि की संख्या की काफी कभी पायी गई। लालमिट्टी में सूत्रकृमि ज्यादा एवं सबसे कम एलूवियल मिट्टी में पाया गया।

पनामा विल्ट बिमारी पूवन जाति में पहली बार भारत में रिपोर्ट की गयी। बायोकन्ट्रोल एजेन्ट ट्राईकोडरमा, विरीडाइड एवं सूडोमोनास फ्लोरो सेस डुयल कल्चर में विलट पैथोजन कम करने में सक्षम पाये गये। ब्लैकसिगाटोका एवं सेप्टोरिया लीफस्पाट का भी प्रभाव देखा गया। टिल्ट (प्रोपीकेनरजोल) या एनाविल (होवजा केले जोल) 0.1% की दर से प्रयोग ब्लैक सिगाटोका एवं लीफ्स्पाट बिमारी को रोकने में सक्षम पाया गया। बनाना ब्रैक्ट मोजैक वाइरस (बी.बी.एम.वी.) एवं बनाना स्ट्रीक वाइरय (बी.एस.वी.) की फैलाव भारत के पूरे केला उत्पादक क्षेत्रों में देखा गया। इलेक्ट्रान सूक्ष्मदर्शी एवं सेरो लानिजकल विश्लेष्ण के द्वारा इनकी उपास्थिति को सही पाया गया। बी.बी.एम.वी. एवं बी.एस.वी से नुकसान 48-70 % प्रतिशत तक दर्ज किया गया।

पँसल दैहिकी एवं जीव रसायन

विभिन्न जनन द्रव्यों के प्रक्षेत्रमूल्यांकन में पिसांग सेरीष में पत्तियों संख्या। एवं पत्ती का क्षेत्रफल फूल निकलने के समय पच्च बोन्दा वचीसा एवं तिरुवन्तपुरम के तुलना में अधिक पाया गया। प्रथम से तृतीय हस्त की तुड़ाई फल के सख्य या भराव (फिलिंग) पर कोई प्रभाव नही डाला। (पौध दैहिकी मूल्यांकन से यह पता चला की केले में आधिक पैदावार एवं गुणवत्ता जीनोम के योगदान के कारण है।


BANANA JUICE
BANANA JAM
BANANA JAM
BANANA BABY FOOD
BANANA POWDER
BANANA DEHYDRATED
BANANA HEALTH DRINK
BANANA BISCUIT
BANANA FRUIT BAR
BANANA WINE