STATUS REPORT ON BANANA

Prepared By

K. Krishnakumary
&
T.C. Radhakrishnan

BANANA RESEARCH STATION
KANNARA : THRISSUR

INTRODUCTION

India ranks 3rd position in fruit production of the world and a large variety of fruits are grown over a total area of 2.34 million ha with the production of 23.76 million tonnes. (Chadha, K.L., 1988). Among the fruits, banana is the 2nd important fruit crop, next to mango, both in area and production. It accounts for 18.36% of the total fruit production.

Banana is essentially a tropical plant requiring a warm humid climate and the limiting factor in banana growing is the frost hazard (Singh, R., 1979).

Banana is grown in most States, excluding the northern and eastern temperate regions. Kerala, Maharashtra and Tamil Nadu together account for half the total area. Other growing States are Gujarat, Karnataka, Andhra Pradesh, Orissa, Bihar, West Bengal and Assam. In India, banana is cultivated in 332,000 ha producing 5.78 million tonnes of fruits annually. This makes India as 2nd only to Brazil in banana production world wide.

AREA AND PRODUCTION IN KERALA

In Kerala, the area under major fruit crops (mango, banana & plantain and pineapple) increased from 115.54 ('000 ha) in 1981-82 to 116.24 ('000 ha) in 1984-85 and 137.73 ('000 ha) in 1989-90. The production of major fruits is estimated at 584.35 ('000 tonnes) in 1984-85 against 735 45 ('000 tonnes) in 1989-90 (F.I.B. 1987 & 1992).

In Kerala, the major fruit crops grown are mango, banana and pineapple (Fig. 1 & 2). Other fruits include jack fruit,

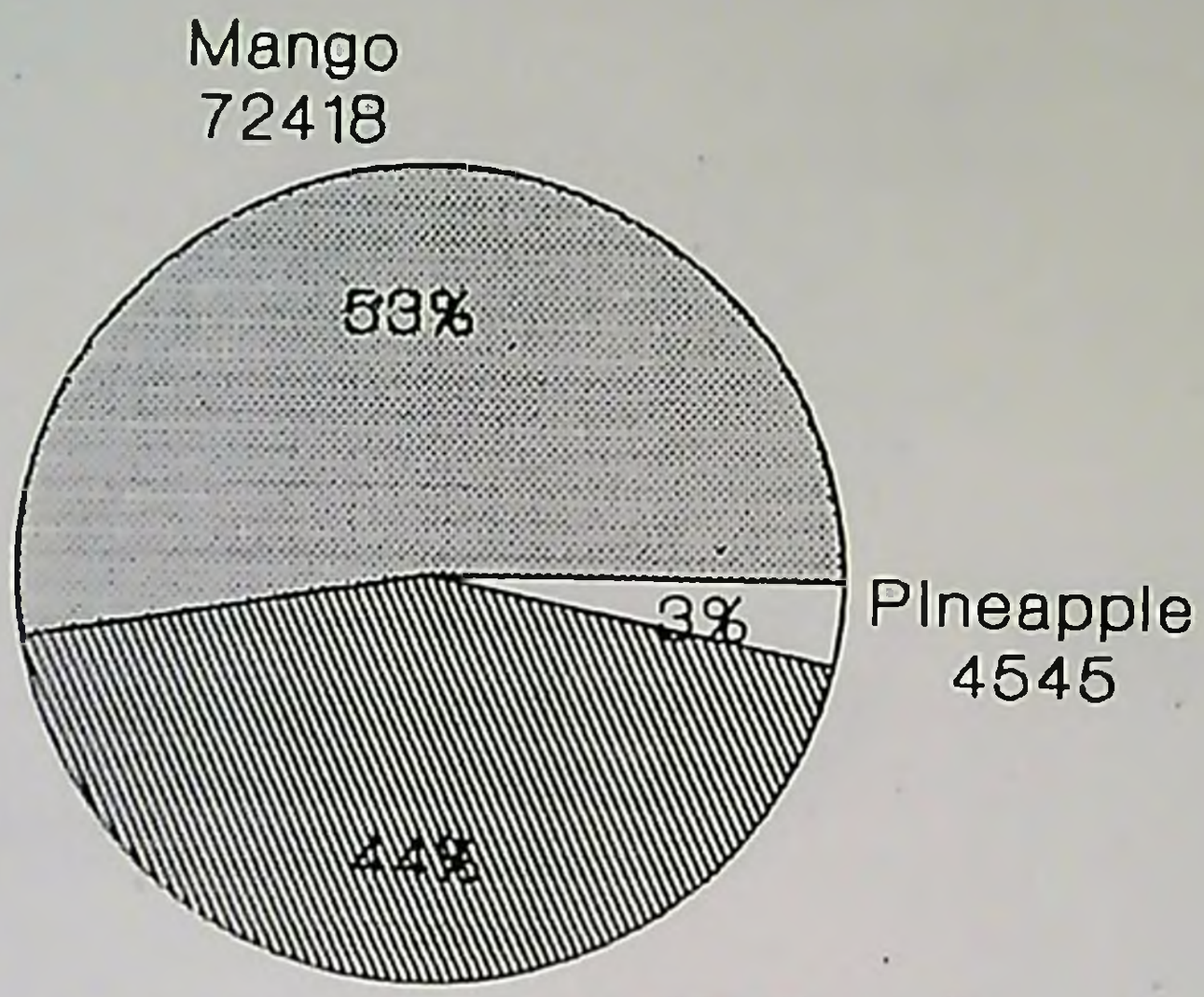

Fig.1 Area under major fruit crops in Kerala (ha) - 1989 - 90

Fig.2 Production of major fruits
in Kerala (tonnes) 1989 -90

papaya, sapota etc. Area and production under major fruit crops in the different districts of the State is given in Tables 1 & 2.

Area under banana and plantains in the State increased from 49.3 ('000 ha) in 1980–81 to 53.0 ('000 ha) in 1985–86 and 60.77 ('000 ha) in 1989–90. Production of the crop in 1980–81 was 317.4 ('000 tonnes), in 1985–86 361.1 ('000 tonnes) and 460.1 ('000 tonnes) in 1989–90. Average yield of banana in Kerala was 6438 kg/ha in 1980–81 and 6813 kg/ha in 1985–86 and 7408 kg/ha in 1989–90 (Fig. 3).

Banana is grown in all the districts of Kerala (Table 1) with maximum area in Malappuram district (6197 ha) followed by Thrissur (6190 ha). The production is maximum in the Malappuram district followed by Ernakulam (Table 2).

Of the varieties grown widely in Kerala, Nendran (AAB) ('French' plantain) is the most important commercial cultivar. It is a multipurpose variety to the Keralite. Other cultivars of importance are Palayankodan (AAB) and Poovan (AAB).

BANANA RESEARCH STATION, KANNARA, TRICHUR, KERALA

The present Banana Research Station came into existence during the year 1963 as a Centre of the Department of Agriculture at Marakkal, Kannara, Thrissur. Under the All India Coordinated Fruit Improvement Project, a Centre was sanctioned at the Kannara Station by the ICAR for carrying out research on all aspects of banana during Fourth Plan period from 1–7–1970. When the Kerala Agricultural University formulated, the Station was taken over under their control from 1–2–1972. In 1974, the venue of the Pineapple Research was shifted to Kerala Agricultural University Main Campus, Vellanikkara.

Banana Research Station is one of the few banana research centres in the country where systematic research programmes on this crop are undertaken.

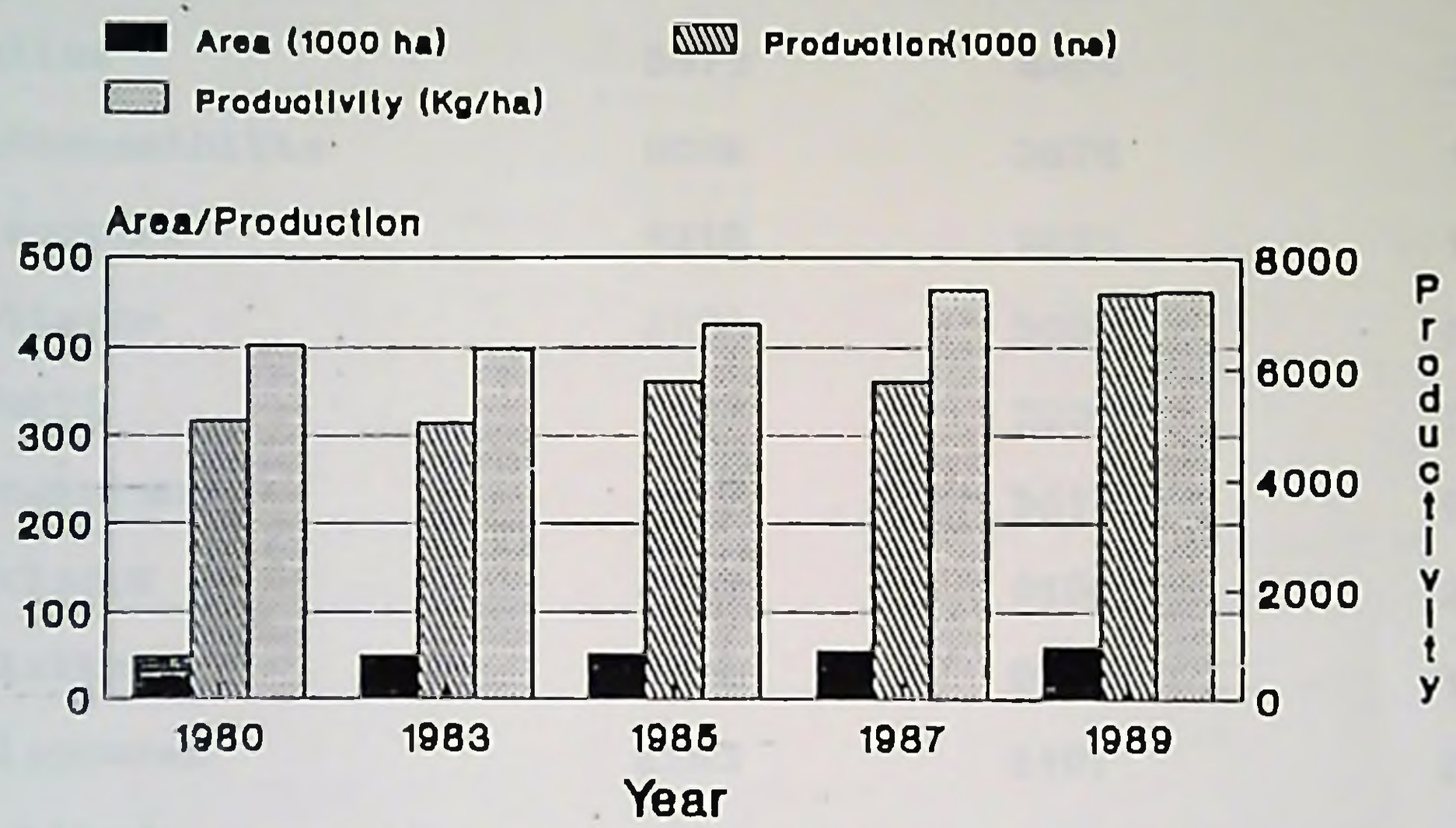

Fig. 3 Yearwise area, production and productivity of Banana and other plantains

Table 1. Area under major fruit crops in Kerala 1989–90 (ha)

District	Mango	Banana and other plantain	Pineapple
Thiruvananthapuram	5988	5508	316
Kollam	5672	4494	333
Pathanamthitta	2098	3678	143
Alappuzha	4218	2422	160
Kottayam	3126	5060	628
Idukki	1483	2206	272
Ernakulam	4413	5615	974
Thrissur	6083	6190	233
Palakkad	6796	5954	122
Malappuram	8283	6197	220
Kozhikode	9780	4105	177
Wynad	2595	2376	81
Kannur	9468	4341	804
Kasaragod	2415	2631	82
State	72418	60767	4545

Source : Farm Guide, 1992

Table 2. Production of important fruit crops in Kerala (1989–90) (tonnes)

Districts	Banana and other plantain	Pineapple	Mango
Thiruvananthapuram	35249	4006	5423
Kollam	29556	3904	17613
Pathanamthitta	44927	1573	5599
Alappuzha	14717	1651	9432
Kottayam	45048	6783	3986
Idukki	18988	3132	2448
Ernakulam	48878	107729	11550
Thrissur	34926	1916	2683
Palakkad	44705	1487	48504
Malappuram	50018	2354	35589
Kozhikode	23080	2387	31654
Wynad	22938	148	3041
Kannur	29118	7962	37776
Kasaragod	17933	1410	9636
State	460081	49432	225934

Source : Farm Guide, 1992

The main objectives of this Station are:

1. To collect, conserve and evaluate large genetic stocks of banana
2. To develop better cultivar or clones of banana through selection and hybridisation
3. To standardise the agrotechniques in banana for getting higher yield
4. To formulate intercropping and rotation schedule in banana to increase the returns from unit area
5. To find out the major pests and diseases of banana and to formulate control measures
6. To formulate small scale post harvest processing techniques in banana

Research programmes on different aspects of the crop like crop improvement, crop management and crop protection have been undertaken and the research findings have been recommended to the farmers of Kerala.

The works done for the last ten years in respect of improvement, management and protection of the crop is reviewed in the following pages.

GENETIC RESOURCES AND BANANA IMPROVEMENT

The significance of conservation, collection and maintenance of genetic resources for the genetic improvement of crop species needs no emphasis and its role with respect to banana was stressed by De Langhe (1987) and Stover & Simmonds (1987).

A rich germplasm is being maintained at this Centre which includes a total collection of 190 genotypes. Out of these, 120 genotypes have been evaluated and described. These include edible *Musa* and related species of indigenous and exotic origin. The accessions maintained comes under different genomic groups viz., AA, AAA, AAAA, BB, AB, AAB, ABB and ABBB. They are listed in Table 3. Based on the results obtained for the last few years, 18 cultivars belonging to different genomic classes viz., AB, AAA, AAB and ABB were found to be suitable for large scale cultivation in Kerala and the same recommended through the Package of Practices of KAU.

Table 3. List of described genotypes maintained in germplasm collection at Banana Research Station, Kannara

Sl.No. (1)	Name (2)	Genomic grouping (3)
1.	Musa ornata	AA
2.	Adakkakunnan	AAB
3.	Adukkan	AB
4.	Agniswar	AB
5.	Alukhel	ABB
6.	Amritsagar	AAA
7.	Anaikomban	AA
8.	Annan	-
9.	Ashybathees	ABB
10.	Bagnan	ABB
11.	Bainsa	ABB
12.	Barsai	ABB
13.	Basrai	AAA
14.	Beula	ABB
15.	Bhurkhel	-
16.	Birbutia	ABB
17.	Bluggoe	ABB
18.	Bodles Altafort	AAAA
19.	Booditha Bontha Bathoesa	-
20.	Boothibale	ABB
21.	Chakkia	ABB
22.	Charapadathi	ABB
23.	Cheenabale	AAB
24.	Chenkadali	AAA
25.	Chetty	ABB
26.	Chinali	ABB
27.	Chinia	ABB
28.	Chirapunchi	AAB
29.	CO-1	AAB
30.	Dakshinsagar	ABB

(Contd)

1	2	3
31.	Dudhsagar	ABB
32.	Dwarf Cavendish	AAA
33.	Elavazhai	ABB
34.	Ennabenian	ABB
35.	Erachivazhai	AAA
36.	Gauria	ABB
37.	Govakkai	ABB
38.	Gros Michel	AAA
39.	Highgate	AAA
40.	Hybrid Sawai	ABBB
41.	Jurmani Koondali	ABB
42.	Kadali	AA
43.	Kalibale	ABB
44.	Kalibow	AAB
45.	Kallar	AAB
46.	Kallu monthan	ABB
47.	Kanchikela	ABB
48.	Karim bontha	ABB
49.	Karimkadali	AAB
50.	Karpooravally	ABB
51.	Klueteparod	ABBB
52.	KNR 2/75	ABB
53.	Kodappanilla kunnan	AAB
54.	Kostha bontha	ABB
55.	Krishnavazhai	AAB
56.	Kullan	AAB
57.	Kunnan	AB
58.	Lacatan	AAA
59.	Ladies finger	AAB
60.	Lambi	ABB

(Contd)

1	2	3
61.	Malaikali	AAB
62.	Malai monthan	ABB
63.	Malbhog	AAB
64.	Mannan	AAB
65.	Manoranjitham	AAA
66.	Martman	AAB
67.	Mas	AAB
68.	Matti	AA
69.	Monsmarie	AAA
70.	Monthan	ABB
71.	Mottapoovan	AAB
72.	Myndoli	AAB
73.	Mysore ethan	AAB
74.	Nakitemb	AAA
75.	Namrai	AA
76.	Namkanika	AAA
77.	Nattu poovan	AB
78.	Nendrapadathi	AAB
79.	Neyvannan	ABB
80.	Njalipoovan	AB
81.	Octoman	ABB
82.	Patcha bontha bathees	ABB
83.	Pachakappa	AAA
84.	Pachanadan	AAB
85.	Padalimoongil	AAB
86.	Padathi	AAB
87.	Palayankodan	AAB
88.	Peddapacha	AAA
89.	Perumpadali	-
90.	Peyan	ABB

(Contd)

1	2	3
91.	Pey kunnan	ABB
92.	Pidimonthan	ABB
93.	Pisang lilin	AA
94.	Pisang Mas	AAA
95.	Pisang Seribu	AAB
96.	Poomkalli	-
97.	Poovan	AAB
98.	Rajavazhai	ABB
99.	Redja sirre	AAB
100.	Robusta	AAA
101.	Sambrani monthan	ABB
102.	Sannachenkadali	AA
103.	Sapumal Annamalu	AAA
104.	Sawai	ABB
105.	Sikuzani	AA
106.	Singhial	AAB
107.	Sirumalai	AAB
108.	Sugandhi	AAB
109.	Thekkanthulladan	AAB
110.	Thiruvananthapuram	ABB
111.	Tongat	AA
112.	Valiyakunnan	AB
113.	Valiyapoovan	-
114.	Vannan	AAB
115.	Velipadathi	-
116.	Vellapalayankodan	AAB
117.	Vennestu mannan	ABB
118.	Virupakshi	AAB
119.	Wather	AAA
120.	Zanzibar	AAB

Source : Achievements & Activities, KAU, 1990

They are:

Nendran group:

1) Nedunendran
2) Zanzibar

Table varieties:

1) Monsmarie
2) Robusta
2) Giant Governor
4) Dwarf Cavendish
5) Chenkadali
6) Poovan
7) Palayankodan
8) Njalipoovan
9) Amritsagar
10) Gros Michel
11) Karpooravally
12) Poomkalli

Culinary varieties:

1) Monthan
2) Batheesa
3) Kanchikela
4) Nendrapadathi

Trend analysis was conducted in 87 distinct banana clones belonging to various genomic groups to locate stable and adaptable clones (Annual Research Report, KAU, 1991-92). Stability of the clones was judged based on the overall performance in terms of yield attributes viz., weight of bunch, number of hands, number of fingers, duration, total soluble solids and reaction towards the yield limiting biotic stress viz., rhizome weevil (Cosmopolites sordidus), banana nematode (Radopholus similis) and sigatoka leaf spot (Mycosphaerella musicola). Stability analysis was attempted as proposed by Eberhart & Russell (1966).

Among the 14 diploid clones evaluated, 'Njalipoovan' (AB) was found most stable. Among the triploids (AAA group), 'Peddapacha' was ranked as most stable followed by Dwarf Cavendish and Monsmarie. In AAB group, Palayankodan (Syn. Mysore Poovan) and Malikali were found equally stable clones. In ABB group, Chakkia was ranked as the most stable one followed by KNR 2/75 (a breeding line). Other clones coming in different genomic groups which are found stable are listed in Table 4.

Table 4. List of stable clones and their genomic group

Group	Total number of clones evaluated for stability	Stable clones	
Diploids	14 Nos.	Njalipoovan	(AB)
		Poomkalli	(AB)
		Sikuzani	(AA)
		Tongat	(AA)
		Adukkan	(AB)
		Kadali	(AA)
		Kunnan	(AB)
Triploids:			
AAA group	18 Nos.	Peddapacha, Dwarf Cavendish, Monsmario, Pachakappa, Robusta, Highgate and Grosmichel	
AAB group	27 Nos.	Palayankodan (Syn. Mysore poovan) Malaikali, Chinali, Martaban, Krishnavazhai, Kodappanilla kunnan, Dhudsagar, Mottapoovan, Mysore ethan, Nendran and Myndoli	
ABB group	28 Nos.	Chakkia, KNR 2/75 (a breeding line), Boula, Ashybatheos, Jamani, Malai monthan and Karpooravalli	

Source: Annual Research Report, KAU, 1991-92

Critical evaluation are still in progress considering the location specific problems of the banana growers and consumer preferencesin Kerala. There is immense scope for further collection, covering the entire genetic variability on bananas and critical evaluation to identify sources of various stress genes for further utilization.

In a banana cultivar itself, lot of variability exist and after identifying superior clones, they can be popularised among farmers. Clonal variation studies were conducted with 144 Nendran and 24 Palayankodan clones collected from various banana belts of Kerala. Among the Nendran clones tried, 5 Nos. were selected as better clones. They are:

1. Clone No. 35 (Muttathukonam - Quilon)
2. " 49 (Kothala)
3. " 100 (Pandallore)
4. " 123 (Puthoor - Thrissur)
5. " 132 (Poovanchira)

All these clones were found to perform better than the local clone at the Banana Research Station, Kannara and in other centres also. Clonal variation studies conducted in Palayankodan cultivar resulted in locating 5 superior clones viz., 7 (Morayur), 11 (Udumbannur), 18 (Anchal), 19 (Vellayani) and 21 (Kalavoor) (Rajeevan, 1985).

BANANA BREEDING

Objective of breeding programme in banana is to study the possibility of recombining desirable economic traits like high yield, superior quality, earliness, dwarf stature, disease and pest tolerance by hybridization and mutation in selected cultivars. Breeding in banana is very difficult due to female sterility, parthenocarpy etc.

In a set of crosses tried at this Station, 7 hybrids were obtained. They are:

1) H_1 - Agniswar x Pisang lilin
2) H_2 - Vannan x " "
3) H_3 - Mannan x " "
4) H_4 - Harichal x " "
5) H_5 - Musa ornata x "
6) H_6 - Karpooravally x "
7) H_7 - Klustoparod x "

Pisang lilin, a diploid acuminata cultivar, was found to be the best pollen parent with respect to the compatibility status. Pollen studies revealed that pollen viability and production were more in pure Musa acuminata and Musa balbisiana groups than in groups of hybrid origin (Valsalakumari, 1984). This indicates the possibility of inclusion of the cultivars with viable pollen as male parents in hybridization programme.

The performance of the hybrids and quality attributes were compared with their parents. Among the 7 hybrids produced, H_1 and H_2 were found promising. Both these hybrids were superior to their parents in terms of bunch weight, number of hands and number of fingers (Pushkaran et al. 1989). The hybrid H_1 was found to be dwarf, shorter in duration, had less incidence of sigatoka leaf spot disease, the yield was medium and quality rated 'good'. The hybrid H_2 was an average yielder with good culinary attributes and average dessert qualities. The plants were hardy with low incidence of leaf spot disease. The ratoon crops of the hybrids were very early, a character inherited from the male parent Pisang lilin.

Recently hybridization programme was undertaken with the specific objective of producing a dwarf (resistant to wind damage) clone of Nendran with increased yield and quality.

Natural mutations are sources of variation in a crop species which may suit a particular requirement. In bananas, a lot of natural mutations have been reported by workers such as

Gross and Simmonds (1954) and Richardson (1961). Nayer (1958) observed that in the clone 'Nendran' at least 6 mutants occurs which believed true-to-type. A widely known natural mutation in banana is the change of the 'Red banana' to 'Green' (Pushkaran, 1989). This is considered as a case of chimerism by Simmonds (1959). A natural change from 'Red' to 'Green' is seen and the vice versa has not been reported at all. In all respects, the 'Green type' is similar to the 'Red type' except that the 'Green type' is devoid of the peculiar red pigmentation of the 'Red banana'. The cultivation of both 'Red banana' and 'Green' has become very popular in Kerala and the bunch fetch a premium price.

With the objective of inducing variability to economic traits such as duration, plant height, yield, quality, tolerance to pests and diseases, banana rhizomes were subjected to gamma irradiation in different doses (1, 1.5, 2 and 3 KR) at Banana Research Station, Kannara. It was found that the survival percentage decreased with increasing doses of gamma rays. The higher doses also reduced plant height, number and size of leaves in the initial stages. But towards maturity, appreciable phenotypic differences could not be noticed among the different treatments (KAU Annual Research Report).

The favourable effect of physical mutagens in enhancing seed germination was reported in many crops. Very poor seed germination is one among many problems faced by banana breeders.

To explore the possibility of enhancing seed germination and genetic variability, hybrid seeds from the cross Karpooravally and Pisang lilin were irradiated with gamma rays from 20 to 80 KR at 10 KR interval. Maximum seed germination was obtained at 40 KR and it indicated that gamma ray irradiation favoured hybrid seed germination in banana (Pushkaran, 1989).

NUTRITION

Adequate fertilization is essential for the growth and yield of banana (Simmonds, 1966). It is estimated that an average

crop of Nendran banana removes 300 kg N, 80 kg P_2O_5 and 800 kg K_2O from a hectare of land (Veeraraghavan, 1972).

In an experiment to find out organic and inorganic ratio of manure and fertilizer on growth and yield of banana results indicated that total N requirements of banana can be provided by applying 25% of total N through organic fertilizers like neem cake or farmyard manure and 75% of the total N through inorganic fertilizers. The treatments with neem cake, FYM plus green leaves and FYM alone (supplying 25% of N requirement) and inorganic N (supplying 75% of N requirement) recorded a yield increase of 26, 23and 20% respectively over treatment with inorganic N supplying 100% requirement.

The banana variety Nendran required Nitrogen during vegetative and reproductive phase. A study by Pillai et al. 1977 on the response of Nendran banana to different levels of N, P and K revealed that nutrients N & K exerted a significant positive influence on fruit number and bunch weight. There was, however, little or no response to P_2O_5. Dugain (1959) reported that the fractional application of N was more profitable than infrequent application of larger quantities. Gopimony et al. (1979) studied the effects of top dressing urea at the 5th month in 'Zanzibar' variety. They obtained a significant increase in the bunch weight and number of fingers per bunch as a result of the treatment.

An experiment conducted to find out the need of nitrogen during vegetative and reproductive phase and to standardise optimum dose and time of nitrogen application in Nendran banana revealed that there is additional benefit in yield when the total quantity of 200 g N applied in 4 + 3 splits than in 4 splits (Annual Research Report 1991-92). Kerala Agricultural University has recommended split application of total fertilizers (190 N : 115 P_2O_5 : 300 K_2O g/plant/annum (6 splits) starting from planting at monthly interval through the package of practices recommendations. Beena Natesh (1987) obtained good results with split application of recommended dose of fertilizer in irrigated Nendran banana.

Turner and Barkus (1982) observed that low K supply considerably reduced the bunch weight and the various yield components in banana. An experiment conducted to find out the need of potassium and to standardise optimum dose and time of potassium application in Nendran banana indicated that it requires 300 g potassium per plant which can be applied in two split doses during 60 days and 120 days after planting. There is no additional beneficial effect when the nutrients applied during later stage of development, ie., potassium requirement of the plant can be accomplished during vegetative phase (AICFIP Annual Research Report 1991-92).

In an experiment in rainfed 'Palayankodan' to study the effect of N, it indicated that the height and girth of the pseudostem as well as the length of the petiole increased significantly with increasing levels of N. No effect of N was observed on the number of functional leaves and leaf area (Mathew, 1980). He observed nitrogen to have a positive effect on the dry matter production in rainfed 'Palayankodan'. In another experiment on the same variety indicated that only the plant height was increased by the supply of K (Sheela 1982). The highest level of K induced early harvest of the bunch. She obtained increased yields with increasing levels of K and established the optimum level of K to be 600 g/plant for Palayankodan.

In a study to ascertain the influence of split application of the recommended dose of fertilizer (200 g N, 200 g P_2O_5 and 400 g K_2O/plant) from two to eight months of planting (2nd, 4th, 6th and 8th months) in cv. 'Palayankodan' revealed that the split 3/4, 0 1/4, 0) recorded the highest dry matter production and the yield could be improved upto 17.8% more than the control (Rajeevan, 1985).

An experiment in Banana Research Station on nutritional requirement of rainfed Palayankodan revealed that 150 g N/plant and 200 g K_2O/plant were economical in producing maximum bunch

weight. The different levels of P_2O_5 did not make any significant effect on bunch characters as well as vegetative characters (Annual Research Report, KAU).

ORCHARD MANAGEMENT

Numerous trials have shown that weed free bananas grow faster and yield more. Immediately after planting and until a mature canopy is established, grass control is the major problem. Survey conducted in banana growing areas covering three districts of Kerala indicated that the following are the major weeds in these areas:

1. Cynodon dactylon
2. Cyperus rotundus
3. Mimosa pudica
4. Centella asiatica
5. Sida sp
6. Euphorbia hirta
7. Ageratum conyzoides
8. Lipia nudiflora

Traditional weeding practice ie. weeding at the time of fertilizer application and taking irrigation channels was found to be the most economical, eventhough frequent weeding gave higher bunch weight. Weeding especially in the initial stage is necessary for proper growth and development of banana.

The results of an experiment to standardise a suitable weed control method in banana showed that cowpea sowing (double crop) gave maximum returns by smothering weed growth. In addition to the lesser cost involved, the benefit of addition of organic manure and fixing atmospheric nitrogen in the soil are the advantages of cowpea. Among the chemicals tried, spraying of glyphosate (2 kg ai/ha) followed by grammaxone (1.8 litres/ha) were found to give best returns.

Desuckering is an important operation influencing the yield in banana. A study by Nambiar et al. 1979 showed that it is not advisable to retain the suckers in Robusta banana before flowering. Retention of one or two suckers after flowering, however, does not affect the yield of the mother plant.

Homesteads with a combination of crops around the house is a peculiar system of farming in Kerala and banana is grown along coconut for household purposes. Sixteen popular/commercial banana cultivars belonging to the different genomic groups were evaluated in the coconut garden at Banana Research Station, Kannara. Results show that Poovan, Chenkadali, Karpooravally, Palayankodan and Njalipoovan can be recommended for commercial cultivation in coconut garden (Pushkaran et al, 1989).

Intercropping banana with seasonal/annual crops is a common practice in Kerala. Results of an experiment conducted to find out the most economic cropping system for banana cv. Nendran revealed that maximum benefit cost ratio was for banana and tapioca combination (1.9) followed by banana and elephant foot yam (1.62). This combination will be helpful for the farmers to increase the income from unit area (Suma et al, 1990).

Continuous cultivation of banana for more than three years was not found advantageous. In an experiment to find out the best crop rotation for economic yield of banana, Nendran banana was rotated with tuber crops, vegetables, paddy and pulses in a three year rotation with different crop combinations. Among the different crop rotations tried, banana-paddy-cowpea-elephant foot yam system was found to be the best with respect to yield of banana after the rotation and benefit cost ratio of the system (2.33) (AICFIP Annual Research Report, 1992).

In a study "Ratooning of banana cultivar Palayankodan (AAB) and follower sequence", results of the plant crop and first ratoon crop revealed that the followers can be retained at any stage of development in plant crop ie. before flowering, around flowering or after harvest of plant crop. The yield and duration of first ratoon crop was not affected by the time of retention of followers. The optimum nutrient requirement of first ratoon crop was found to be 100% fertilizers as per plant crop (100 g N, 200 g P_2O_5 and 400 g K_2O per plant per annum), which effected a benefit cost ratio of Rs.2.55 (KAU Annual Research Report, 1992).

Yield of the first ratoon crop was reduced by 23% than plant crop yield. One of the reasons for the reduction of yield in ratoon crop could probably be related with low light intensities received by growing followers during early vegetative phase caused by overlapped canopy of plant crop. Simmonds (1959) and Wardlaw (1972) had reported that ratoon crop required wider spacing than plant crop and optimum pruning of suckers, facilitating maximum possible light conditions for achieving yields better than plant crop yield.

Results of the first ratoon crop in a study "Ratooning of banana variety Nendran" revealed that the ratoon plants required a wider spacing of 2 x 3 m for obtaining optimum yield per hectare. The depth of planting of plant crop optimum for ratoon crop was 50 cm and medium sized suckers were better in giving yield than large sized suckers. The cost of cultivation of ratoon crop was comparatively lesser than plant crop and cultivating an intercrop of amaranthus in ratoon crop under wider spacing of 2 x 3 m or 2 x 4 m gave a B/C ratio higher than 2.

By comparing the growth and yield of plant crop and first ratoon, it was found that the ratoon crop had a tendency to grow taller and stouter than the plant crop with a reduction in leaf number and leaf area. Of the 40 varieties tried, varieties viz., Pachachingan, Nemarai, Pisang lilin, Sirumalai, Virupakshi, Palayankodan, Vannan, Mannan, Padalimoongil and Nendrakunnan were found to be suitable for ratooning (Geetha et al, 1986).

SPACING

Spacing is determined by soil fertility, the more fertile the soil the larger the plant, including foliage. This necessitates lower populations, but higher populations where individual plants are smaller. The leaf area index (LAI) is a useful guide in canopy management (Stover, 1984).

The spacing and population density experiments gave the recommendations for the popular varieties (KAU, 1989) in Table 5.

Table 5. Spacing of the popular varieties

Variety	Spacing (m)	No. of suckers/ha
Nendran	2 x 2	2500
Poovan	2.13 x 2.13	2150
Chenkadali	"	2150
Palayankodan	"	2150
Monthan	"	2150
Grosmichel	2.4 x 2.4	1730
Robusta, Monsmarie & Dwarf Cavendish	2.4 x 1.8	2310

Recently high density planting has gained considerable importance. A trial to study the feasibility of growing Nendran with a lower spacing indicated that it can be grown successfully with a closer spacing of 1.2 x 1.2 x 2 m for getting maximum net returns from a unit area. But it was reported that close planting favour the build up of inoculum causing leaf spot (Anon, 1977). Similar result was noticed in the population density experiment also. A spacing accommodating highest number of plants per unit area showed highest incidence of sigatoka leaf spot and the incidence was minimum in the planting system with wider spacing (Annual Research Report, 1991-92).

In Robusta, single hedge method of planting with a plant population of 5000 suckers/ha raised at a spacing of 2 m between rows and 1 m between plants was found to give more yield than the recommended spacing of 2.4 m x 1.8 m (Rajamony, 1990).

Population density trial revealed that in Palayankodan the optimum plant population density is 2500 plants/ha in square or rectangular method and in Poovan 2500 plants/ha under rectangular method of planting was found economical.

Crop geometry studies in various crops are being attempted as a method of increasing the productivity of one or a group of crops. A method of planting called paired row planting give more continuous space for the intercrops with less shade effect.

Cultural operations for the intercrops could be done more effectively. Yield of banana was no way affected by the paired row planting of banana (Pushkaran et al. 1989). A study revealed that paired row planting of Nendran banana at a spacing of 3x1x2 m with Vellari as intercrop gave the maximum benefit cost ratio of 3.74.

Recently hexagonal method of planting was found good since it makes more efficient use of the area to be planted (Stover & Simmonds, 1987).

WATER REQUIREMENTS

Aubert (1968) has indicated the large amount of water required by bananas. The banana plant is very sensitive to water deficiency. This is first reflected in a reduction in the length of the fingers and a reduced greenness of the foliage. When the deficiency becomes severe, older leaves fall prematurely and the pseudostem tissue collapses at a point about midway between the ground and lowest leaves and the plant falls over or 'doubles' (Simmonds, 1987).

In an experiment to study the effect of various irrigation treatments on the yield and yield attributes of banana cv. Nendran indicated that irrigation at 20 CPE recorded the highest bunch weight. Reduction in yield and yield parameters were recorded when irrigation was given at 60, 80 and 100 CPE.

At the same time, requirement of drainage is very important. Saturated soil and high water-tables have been found to reduce amount of roots, root growth and yield (Stover, 1972, Holder & Gumbs, 1983 b). Water tables should be below 1 m and preferably 1.2 m (Stover, 1972). Particularly damaging to an established root system is a fluctuating water-table. Once a water-table rises into a root zone and remains from 24 hours or more many of the roots die and rot. Poor drainage is indicated by shallow root

systems and small plants and fruit. Standing surface water should not be present for more than 2 hours after a heavy rainfall. The water table should drop 1 m in less than 24 hours (Stover & Simmonds, 1987).

INSECT PESTS

Banana, Musa sp. harbour more than 180 insect pests (Simmonds, 1959). Among these, 44 pests have been reported from India (Nair, M.R.G.K., 1986). Field survey conducted to identify the pests attacking the banana crop in different banana growing tracts of the State indicated the incidence of the following pests:

1. Banana rhizome weevil - Cosmopolites sordidus
2. Banana aphid - Pentalonia nigronervosa
3. Banana pseudostem borer - Odoiporus longicollis
4. Spittle bug - Phymatostetha deschampes
5. Lacewing bug - Stephanitis typicus
6. Leaf thrips - Helionothrips kadaliphillus

Among the various pests attacking the crop, rhizome weevil is the most serious one. Nair, 1970 reported that it is possible to reduce the incidence through planting of pest free suckers and by spraying BHC 0.1%. A detailed investigation carried out at the Station to find out the best insecticide to treat the suckers to reduce the incidence of rhizome weevil revealed that dipping of pared suckers in Phosphamidon (0.5%) for 30 minutes reduced the intensity of rhizome damage significantly and thereby increased the yield in terms of bunch weight. Chemicals proved effective in controlling this weevil is given in Table 6.

For controlling the same pest, soil applications of Carbofuran or Phorate at the rate of 20 g and 25 g at planting and 3 months after planting respectively will reduce the rhizome weevil infestation.

In 1981-82, among the varieties screened for the attack by rhizome weevil, two varieties Chenkadali and Poomkalli were found

Table 6. Chemical control of rhizome weevil in banana variety Nendran

Chemical	Bunch weight (kg)	Yield/ha (tonnes)	Percent rhizome damage
Phosphamidon 0.5%	9.54	23.85	7.00
Monocrotophos 0.5%	9.25	23.13	7.95
Control (No chemical)	6.89	13.23	11.72

least affected by the rhizome weevil (no attack) whereas Nendran was found highly susceptible to the pest (13%).

A screening trial in 1982-83, showed that varieties Matti and Mottapoovan were highly susceptible to weevil attack whereas Sannachenkadali, Sugandi and Chakkarapoovan were least susceptible.

In 1985-86, the existing germplasm was screened for rhizome weevil attack and the reaction of varieties to rhizome weevil attack is furnished in the Table 7. During 1987-88, 38 varieties in the germplasm were screened for the weevil and reaction of varieties to its attack is also included in the Table 7.

Stability analysis conducted on 87 distinct banana clones showed that Palayankodan (AAB group) was found resistant to the biotic stress caused by the rhizome weevil. Also Kosthabontha (ABB group) was found free from the damage due to rhizome weevil (Annual Research Report, 91-92).

The varieties thus identified as resistant under field condition were popularised for growing in areas where the incidence of rhizome weevil is more.

In an experiment to study the life cycle of aphid and to study the relative intensity of aphid population, it was observed that aphid population was low from March to July and thereafter it increased and reached maximum in October to December. This information will help the farmers to take precautions against the high population during the period.

Table 7. Reaction of banana varieties to rhizome weevil incidence

Percent rhizome damage	Varieties
1–5% damage (light damage)	Vennettu mannan, Ambalakadali, Poovan, Sâwai, Chetti, Sikuzani, Pisang Mas, Chakkarakadali, Namrai, Kadali, Valiyakunnan, Barsai, Malakali, Pisang Seribu, Charapadathi, Kalibale, Kallumonthan, Ennabanian, Neyvannan, Tongat, Nondrapadathi, Virupakshi, Sirumalai, Highgate, Harichal, Manoranjitham, Binkhel, Lacatan.
6–10% damage (Moderate damage)	Erachivazhai, Alukhel, Kluoteparod, Pisang raja, Pisang lilin, Suvandal, Amritsagar, Chinia, Koombillakannan, Mottapoovan, Peykunnan, Sannachenkadali, Kanchikela, Matti, Gros Michel, Monthan, Kosthabontha, Chakkia, Monsmari, Padalimoongil.
11–15% damage (heavy damage)	Chinali, Dwarf Cavendish, Karim bontha, Bluggoe, Wather, Anaikomban, Agniswar, Jumani kunthali, Chenkadali, HybridSâwai, Malaimonthan, Adakkakunnan, Karimkadali, Vannan, Dudhsagar, Martman.
16–20% damage (sovere damage)	Peyan, Krishnavazhai, Adukkan, Sambranimonthan, Robusta, Giant governor, Palayankodan, Kullan, Basrai, Karpooravally, Thiruvananthapuram.

A new record on the occurrence of a pest Prodromus simplatus Distant (Heteroptera-miridae) on banana (Musa sp) in India was made from this Station (KAU Annual Research Report, 1990-91). The pest is found feeding exclusively on banana leaves. The adult and nymphs suck sap from the under surface of the leaves. The population appears high during the period of August-September.

NEMATODES

Among the several factors responsible for the low productivity in Kerala, nematodes play an important role. Like any pathogen and pest, nematode parasitism causes serious root damage in banana. Major nematodes associated with banana in different districts of Kerala are given below:

1. Burrowing nematode - Radopholus similis
2. Cyst nematode - Heterodera spp.
3. Spiral nematode - Helicotylenchus multicinctus
4. Root lesion nematode - Pratylenchus coffeae
5. Root knot nematode - Meloidogyne sp.
6. Reniform nematode - Rotylenchulus reniformis

The occurrence of Heterodera infection in banana in Kerala was reported by Venkitesan and Charles, 1985. Pathogenicity of the cyst nematode on banana cv. Nendran carried out (Charles, 1989) revealed that the nematode can affect crop growth and yield at lowest initial inoculum of 100 cysts per plant. However, the threshold level of initial inoculum of 800 to 1000 cysts per plant, the growth, yield and quality of fruits were considerably reduced. The nematode infection was observed to affect quality of fruits by increasing acidity and reducing total sugars. A significant negative correlation was found to exist with plant growth parameters, bunch characteristics and root weight with the initial inoculum levels of cyst nematode population (Charles, 1989).

Complete eradication of nematodes is not possible. Only control practices have to be adopted for bringing down the nematode population below the threshold level of economic loss. The threshold level of nematodes is reported to be 100 numbers or more in 1 g root. Yield reduction can go up even to 50% by the nematode attack (Venkitesan, 1984).

The burrowing nematode (Radopholus similis) is becoming a serious threat to banana cultivation in Kerala (Nair et al. 1966 and Koshy et al, 1978). In an experiment to find out economic control measures, carbofuran or phorate can be applied to check infection of both burrowing nematode and weevil attack (Charles et al, 1986). Application of Carbofuran @ 20 g/plant at planting and the same dose 65 and 175 days after planting in the leaf axils was found effective as an integrated control measure against rhizome weevil, banana aphids and nematode (KAU, 1989).

The growing of plants as intercrops which reduce plant parasitic nematodes population in soil has been suggested as a means of control by Oostenbrink (1961) and Good (1968). Among the intercrops tried, Sunnhemp was found to be the best antagonistic intercrop in banana variety Robusta followed by sesamum and marigold in controlling the nematodes (Rajamony, 1990). A study by Charles et al (1985) on the comparative efficacy of antagonistic intercrops with Carbofuran in control of burrowing nematode R. similis in banana variety Nendran revealed that the application of Carbofuran was more effective than raising intercrops.

The most economically viable and environmentally safe method of nematode management is the use of resistant varieties. Trend analysis conducted showed that among AAB clones 'Thiruvananthapuram', 'Mysore ethan' and 'Padalimoongil' and among ABB clones 'Malaimonthan', 'Peykunnan' and 'Jamani' were found with moderate level of multiple resistance under field conditions uniformly against rhizome weevil, banana nematode and sigatoka leaf spot (KAU Annual Research Report, 1991-92).

Table 8. Degree of resistance to nematodes among the banana varieties maintained in germplasm collection screened under field condition

Year of study	Nematode	Resistant (no nematode)	Moderately resistant (1-10 nematode/10 g root)
1981	Burrowing nematode *R. similis*	Martaman, Pisang Seribu, Poomkalli, Kadali, Kunnan.	Karimkadali, Mottapoovan, Nallachakkarakeli, Gauria, Namarai, Chakkarakadali, Padalimoongil, Sikuzani & Highgate
1982	"	—	Harichal, Bodles altafort, Nendrakunnan, Poochakunnan, Adakkakunnan.
1985-86	*Rotylenchulus reniformis*	Pisang raja, Monthan, Sannachenkadali, Karpooravally, Jurmani kunthali, Matti, Chetti, Mannan, Kunnan, Kanchikela, Beula, Adukkan, Ambalakadali, Bodles altafort, Sikuzani, Namarai.	Adakkakunnan, Mottapoovan, Kullan, Chinali, Sawai, Peykunnan, Wather, Pisang lilin, Ashybatheea, Kadali, Chakkarakadali, Pisang Mas, Anakomban, Giant governor, Peyan, Sambrani monthan
1986-87	*Rotylenchulus reniformis*	Chingan, Monamari, Chakkia, Sambrani monthan, Padalimoongil, Mas, Nendrakunnan, Pisang Seribu, Klue teparod, Hybrid Sawai, Malakali	Ambalakadali, Harichal, Manoranjitham, Neyvannan, Kallumonthan
1987-88	*Meloidogyne* sp	Pisang lilin, Sikuzani, Namarai, Kadali, Sannachenkadali, Tongat, Adukkan, Kunnan, Virupakshi, CO-1, Namkanika, Nakitomb, Mannan, Poomkalli, Mas, Pachanadan, Charapadathi, Nendrapadathi, Peykunnan, Chetti, Peyan.	—
1988-89	"	Alukhel, Ennabanian, Tongat, Malakali, Lacatan, Karimkadali, Kostha bontha, Adakkakunnan, Valiyakunnan, Annan, Redjasirra, Malbhog, Govakkai, Burkhel, Kalibow, Perumpadali, Sapumal Annamalu	—

In an experiment of field screening of banana germplasm against nematode the results are presented in the Table 8.

During 1990–91, 15 varieties were screened against R.similis stock. Out of this, 7 varieties were found resistant and 8 varieties were found susceptible. They are listed in Table 9.

ble 9. Categorization of banana varieties to the incidence of R. similis

	Varieties	Final nematode population (100 g soil) range
sistant	Mottapoovan Pisang Seribu Monthan Sannachenkadali Matti Pisang Mas Erachivazhai	1700–6200
sceptible	Bodles altafort Amritsagar Poovan Highgate Karimkadali Kanchikela Njalipoovan H_1	12000–631000

SEASES

The major diseases in Kerala and their causal organisms listed below:

Leaf spots:

a) Sigatoka leaf spot – Cercospora musae
b) Cordana leaf spot – Cordana musae
c) Freckle leaf spot – Macrophoma musae
d) Black spot disease – Deightoniella torulosum

Panama wilt – Fusarium oxysporum
Rhizome rot – Erwinia sp.

4) Bunchy top - Virus Vector - Pentalonia nigronervosa
5) Infectious chlorosis - Virus Vector - Aphis gossypi
6) Kokkan disease - Unknown etiology

Leaf Spot Disease

In Kerala, sigatoka leaf spot caused by Cercospora musae is a serious problem especially during south west monsoon periods. If the intensity of leaf spot disease is more than 50%, yield reduction to the extent of 25% was observed. The results of roving survey conducted in different years in different districts in Nendran banana are given in the Table 10.

Chemicals recommended presently for the control of sigatoka leaf spot are spraying of 1% Bordeaux mixture or Captafol 0.3% or Power oil (mineral oil) 1% emulsion (KAU, 1989). In addition to that several other chemicals were tried in an experiment to control the disease. Results of the study revealed that Bavistin 0.1% and Calixin (0.05%) can reduce the intensity of the disease.

An investigation was undertaken to screen the banana germplasm available at Banana Research Station, Kannara against sigatoka leaf spot to locate resistant/tolerant varieties for popularisation among farmers and also to find out the resistance source which can be used in resistance breeding programme against the disease. Varieties viz., Pisang lilin, Sanna chenkadali, Manjoranjitham and Thiruvananthapuram were found tolerant/resistant (< 10%) to the diseases. Reaction of other varieties to the disease are furnished in the Table 11 (Estelitta et al, 1990).

Kokkan Disease

The 'kokkan' disease, the etiology of which is still not clearly established, was found to be a fast spreading menace to the banana crop in the State. It was considered to be one of the very minor disease which was reported by Samraj et al (1966). But in recent years, this melady has become a serious problem and is fast spreading.

Table 10. Details of survey work conducted in districts of Kerala (var. Nendran)

Districts	Years	Leaf spot disease (Percentage infection)	Kokkan disease (Percentage infection)	Bunchy top (Percentage infection)	Infectious chlorosis (Percentage)	Rhizome rot (Percentage)
Thrissur	1987-88	70-100	15.73	1.60	-	-
Palakkad		60-80	13.46	3.33	-	-
Thiruvananthapuram		60-90	14.87	3.08	-	-
Ernakulam	1988-89	15-50	25.00	8.00	-	-
Thrissur	1990	10-65	3-4.75	2 - 3.10	-	3.80
Palakkad		5-30	12.10	2 - 3.80	< 2	2.10
Ernakulam		10-50	7-36	3 - 6.20	-	8.20
Thrissur	1991	7-58	13.80	3 - 4.20	1.8	5.20
Kottayam		5-60	27.20	1.20 - 3.80	-	4.80

Table 11. Banana germplasm classified according to the reaction type of sigatoka leaf spot

Genomic group	Immune	Resistant <10%	Moderately resistant 10-25%	Susceptible 25-50%	Moderately susceptible 50-75%	Highly susceptible >75%
AA	-	Musa ornata Pisang lilin Sikuzani	Sanna chenkadali, Tongat, Pisang Seribu	-	Namarai, Matti, Kadali, Anaikomban	Erachi-vazhai
AAA	-	Rajavazhai Manoranjitham	Pachakappa Chenkadali	Sapumal anamalu	Highgate, Basrai, Nather, Lacatan, Gros Michel	Robusta Monsmari, Poddapacha, Amritsagar Dwarf cavendish Karimkadali
AB	-	-	Njalipoovan, Adukkan, Valiakunnan	Padalimoongil, Krishnavazhai, Vannan	Virupakshi, Sirumalai, Agniswar	-
AAB	-	Namkanika, Dudhsagar, Vellapalayankodan, Thiruvananthapuram, Poomkalli, Adakkakunnan	Nakitemb, Annan, Thekkanthulladan, Valiyapoovan, Perumpadali, Mysore ethan, Sugandhi, Mottapoovan, Palayankodan, Chinali, Malakali, Nattupoovan, Malbhog	Suwandal, Ladiesfinger, Redjasirre, Pachanadan, Mannan, Kodappanillakunnan, Mas, Dakshinsagar, Chinia, Rasthali, Martaman, Nendrapadathy, Zanzibar	Charapadathy, Nendran, CO-1	-
BB	-	Kalibow, Kosathabontha, Jurmani kunthali, Boothibale, Burkel	Octoman, Birbutia, Myndoli, Kanchikela, Chakkia, Gauria, Bluggoe, Malaimonthan, Monthan, Sambranimonthan, Ashybathees, Chetti, KNR 2/75, Karpooravally, Peyan, Peykunnan, Venneettumanna, Chirapunchi.	Bagnan, Singhial, Govakkai, Pidimonthan, Lambi, Kallar, Pisang Mas, Beula, Bainsa, Karimbontha, Boooditha bontha bathees, Alukhel, Neyvannan, Cheenabale, Barsai.	Kalibale, Volipadathi, Pacha bontha bathees, Kallumonthan, Kullan, Ennabenian	Padathi
AAAA	-	-	Bodles Altafort	-	-	-
ABBB	-	-	-	Klue teparod	Hybrid Sawai	-
BB	-	-	Sawai Elavazhai	-	-	-

Symptomatological studies on the disease had revealed that the disease could be identified even in the early stages of growth (2–3 month) by the presence of reddish streaks which initiates from the base and develop upwards. It was found to be transmitted through suckers from one generation to another. Other symptoms include unusual separation of leaf sheath, necrotic streaks on pseudostem, leaf sheath, midrib of leaves and in some cases travellers palm appearance of the diseased plant (KAU, 1989).

Anatomical studies of kokkan affected and healthy samples of Nendran did not reveal much of difference between the two samples. In the flower primordia, anatomical changes were found only in the ovary, the size of which was found to be considerably reduced in kokkan affected plants. The presence of starch granules in diseased primordia was another important observation (Annual Research Report 1991–92). Fluorescent microscopic studies indicated the presence of more number of mechanical tissues ie. xylem and fibres (sclerides) in kokkan affected plants.

Spraying of growth regulators like NAA and 2,4–D were found to be effective in increasing the bunch weight of kokkan affected Nendran banana. Also Bavistin 0.2% treated plants produced maximum bunch weight. But net treatments were found to reverse or inhibit the symptoms of kokkan disease.

Virus Diseases

Virus diseases of banana include bunchy top and infectious chlorosis. In India, losses of about Rs.40 million annually due to BBTV were reported as early as 1964 (Mehta et al, 1964). Control depends upon early detection and destruction of the diseased plants and to avoid taking suckers from diseased areas. Since no good control measure is available to check the disease, screening for resistant cultivars were undertaken. Karpooravally, Kanchikela, Njalipoovan and Koompillakannan are found less susceptible to

bunchy top virus (KAU, 1989). In an experiment conducted in 1982-83, out of five varieties screened against the disease Palayankodan and Chenkadali were found least susceptible. Use of benedict solution for detection of the disease can be utilised in the field of farmers. This will help easy eradication and spread of the disease (Annual Research Report, 1992).

Infectious chlorosis caused by a strain of cucumber mosaic virus (CMV) has been reported to the extent of 0-2% from Trichur district (Annual Research Report, 1991-92).

Panama Wilt

In India, the disease was first reported in West Bengal in 1911 (Chandra, 1991). According to Lakshmanan et al (1987), corm injection with 2% carbendazium or embedding into the corm 50 mg of carbendazim in a capsule at the 5th, 7th and 9th month after planting is likewise effective in controlling the disease. Panama wilt is not observed in Cavendish group whereas Rasthali (Silk, AAB) is the most susceptible (Chandra, 1991).

The disease is not a major problem in Kerala. An experiment started to find out suitable control measures for the disease indicated that the disease incidence was minimum in Bavistin injection (rhizome injection - 3 ml 2% solution) followed by Bavistin (0.2%) drenching.

Based on the results of fixed plot survey, a crop calendar was prepared for the banana farmers and are presented in Table 12.

Incidence of leafspots were found prevalent throughout the year with less intensity during December-April months and severe during May-September. Rhizome rot, bunchy top and infectious chlorosis were found more during rainy season (May-September).

Table 12. Crop calendar for diseases of banana

Diseases	Months	Per cent of infection	Recommendations
I. Leaf spot (Sigatoka)	October–November December–January February–March	5–10	
Leaf spot 1) Sigatoka 2) Cordana 3) Freckle 4) Phyllanchora	April–May June–July August–September	50–75	Removal and destruction of older affected leaves. Spray 0.1% Bavistin or BM 1%
II. Kokkan	October–November December–January February–March	15	Avoid taking suckers from diseased plants
	April–May June–July August–September	15	
III. Bunchy top	October–November December–January February–March	10	Rogueing of infected plants
	April–May June–July August–September	15	
IV. Infectious chlorosis	October–November December–January February–March	-	1) Eradication 2) Disease free suckers for planting
	April–May June–July August–September	5	
V. Rhizome rot	April–May June–July August–September	15	1) Adequate drainage 2) Drenching with Emisan–6 (0.05%) or BM (1%)

RESEARCH NEEDS

Nendran is the commercial cultivar of banana in Kerala. In the same cultivar itself, different types of clones are found cultivated and identification of superior clones result in an increased yield. Nendran is susceptible to sigatoka leaf spot and its control by chemicals is very expensive. Breeding and the genetic manipulation of tissue *in vitro* offer the only approach to resolving the major problems facing the banana grower - a yield plateau and high cost of sigatoka control. Breeding research must continue to seek a leaf spot and nematode resistant, dwarf variety with the characteristic of Nendran. Even though some varieties have been identified as resistant in field conditions, new experiments should be conducted under artificial epizootic conditions and locate the genetically resistant cultivars. Such varieties could also be used as a parent in crossing programme. Another aspect is the development of proper forecasting models so that the farmers can take precautionary steps against pest/disease incidence. Investigation on kokkan disease etiology is to be carried out. Development of a quick, reliable and sensitive diagnostic and detection technique for banana needs immediate attention for application in quarantine and eradication programme.

REFERENCES

AICFIP 1982-1992. Annual Research Reports. Banana Research Station, Kannara, Kerala Agricultural University.

Anon, 1977. Pest control in bananas. Pans manual No.1 3rd Ed. Centre for Overseas Pest Research, London. pp 22.

Anon, 1990. Area & Production of Principal Crops in India. Directorate of Economics & Statistics. Department of Agriculture & Co-operation, Government of India, New Delhi.

Aubert, B., 1968. Etude Preliminaire des phenomenes de transpiration ches le bananier. Fruits, 23 : 357-81

Beena Natesh, B. 1987. Effect of split application of fertilizers in banana cv. Nendran. M.Sc. (Hort) Thesis submitted to Kerala Agricultural University.

Chadha, K.L. 1988. Accent on high yielders (Hort'l Crops). The Hindu, Survey of Indian Agriculture. 125-127

Chandra, K.J. 1991. Status of banana diseases in India. In: Valmayor, Ramon, V., Umali, Bethilda, E., Bejosano, Cristina, P. (Editors), Banana diseases in Asia and the Pacific. Proceedings of a technical meeting on diseases affecting banana and plantain in Asia and the Pacific, Brisbane, Australia, 15-18 April 1991. Mont Pellier, France : INIBAP, 1991. pp. 38-43.

Charles, J.S.K., 1989. Bio-ecology of the cyst nematode infecting banana. Ph.D (Ag). Thesis submitted to Kerala Agricultural University.

Charles, J.S.K. and Venkitesan, T.S., 1984. New hosts of Heterodera oryzicola in Kerala, India. Indian J. Nematol. 14 : 181-182

Charles, J.S.K., Thomas, Y., Venkitesan, T.S. and Abraham, C.C., 1986. Integrated control of the rhizome weevil and burrowing nematode infesting banana variety Nendran. Pesticides. 20: 10-11

Charles, J.S.K., Venkitesan, T.S. and Thomas, Y., 1985. Comparative efficacy of antagonistic intercrops with Carbofuran in control of burrowing nematode in the banana cv. Nendran. Indian J. Nematol. 15 (2): 241-242

De Langhe, E., 1987. Towards an international strategy for genetic improvement in the Genus Musa. Proceedings of an international workshop held at Cairns, Australia, 13-17 October, 1986. AICAR Proceedings. 21 : pp. 187

Dugain, F., 1959. Ammonium Sulphate in the soil for growing bananas in low lying area. Fruits d' Cutre Mer. 14: 163-9 Bibl-8

Eberhart, S.A. and Russell, 1966. Stability parameters for comparing varieties. Crop Sci., 6: 36-40

Estelitta, S.; Suma, A.; Sujatha, V.S.; and Darley, J., 1991. A note on the field screening of banana germplasm against sigatoka leaf spot. Indian J. Hort. 48 (1): 29-31

F.I.B., 1987. Farm guide. Farm Information Bureau, Govt. of Kerala, India.

F.I.B., 1992. Farm guide. Farm Information Bureau, Government of Kerala, India.

Geetha, C.K.; Rajeevan, P.K.; and Rosamma, C.A. 19[illegible]. Investigations on ratooning in banana. Agric. Res. J. Kerala [illegible]

Good, J.M., 1968. Relation of the plant parasitic nematodes in soil management practices. In Tropical Nematology. Eds. G.C. Smart Jr. and V.G. Perry. Univ. Florida Press, Gainsville. p. 113-138

Gopimony, R., Marykutty, K.C. and Kannan, K., 1979. Effect of top dressing with Urea at flower initiation time in 'Zanzibar' variety of banana. Agric. Res. J. Kerala, 17 : 293-6

Gross, R.A. and Simmonds, N.W., 1954. Mutations in Cavendish banana group. Trop. Agriculture, Trin. 31 : 131-32

Holder, G.D. and Gumbs, F.A., 1983 b. Effects of waterlogging on the growth and yield of banana. Trop. Agriculture, Trin., 60: 111-16

K.A.U., 1982-1992. Annual Research Reports. Banana Research Station, Kannara, Kerala Agricultural University

K.A.U., 1989. Package of Practices - Recommendations Crops (9th Ed.). Directorate of Extension, Kerala Agricultural University, Trichur, Kerala. pp. 132-138

Koshy, P.K.; Sundara Raju and Sosamma, V.K., 1978. Occurrence and distribution of Radopholus similis in S. India. Indian J. Nematol. 8 : 49-58

Lakshmanan, P.; Selvaraj, P. and Mohan, S., 1987. Efficacy of different methods for the control of Panama disease. Tropical pest management. 33 : 373-6

Mathew, V., 1980. Nitrogen nutrition in rainfed banana cv. Palayankodan. M.Sc (Hort) Thesis submitted to the Kerala Agricultural University.

Mehta, P.R; Joshi, N.C.; Rao, M.H. and Renjhen, P.L., 1964. "Bunchy top : a serious disease in India". Sci & Cult. 30 : 259-63

Nair, M.R.G.K., 1970. Insect pests and mites of crops in India. ICAR, New Delhi. pp. 191

Nair, M.R.G.K., 1986. Insect pests and mites of crops in India. 2nd Ed. ICAR, New Delhi. pp. 370

Nair, M.R.G.K.; Das, N.M. and Menon, M.R., 1966. On the occurrence of the burrowing nematode, Radopholus similis on banana in Kerala. Indian J. Ent. 28 : 553–4

Nambiar, I.P.S.; Balakrishnan, S. and Marykutty, K.C., 1979. Influence of desuckering and retention of varying number of suckers on plant growth and yield of Robusta banana. Agric. Res. J. Kerala. 17 (2): 248–50

Nayar, T.G., 1958. Genetic variability and the scope for improvement of the banana in India. Indian J. Hort. 15: 215–19

Oostenbrink, M., 1961. Nematodes in relation to plant growth II. The influence of the crop on the nematode population. Neth. J. Agric. Sci. 9 : 5–60

Pillai, G.R.; Balakrishnan, S.; Veeraraghavan, P.G.; Santhakumary, G. and Gopalakrishnan, R., 1977. Response of Nendran banana to different levels of N, P and K. Agric. Res.J. Kerala. 15 (1): 37–40

Pushkaran, K., 1989. Extent of 'budsports' in red banana (Musa (AAA group). Banana Newsletter 12 : 15

Pushkaran, K., 1989. Gamma rays favour hybrid seed germination. Banana Newsletter 12 : 3

Pushkaran, K.; Aravindakshan, M.; Rajeevan, P.K.; Babylatha, A.K.; Varkey, P.A.; Suma, A. and Darley, J. 1989. Performance of four banana hybrids. Banana Newsletter 12 : 17

Pushkaran, K.; Nybe, E.V. and Prasannakumari Amma, S., 1989. Paired row planting of banana for better intercropping. Banana Newsletter. 12 : 23

Pushkaran, K.; Suma, A. and Babylatha, A.K., 1989. Suitable banana cultivars for intercropping in coconut gardens in Kerala. Banana Newsletter 12: 21

Rajamony, L., 1990. Achievements & activities (B.R.S & P.R.C). Kerala Agricultural University.

Rajeevan, P.K., 1985. Intraclonal variations and nutritional studies in banana cv. 'Palayankodan'. Ph.D. (Hort) Thesis submitted to Kerala Agricultural University.

Richardson, D.L., 1961. Note on the reversion of the dwarf banana 'Cocos' to 'Grosmichel'. Trop. Agriculture, Trin. : 38 : 35-37

Samraj, J.; Ramanatha Menon, M.; Christudas, S.P. and Sathyarajan, P.K. 1966. 'Kokkan' - A new disease of banana. Agric. Res. J. Kerala 4 (1): 116

Sheela, V.L., 1982. Potassium nutrition in rainfed banana Musa (AAB group) 'Palayankodan' M.Sc. (Hort). Thesis submitted to the Kerala Agricultural University.

Simmonds, N.W., 1959. Bananas. Longmans, Green & Co. Ltd., London

Simmonds, N.W., 1966. Planting and Management. Bananas. 2nd Ed. Longman, Green & Co. Ltd. London. pp. 156-204

Singh, R., 1979. Fruits. 3rd Ed. National Book Trust, India, New Delhi, pp. 50.

Stover, R.H., 1972. Banana, Plantain and Abaca Diseases. Commonw. Mycol. Instit, Kew

Stover, R.H., 1984. Canopy management in 'Valery' & 'Grand Nain' using leaf area index and photosynthetically active radiation measurements. Fruits, 39: 89-93

Stover, R.H. and Simmonds, N.W., 1987. Bananas. 3rd Ed. Longman scientific and technical, Longman House, England. pp.242

Suma, A.; Estelitta, S.; Sujatha, V.S.; Nybe, E.V.; Pushkaran, K. and Babylatha, A.K., 1990. 'Cassava' - A potential intercrop for banana'. National symposiu,. CTCRI, Sreekariyam, Thiruvananthapuram.

Turner, D.W. and Barkus, B., 1982. Yield, chemical composition, growth and maturity of Williams banana fruit in relation to supply of Potassium, Magnesium and Manganese. Sci. Hort. 17 : 239-52

Valsalakumari, P.K., 1984. Cytotaxonomical studies on banane cultivars. Ph.D (Hort.). Thesis submitted to Kerala Agril. University.

Veeraraghavan, P.G., 1972. Manurial cum liming experiment on Nendran banana. Agric. Res. J. Kerala. 10 : 116-18

Venkatesan, T.S., 1984. Nematodes. Technical Bulletin, Kerala Agricultural University. pp. 27

Venkatesan, T.S. and Charles, J.S.K., 1985. A note on the occurren of Heterodera infection in banana in Kerala infection in banana in Kerala. Proc. Nematol. Symp., Udaipur. 279.

Wardlaw, C.W., 1972. Banana diseases including plantains and abaca. Longman, London.