INVESTIGATIONS ON YELLOW LEAF DISEASE OF ARECANUT (ARECA CATECHU L.)

Final Report

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

(Indian Council of Agricultural Research)

REGIONAL STATION, KAYANGULAM, KRISHNAPURAM

PIN- 690 533, KERALA.

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INDIAN COUNCIL OF AGRICULTURAL RESEARCH

FINAL REPORT

PROJECT TITLE

INVESTIGATIONS ON YELLOW LEAF DISEASE OF ARECANUT (*ARECA CATECHU* L.)

Date of Start : **May 1998**

Date of Completion : **April 2003**

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RPF III

FINAL REPORT

1. **Institute Code Number** : **Path. XVIII (131)**
2. **ICAR Code Number** : **PI- 98/2-ICI/HZO/2710**
3. **Name and Address of Research Institute / Centre** : **Central Plantation Crops Research Institute, Regional Station, Kayangulam.**
4. **Project Title** : **Investigations on Yellow Leaf Disease of Arecanut (*Areca catechu* L)**
5. **Name and Designation of Project Leader** : **Dr. R. ChandraMohanan, Principal Scientist**
6. **Name(s) and Designation(s) of the Project Associates including Project Leader and Work Done**

Sl. No.	Name and Designation	Time spent (Man Months)	Work Done
1.	R. ChandraMohanan Principal Scientist	27	Identification of YLD free elite palms in Kerala. Disease incidence in Saigon x Mangala combinations at Palode. Conformation of disease free nature of elite palms, raising OP and selfed seedlings of elite palms and planting in YLD affected gardens. Screening of arecanut accessions. YLD management trial.
2.	N. Saraswathy Principal Scientist	14	Identification of YLD symptom free elite palms in Karnataka and conformation of disease free nature. YLD management trial. Screening of arecanut hybrids and accessions.

3.	K. S. Ananda Senior Scientist	7	Raising OP and selfed seedlings of elite palms in Karnataka and planting in YLD affected gardens. Screening of arecanut hybrids and accessions.
4	P. Rajan Senior Scientist	3	Maintenance of arecanut nursery and arecanut garden (Management trial) at Kannara.

7. Location of Research Project with complete address : **Plant pathology laboratory Central Plantation Crops Research Institute, Regional Station, Krishnapuram 690533, Kayangulam, Kerala and CPCRI Regional Station, Vittal 574 243, Karnataka.**

8. Date of Start : **May 1998**

9. Date of Termination: : **April 2003**

10. (a) Objectives (Not more than 150 words):

1. To identify yellow leaf disease free elite arecanut palms in hot spots in Kerala and Karnataka states.
2. To confirm the disease free nature of elite palms by light microscopic tests.
3. To monitor the elite palms for YLD symptom in subsequent years.
4. To find out the present status of YLD incidence in F1 generation of Saigon x Mangala (At NRC, Palode).
5. To raise OP and selfed seedlings of elite palms and to plant in YLD affected gardens for screening as well as for nucleus seed gardens.
6. To screen promising arecanut hybrids and accessions.
7. To lay out field management trials in YLD affected arecanut gardens in Kerala and Karnataka state.

(b) Practical Utility (Not more than 100 words):

Yellow leaf disease is the most serious problem of arecanut in Kerala and Karnataka states. It affects the normal growth and vigour of palms. the yield of affected palms is reduced to the extent of 50% over a period of three years. Phytoplasma is the causal organism of the disease.

Since phytoplasmal diseases are not amenable to control by conventional plant protection measures, it became imperative to took into other measures of management. It is very important to mange the disease in heavily YLD affected areas to get sustainable yield.

Breeding for disease resistance though time consuming, appears to be ultimate permanent solution to this disease. Review of work done on screening against YLD indicates that, at present, there are no hybrids or varieties which are resistant to YLD. As no positive results on disease tolerance was obtained after screening a large number of genotypes it is worthwhile to conduct an intensive survey in hot spot areas, identifying field tolerant palms and to plant their progenies in hot spots for screening against the disease as well as to establish nucleus seed gardens. YLD resistant/ tolerant palms can be used for future disease resistance breeding programmes by utilizing selected palms in the nucleus seed gardens to evolve a high yielding variety resistant/ tolerant to YLD.

A viable management strategy is the immediate requirement of arecanut growers in southern states of the country, especially Kerala and Karnataka so as to check the intensity of the disease and to get higher yield from YLD affected gardens till the diseased palms are replaced with resistant/ tolerant ones in a phased manner.

11. Technical Programme: (Indicate briefly plan of procedure, techniques, instruments and special materials, organism, special environments, etc.)

1. Survey of severely YLD affected areas (hot spots) in Kerala and Karnataka to locate YLD free elite palms in hot spots.

2. Monitoring the YLD free elite palms for symptoms of YLD and yield in subsequent years.

3. Confirming the disease free nature of field tolerant palms using light microscopic test.

4. Selfing the elite palms.

5. Collection of OP and selfed nuts, raising nursery and planting the elite seedlings in severely YLD affected gardens in hot spots for screening and raising nucleus seed gardens in future.

6. Screening of promising arecanut hybrids and accessions.

7. Laying out field management trials in Kerala and Karnataka states to find out the effect of different treatments on disease intensity and yield.

SYMPTOMS OF YELLOW LEAF DISEASE

Yellow leaf disease affected arecanut palm

Single leaf showing typical symptoms of YLD

Leaflets showing initial symptoms - Yellowing starting from tip of leaflets

Kernel discolouration

Rotting of roots

12. FINAL REPORT

Investigations on Yellow Leaf Disease of Arecanut (*Areca catechu* L.)

Yellow leaf disease (YLD) of arecanut (*Areca catechu* L.) is the most serious problem of arecanut growers in Kerala and Karnataka states. Though the disease first made its appearance as early as in 1914 in Central Kerala (Nambiar, 1949) there is no solution to tackle this malady till today. YLD is prevalent in all districts of Kerala, five districts of Karnataka and some parts of Tamil Nadu and Maharashtra causing heavy economic loss to the growers.

Phytoplasma is the causal organism of YLD and the plant hopper, *Proutista moesta* is the vector. Detailed studies were conducted on disease transmission, antibiotic therapy, vector control and screening of varieties and hybrids. Since phytoplasmal diseases are not amenable to control by conventional plant protection measures, a lasting solution to this malady is to evolve disease tolerant/resistant variety. As no positive result on disease tolerance was obtained even after screening 140 genotypes, it has been decided to identify field tolerant/resistant palms which are high yielding. This project was initiated in 1998 to evolve a population of YLD tolerant/resistant palms for establishing nucleus seed gardens, to screen varieties and hybrids and to evolve a package of practices for managing YLD affected arecanut palms for sustaining productivity.

1. Identification of YLD free elite arecanut palms

Survey was conducted to locate YLD free elite arecanut palms in hot spot areas of Ernakulam and Thrissur districts of Kerala state and Sullia taluk of Dakshina Kannada district, Karnataka. Among the gardens survey in hot spot areas during 1998, nine gardens in Ernakulam District, 18 gardens in Thrissur district and 4 gardens in Sullia taluk with more than 90% YLD palms were selected for recording observations. A total of 6393 palms in 27 gardens in Ernakulam and Thrissur districts were observed. Of these, 6320 palms

were found to be YLD affected. Among the 73 palms without any YLD symptoms, 22 palms were identified as elite palms. out of the 3790 palms observed in Sullia taluk 200 palms were free of YLD symptoms. Of these, 36 palms were marked as elite palms without YLD symptoms.

The elite palms identified in Ernakulam and Thrissur districts were further monitored for the appearance of any YLD symptoms during the peak period of symptom expression. YLD symptoms appeared on 7 palms out of the 17 palms identified as elite palms in Ernakulam district. Thus, a total of 15 palms (10 in Ernakulam and 5 in Thrissur were selected and marked.

During the survey conducted in 1999, a 'second generation' YLD free arecanut garden was located in Ernakulam district. This arecanut garden consisting of 52 palms raised from the seed nuts collected from a YLD free elite palm in the middle of all YLD affected palms at Mambra, Ernakulam district did not exhibit any YLD symptoms for the last 23 years except 3 palms showing kernel discolouration.

Seven arecanut gardens in Dakshina Kannada district were surveyed and 42 disease free elite palms were recoded during 1999.

Observations on disease incidence of Saigon x Mangala combinations (F1) at CPCRI, Research Center, Palode (Now, NRC for oil palm) were recorded. Out of the five palms of 300 Saigon x 108 Mangala combinations identified earlier three palms did not show any YLD symptoms. Among the 12 palms of 300 Saigon x 125 Mangala combinations, 5 palms were free of YLD symptoms. The symptom free palms were further monitored.

The palms identified in Ernakulam, Thrissur and Dakshina Kannada districts during 1998 and 1999 were further monitored for disease symptom expression.

Based on the observations on yield and symptom expression, a total of 75 palms were identified as YLD symptom free elite palms in Kerala and Karnataka (Table- 1).

2. Confirmation of Disease free nature of elite palms

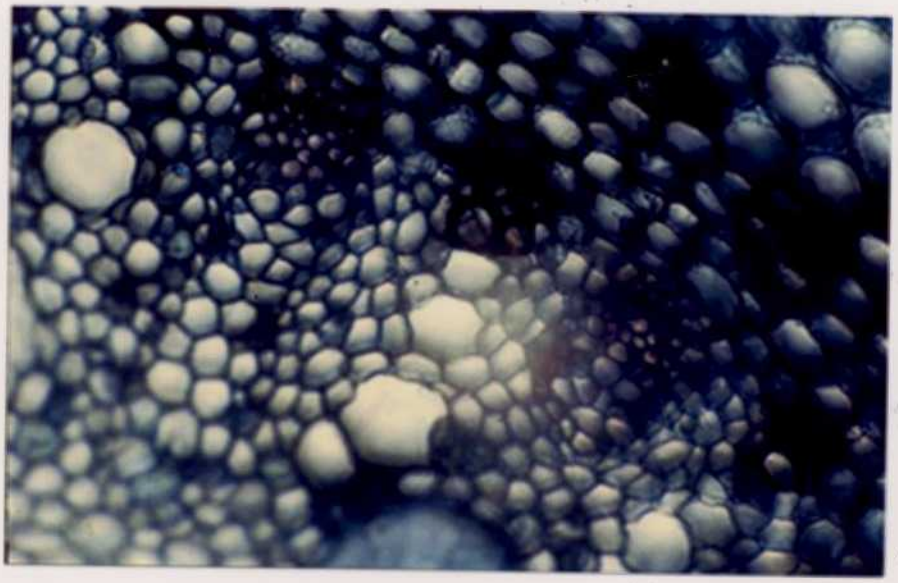
To standardize the light microscopic test for conformation of disease free nature of elite palms identified in hot spot areas, areca seed nuts of Mangala, Sumangala and Dakshina Kannada (local) varieties were collected from healthy palms at CPCRI, Regional Station, Vittal and sown in pots kept under insect proof cages.

Root samples of YLD symptom free elite palms identified in different localities of Kerala state were collected. Simultaneously root samples were collected from palms with typical YLD symptoms occurring in Ernakulam and Thrissur district as well as at Kayamkulam. Root samples of healthy areca seedlings of three different varieties raised under insect proof cages were used for comparison. All the root samples were fixed in FAA immediately after collection. Reaction to Dienes' stain in transverse section of roots of YLD symptom free palms were studied and compared with that of YLD affected palms and healthy seedlings. The phloem tissues of YLD affected palms developed a distinct blue colour while the phloem of healthy samples remained unstained.

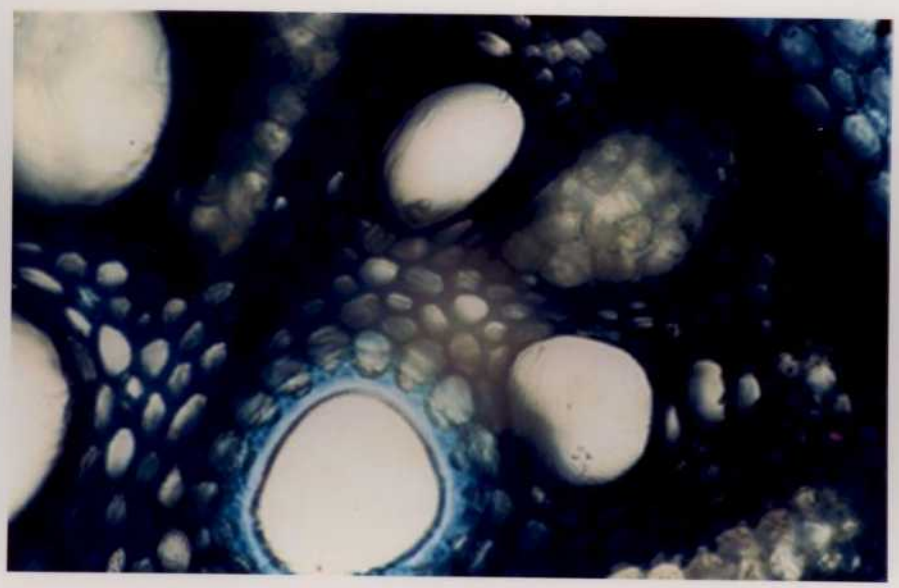
The 10 YLD symptom free elite palms in Neriamangalam area (Ernakulam district) were negative in their reaction to Dienes' stain.

Out of the 52 palms selected at Mambra, near Angamali, Ernakulam district, 33 palms were negative in reaction to Dienes' stain. Among these 33 palms, 24 palms were identified as elite palms with more than 200 nuts per palm under neglected condition of the garden.

All the 4 palms (Saigon x Mangala) at Palode were positive.



T. S. of root of YLD affected arecanut palm stained with Dienes' stain (phloem with distinct blue colour)



T. S. of root of healthy arecanut palm stained with Dienes' stain (phloem - unstained)

Table- 1. YLD Symptom free elite palms identified in Kerala and Karnataka sates

State/District	No. of symptom free palms 1998-199	Palms with symptoms after 1999	No. of elite palm (selected) without symptom
Kerala			
Ernakulam	17	7	10
Thrissur	5	-	5
Trivandrum	8	4	4
Karnataka			
Dakshina Kannada	242	186	56
Total	272	197	75

Out of the five elite palms identified in Thrissur district, only one palm was found to be negative to staining reaction. Thus, 24 palms at Mambra, 10 palms at Neriamangalam and one palm at Kannara were selected as YLD free elite palms in Kerala state.

Out of the 56 YLD symptom free elite palms identified in Dakshina Kannada district of Karnataka State, 44 palms were –Ve in reaction to Dienes' stain (Table-2). Subsequently 10 YLD symptom free palms identified in Ernakulam district developed typical symptoms of YLD. Ultimately, 69 palms were selected as YLD free elite palms (Table- 3).

3. Collection of seed nuts (OP) and raising seedlings

A total of 3387 OP seed nuts were collected from 24 elite palms and sown at CPCRI, RS. Kayamkulam. The germinated nuts were planted in secondary nursery. Out of 3217 seedlings in secondary nursery, 2661 seedlings were selected based on the criteria for selection of arecanut seedlings. These selected seedlings were planted in YLD affected arecanut gardens in hot spots (Sringeri and Sampaje) of Karnataka State. Out of these, 2048 seedlings were planted in 11 gardens in Sampaje and 613 seedlings were planted in 3 gardens in Sringeri (Table- 4).

Fifty OP seedlings of elite palms at Kannara, Thrissur district were also planted inside YLD affected gardens at Sampaje, Dakshina Kannada district.

4. Screening of selfed seedlings of YLD free elite palms identified in Dakshina Kannada and Thrissur districts

A total of 512 selfed seedlings of YLD free elite palms in Dakshina Kannada district were planted inside 7 YLD affected gardens at Sampaje. In addition, 730 selfed seedlings of elite palms in Dakshina Kannada district and 75 selfed seedlings of the elite palm at Kannara were maintained in secondary nurseries inside 8 YLD affected gardens in Dakshina Kannada

Table -2. Reaction to Dienes' Stain in transverse section of roots of selected disease free palms in hot spots

State	District	Locality	No. of palms tested	Blue staining reaction in phloem
KERALA	Ernakulam (Near Idukki)	Nellimattom	2	-Ve
		Kavalangad	3	-Ve
		Unnukallu	3	-Ve
		Neriamangalam	2	-Ve
		Mambra (Angamali)	*52	-Ve (33) +Ve (19)
	Thiruvananthapuram	CPCRI Palode	4 (Saigon x Mangala)	+Ve
	Thrissur	Kannara	1	-Ve
		Varantharappally	1	+Ve
		Alppara	2	+Ve
		Chuvannamannu	1	+Ve
KARNATAKA	Dakshina Kannada	Sullia	56	-Ve (44) +Ve (12)

* 20 year old palms raised from the nuts collected from a high yielding YLD symptom free palm

Table- 3. Disease free elite arecanut palms

District	Locality	No. of elite palms
Dakshina Kannada	Sullia	44
Ernakulam	Mambra	24
Thrissur	Kannara	1
Total		**69**

Table- 4. Screening of seedlings (O.P.) of second generation YLD free elite palms at Mambra (Ernakulam district) (Year of planting: October 2001)

Locality	Garden No.	No. of seedlings* planted
(a).Sampaje	1	147
	2	68
	3	250
	4	105
	5	364
	6	634
	7	170
	8	100
	9	58
	10	51
	11	101
Total (a)		2048
(b).Sringeri	1	409
	2	104
	3	100
Total (b)		613
Total (a) + (b)	**14**	**2661**

* Total No. of accessions (elite palms) : 24

Yellow leaf disease free elite arecanut palm

Secondary nursery of selfed seedlings of elite arecanut palm at Kannara, Thrissur

district (Table- 5). Planting of the seedlings will be undertaken as a programme under YLD ad-hoc scheme.

5. Screening of arecanut hybrids and accessions

This study was undertaken to find out the susceptibility of hybrids of released varieties and Hirehalli Dwarf variety as well as their parental tissues. The details of hybrid combinations, parental tissues and accessions are given below:

Hybrids:-

(1) Mangala x Hirehalli Dwarf

(2) H. Dwarf x Mangala

(3) Sumangala x H. Dwarf

(4) H. Dwarf x Sumangala

(5) Sreemangala x H. Dwarf

(6) H. Dwarf x Sreemangala

(7) Mohitnagar x H. Dwarf

(8) H. Dwarf x Mohitnagar

(9) Hirehalli Tall x H. Dwarf

(10) H. Dwarf x H. Tall

(11) S.K Local x H. Dwarf

(12) H. Dwarf x S.K Local

Parents:- Hirehalli Dwarf, Mangala, Sumangala, Sreemangala, Mohitnagar, Hirehalli Tall, S.K local

Accessions:- Calicut- 17, Sagar- 3, Calicut- 34

These 12 hybrid combinations, 7 parental lines and three indigenous accessions were planted inside severely YLD affected gardens at Sampaje

Table- 5. Screening of Selfed/O. P. seedlings of YLD free elite arecanut palms in D. K. district and Thrissur district. (Year of planting : 2002)

A. Dakshina Kannada district				
Accession	**Locality**	**Garden No.**	**No. of selfed seedlings planted in YLD affected garden**	**No. of selfed seedlings in nursery**
S.K. Local	Sampaje	1	60	-
		2	152	-
		3	300	-
Total		**3**	**512**	-
S.K. Local	Gunadka and Balembi areas of D. K. district	1	-	235
		2	-	160
		3	-	35
		4	-	300
Total		**4**	-	**730**
B. Thrissur district			**Open pollinated**	
T3 (Kannara)	Sampaje	1 – 4	50	75

during 1997. These plants were observed every year for YLD symptoms. All the parents of hybrids and the three accessions were found to be susceptible to YLD within 5 years of planting. Among the hybrid combinations, Mangala x H. Dwarf, H. Dwarf x Mangala, Sumangala x H. Dwarf, Mohitnagar x H. Dwarf, H. Dwarf x H. Tall and H. Dwarf x S.K Local did not exhibit any symptoms of YLD till 2002 (five years after planting). Other hybrid combinations were susceptible to YLD (Table- 6).

6. Screening of Promising Indigenous Accessions

Seedlings of 9 promising indigenous arecanut accessions (Calicut- 6, Calicut- 17, Calicut- 33, Calicut- 29, Calicut- 35, Sreevardhan- 2, VTL- 18 (a), VTL- 28 (a), Sagar and S.K local) were planted in 2 arecanut gardens with more than 80% YLD affected palms at Kannara during June, 2000. These plants were observed every year for their susceptibility to YLD. Typical symptoms of YLD were observed in all the accessions during the year 2002. The number of seedlings with YLD symptoms in each accession was recorded (Table- 7). The disease index of each seedling was also recorded.

7. YLD Management Trials

YLD management trial was laid out in five arecanut gardens in Karnataka and one garden in Kerala during October-November, 1999. Out of the five management trials in Karnataka, three trials were laid out in Sringeri and two trials in Sullia. The management trial in Kerala was laid out at CPCRI, Research Centre, Kannara, Thrissur district. The treatments of the management trial laid out in six gardens were:

1. NPK (100:40:140g/palm/year in two splits)
2. NPK + P (1kg SSP in two splits)
3. NPK + Mg + Zn + B
4. NPK + Carbofuran
5. NPK + Copper oxychloride

Table- 6. Screening of arecanut hybrids and accessions at Sampaje (Year of planting : 1997; No. of plants in each category: 6)

Sl. No.	Hybrids	No. of plants with YLD	Parents	No. of plants with YLD
1	Mangala x H. Dwarf	-	H. Dwarf	1
2	H. Dwarf x Mangala	-	Mangala	2
3	Sumangala x H. Dwarf	-	Sumangala	2
4	H. Dwarf x Sumangala	3	Sreemangala	4
5	Sreemangala x H. Dwarf	2	Mohitnagar	2
6	H. Dwarf x Sreemangala	1	H. Tall	2
7	Mohitnagar x H. Dwarf	-	S. K. Local	1
8	H. Dwarf x Mohitnagar	2	*Accessions*	
9	H. Tall x H. Dwarf	1	Calicut-17	4
10	H. Dwarf x H. Tall	-	Sagar-3	1
11	S. K. Local x H. Dwarf	3	Calicut-34	1
12	H. Dwarf x S. K. Local	-		

Table 7. Screening of arecanut accessions at Kannara (Year of planting 2000)

Sl. No.	Accessions	Total No. of plants	No. of plants with YLD	Disease index
1	Calicut 6	5	2	13.3,15
2	Calicut 17	19	8	10 – 20
3	Calicut 33	29	16	10 – 33
4	Calicut 29	15	10	10 – 22.8
5	Calicut 35	14	3	13.3 – 20
6	Sreevardhanan	13	7	10 – 13.3
7	VTL– 18a	14	6	13.3 – 25
8	VTL– 28a	14	8	10 – 21.6
9	Sagar	11	6	10 – 24.1
10	S.K Local	23	13	10 – 26
Total		**157**	**79**	**10 – 33**

6. NPK + Carbofuran + Copper Oxychloride
7. NPK + n-triacontanol
8. NPK + *Trichoderma* + Neem Cake

Details of the Treatments

Mg:- 500g Magnesium sulphate/ palm/ year in to splits

Zn:- 12g Zinc sulphate/palm/year

B:- 250g Borax/ palm/year, in two splits (Only once, at the beginning of the trial during first year)

Carbofuran:- Furadan 3G-33g/palm at quarterly intervals

Copper oxychloride:- 0.3%@ of 25 lit./palm at quarterly intervals

n-triacontanol:- Amrut G-5kg/palm/year in two equal splits

Trichoderma:- *Trichoderma harzianum* 100g/palm/year in two splits

Neem cake:- 3kg/palm/year in two splits

Organic manure was applied as per the recommendation in all the treatments. There were 8 treatments replicated thrice with 24 palms per treatment (8 palm/replication). Pre-treatment disease index and yield data of individual palm were recorded. The management trials were continued for three years. Every year the yield data and disease index of individual palm were recorded and statistically analysed. The details of treatment effects are given in table 8, 9, 10, 11, 12 and 13.

There is no significant difference between treatments in both disease index and yield in any of the five gardens in Karnataka state. In one of the gardens at Sringeri, where the management trial was laid out, the mean pre-treatment disease index was below 10. In this garden the disease intensity did not increase even after three years irrespective of the treatments.

The yield data of the palms in the management trial at Kannara revealed marked increase in yield irrespective of the treatments given when compared with pre-treatment yield. It was a neglected garden before laying

YLD Management Trials in Karnataka State
Disease Index and Yield
Table- 8. Garden No.I

a) Disease Index

Place: Sringeri

	1999	2000		2001		2002	
Treat	Mean index	Mean* index	SE	Mean* index	SE	Mean* index	SE
1	12.35	10.78	2.435	15.88	3.678	19.48	2.827
2	9.30	5.26	2.485	9.55	3.754	11.82	2.885
3	11.37	12.81	2.545	9.43	3.845	11.41	2.955
4	6.59	12.31	2.383	17.76	3.600	15.13	2.767
5	12.62	9.44	2.490	16.85	3.762	14.33	2.891
6	8.86	7.80	2.379	17.92	3.594	17.06	2.762
7	4.50	15.34	2.392	20.48	3.613	17.68	2.777
8	10.17	12.23	2.430	14.06	3.672	13.96	2.822

b) Yield (No.of nuts)

	1999		2000		2001		2002	
Treat	Mean yield	SE	Mean yield	SE	Mean yield	SE	Mean yield	SE
1	128.70	36.80	63.70	20.34	222.17	76.20	95.29	26.48
2	176.67	37.74	52.29	15.04	222.08	66.01	91.46	22.47
3	184.55	33.88	91.14	17.66	546.59	143.27	212.58	52.38
4	138.88	31.01	72.92	18.90	274.79	107.12	115.90	39.06
5	226.67	40.04	58.81	17.96	310.48	100.20	123.10	36.44
6	197.63	38.32	89.17	14.76	271.25	90.14	120.14	32.66
7	198.75	24.86	75.08	18.79	227.92	73.43	101.00	28.47
8	167.61	42.38	54.35	14.90	194.78	62.25	83.04	24.02

* Adjusted mean values based on the covariance analysis

Treatments

1. NPK (100:40:140g/palm/year in two splits)
2. NPK + P (1kg SSP in two splits)
3. NPK + Mg + Zn + B
4. NPK + Carbofuran
5. NPK + Copper oxychloride
6. NPK + Carbofuran + Copper Oxychloride
7. NPK + n-triacontanol
8. NPK + *Trichoderma* + Neem Cake

Table- 9. Garden No. II

a) Disease Index

Place: Sringeri

	1999	2000		2001		2002	
Treat	Mean index	Mean* index	SE	Mean* index	SE	Mean* index	SE
1	19.31	15.80	3.335	16.70	2.792	16.51	2.785
2	6.29	12.73	3.161	11.09	2.646	15.58	2.639
3	13.11	10.56	2.974	16.73	2.490	16.57	2.483
4	14.01	17.65	2.843	16.43	2.380	13.64	2.374
5	11.39	13.99	3.129	12.62	2.619	16.23	2.612
6	12.55	16.07	3.306	11.95	2.768	12.24	2.760
7	11.28	24.33	3.215	15.67	2.691	12.52	2.684
8	15.38	16.28	2.911	15.08	2.437	17.63	2.430

b) Yield (No.of nuts)

		1999	2000		2001		2002	
Treat	Mean yield	SE	Mean yield	SE	Mean yield	SE	Mean yield	SE
1	131.47	31.62	25.18	9.27	118.59	36.49	134.69	38.21
2	108.68	30.35	45.21	19.60	56.32	16.98	155.26	49.86
3	193.77	43.06	30.50	9.77	124.09	36.67	180.23	49.01
4	108.50	26.60	42.00	9.88	133.33	33.63	172.92	45.07
5	102.11	31.98	54.58	15.57	116.05	34.29	117.37	44.11
6	125.00	38.60	74.44	29.46	90.00	31.65	208.33	81.69
7	63.61	22.64	57.83	24.76	156.67	91.97	103.33	40.19
8	81.23	22.06	62.95	15.11	72.05	20.78	139.77	36.46

Table- 10. Garden No. III

a) Disease Index

Place: Sringeri

	1999	2000		2001		2002	
Treat	Mean index	Mean* index	SE	Mean* index	SE	Mean* index	SE
1	3.80	2.43	0.549	0.82	0.359	3.17	0.683
2	3.92	3.23	0.549	1.18	0.358	2.59	0.683
3	5.44	1.75	0.551	-0.17	0.360	2.29	0.685
4	5.54	2.13	0.539	1.15	0.352	3.40	0.671
5	3.82	2.08	0.537	1.09	0.351	3.24	0.668
6	4.65	2.51	0.537	0.17	0.351	1.48	0.668
7	3.69	3.35	0.516	0.83	0.337	2.36	0.643
8	3.12	2.37	0.539	0.61	0.352	2.12	0.671

b) Yield (No.of nuts)

		1999	2000		2001		2002	
Treat	Mean yield	SE	Mean yield	SE	Mean yield	SE	Mean yield	SE
1	146.00	32.02	258.68	38.21	413.40	67.88	1094.00	187.01
2	137.27	32.70	168.64	35.30	403.41	73.07	980.45	166.66
3	168.54	37.38	229.38	36.05	421.25	82.03	973.13	182.63
4	186.21	32.85	306.13	48.83	376.67	59.53	1098.33	164.60
5	170.00	32.53	221.67	32.25	383.96	59.56	845.00	136.69
6	218.54	32.00	301.04	38.74	433.54	61.35	1200.42	153.79
7	142.69	30.44	193.00	31.55	330.38	55.44	1019.42	147.40
8	153.04	32.88	220.43	37.47	418.26	59.16	972.61	193.11

Table - 11. Garden No. IV

a) Disease Index

Place: Sullia

	1999	2000		2001		2002	
Treat	Mean index	Mean* index	SE	Mean* index	SE	Mean* index	SE
1	13.36	14.75	3.027	16.40	3.254	14.18	2.495
2	11.54	15.20	3.482	19.75	3.744	11.63	2.870
3	14.75	18.27	3.119	24.57	3.353	14.21	2.571
4	14.09	10.79	3.241	21.28	3.484	15.11	2.671
5	15.07	16.00	3.115	18.19	3.349	14.96	2.567
6	10.83	14.15	2.768	16.28	2.975	10.88	2.281
7	18.37	13.89	2.858	25.17	3.072	17.48	2.355
8	15.82	13.88	3.017	15.42	3.243	15.58	2.486

b) Yield (No.of nuts)

		1999	2000		2001		2002	
Treat	Mean yield	SE	Mean yield	SE	Mean yield	SE	Mean yield	SE
1	241.67	50.65	133.07	47.41	101.33	25.53	58.67	22.14
2	179.64	39.80	136.29	35.41	76.64	23.61	117.14	28.05
3	161.71	32.08	122.06	25.42	102.65	30.54	45.41	18.07
4	116.60	33.66	155.67	60.22	75.67	18.94	57.67	17.93
5	135.54	28.71	91.46	17.72	77.69	22.56	28.15	17.76
6	136.16	19.86	99.84	25.51	87.63	17.83	74.74	21.05
7	221.00	30.06	274.20	74.76	130.00	35.24	92.00	21.45
8	153.20	44.17	137.47	50.59	95.00	28.50	82.00	28.13

Table- 12. Garden No. V

a) Disease Index

Place: Sullia

	1999	2000		2001		2002	
Treat	Mean index	Mean* index	SE	Mean* index	SE	Mean* index	SE
1	13.47	15.48	3.303	15.07	2.612	13.06	2.093
2	14.70	9.78	4.091	16.48	3.236	12.39	2.593
3	9.13	27.55	3.471	21.12	2.745	18.96	2.200
4	19.84	18.75	3.664	19.25	2.898	14.54	2.322
5	11.53	24.86	3.545	21.95	2.804	19.75	2.247
6	15.04	14.34	3.379	20.51	2.673	17.62	2.142
7	13.00	13.93	3.377	18.78	2.671	14.95	2.140
8	11.36	13.86	3.737	16.57	2.955	11.55	2.368

b) Yield (No.of nuts)

		1999	2000		2001		2002	
Treat	Mean yield	SE	Mean yield	SE	Mean yield	SE	Mean yield	SE
1	88.38	15.41	89.71	19.61	231.25	49.97	220.63	36.21
2	102.00	29.88	66.00	23.08	101.67	30.48	199.33	45.46
3	57.38	8.86	61.90	13.03	154.29	35.64	268.57	39.21
4	110.22	32.39	76.78	26.08	157.78	45.69	176.39	31.00
5	98.50	19.87	76.35	14.26	172.00	44.32	204.00	36.13
6	136.36	26.33	88.41	22.81	200.00	38.85	230.45	34.37
7	103.41	22.83	127.27	22.89	158.18	41.55	275.45	53.33
8	102.90	24.76	118.75	25.88	142.25	49.54	191.75	45.94

YLD Management in Kerala State
Disease Index and Yield

Table- 13. Garden No. VI

a)Disease Index

Place: Kannara

Treat	1999	2000		2001		2002	
	Mean index	Mean* index	SE	Mean* index	SE	Mean* index	SE
1	20.92	26.24	2.45	18.75	2.48	2625	2.90
2	18.91	28.48	2.33	26.01	2.36	28.38	2.76
3	18.74	28.42	2.27	25.91	2.30	25.35	2.69
4	19.39	32.94	2.39	22.59	2.42	23.48	2.83
5	19.11	25.15	2.33	17.67	2.36	19.47	2.76
6	20.64	21.64	2.27	14.24	2.30	16.58	2.69
7	24.28	26.83	2.15	23.24	2.16	23.96	2.53
8	23.67	27.46	2.61	24.76	2.64	32.95	3.09

b)Yield (No.of nuts)

Treat	1999		2000		2001	
	Mean yield	SE	Mean yield	SE	Mean yield	SE
1	125.67	22.20	235.85	36.30	187.33	45.22
2	43.36	10.79	229.45	43.44	169.45	33.77
3	125.15	19.54	217.25	37.83	181.90	36.52
4	95.09	20.33	204.55	38.92	209.18	41.27
5	141.14	28.98	240.24	34.84	197.05	46.33
6	155.10	23.30	260.50	38.89	238.77	47.73
7	70.79	14.26	134.54	20.37	121.96	27.96
8	106.72	29.51	159.32	37.58	154.63	37.16

out the trial. Statistical analysis of the yield data revealed significant difference between treatments in the year 2000 and in other years (2001-2002). There was no significant difference between the treatments.

Statistical analysis of disease index revealed the treatments NPK + Copper oxychloride and NPK + Carbofuran + Copper Oxychloride as significantly better than other treatments. The disease index was significantly less in these two treatments compared to other treatments in the year 2001 and 2002.

13. Approximate expenditure incurred in the project (give reason for variation, if any, from original estimated cost):

Rs. 20 lakhs. (Reduction in cost from the original estimated cost is due to changes in technical programmes based on the results obtained. Some of the item were included under ICAR ad-hoc scheme)

14. Publications (One copy each to be supplied with this proforma)

a) Research:

RAVEENDRAN, P.S; NAMPOOTHIRI, K.U.K; PILLAI, R.S.N; CHANDRAMOHANAN, R and MOHAMMED SAYED, A.A. 2000. Chapter 6. Varietal Reaction. In: *Arecanut Yellow Leaf Disease* CPCRI, Kasaragod- 671 124. pp. 43-50.

CHANDRAMOHANAN, R. and NAMPOOTHIRI, K. U. K.2000. Possibilities of evolving an arecanut variety tolerant to yellow leaf disease. In: Role of Resistance in Intensive Agriculture (2000). Eds. S. Nagarajan and D. P. Singh, Kalyani Publishers, New Delhi. pp. 92-97.

b) Popular Article:

CHANDRAMOHANAN, R. 2001. Arecanut varieties (Malayalam). *Punnya Bhoomi* . 30th November, 2001. pp 8.

c) Reports: 4

d) Seminar in which scientists have participated: 4

e). Materials developed such as new varieties of crop or breeds of farm animals, implements, products etc, in this Project:

Quality arecanut seedlings of field tolerant elite palms for raising nucleus seed gardens.

15. Details (Nos. etc,) of Field/Laboratory note books, final material, and their location:

1. Primary project file – 1
2. Field note books – 2
3. Yield register – 1

CPCRI, Regional Station, Kayamkulam

16. Name and Signature of the Project Leader:

R. ChandraMohanan

17. Names and Signatures of Project Associates:

N. Saraswathy

K. S. Ananda

P. Rajan

18. Signature (with comments if any) of Head of Division/ Section/ Station:

16.03.04

19. Signature (with comments, if any) of Director:

Dr. V. RAJAGOPAL
Director
Plantation Crops Research Institute
Kasaragod - 671 124, Kerala

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ARECANUT YELLOW LEAF DISEASE

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6
VARIETAL REACTION

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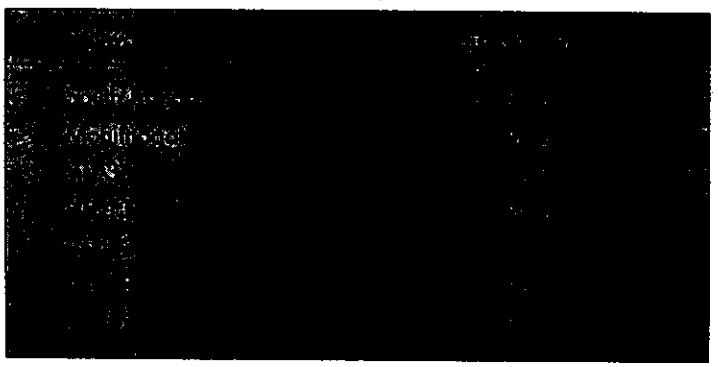
Yellow leaf disease, a malady of Phytoplasmal etiology, is not amenable to control by conventional plant protection measures (Ponnamma *et al.*, 1997). As management practices did not yield any positive results, the only other practical solution available for controlling this malady is to evolve resistant/tolerant varieties. During the past three decades, considerable work has been done on this aspect.

Screening of varieties and hybrids

In a multi location trial conducted during 1970's, six promising cultivars such as VTL-3 (released as Mangala) , VTL-11(released as Sumangala), VTL-12, VTL-13, VTL-17(released as Sreemangala) and Mohitnagar with South Kanara local as check were evaluated and the results indicated that all of them were susceptible (Table 1). The disease index varied from 6.7

Table 1. Reaction of promising cultivars to yellow leaf disease.



(VTL-3) to 34.6 (South Kanara). Nampoothiri (1982) reported that 52 arecanut collections derived from both exotic and indigenous sources also succumbed to YLD with varying degrees of intensity. Further, large scale screening of germplasm collection/ varietal hybrids, hybrids produced from disease escapes, inter-se/selfed progenies of different collections involving 88 different cross combinations comprising of 2,328 palms during 1976-1993 (Table 2) were undertaken in YLD affected belt. All of them were highly susceptible and 18 genotypes showed less than 25 per cent of disease incidence (Table 3). The succeeding account reveals the results of these experiments.

The 21 diallel cross combinations planted at CPCRI, Palode in 1976 have contracted the disease within a period of three years .The disease incidence varied from 63.9 to 100 per cent (Table 4). Maximum incidence was noticed in VTL-3 x VTL-13, VTL-11 x VTL-13,

Table 2. Screening of hybrids / *Inter-se* materials against yellow leaf disease.

Year of planting	Varietal hybrids	Hybrids involving disease escapes	Inter-se	Self	Total
1976	6	-	-	-	6
1981	-	6	-	1	7
1983	9	-	-	-	9
1984	8	-	-	-	8
1985	-	7	1	-	8
1986	3	3	-	1	7
1986	1	6	-	-	7
1988	3	-	5	-	8
1989	2	-	5	-	7
1990	5	-	2	-	7
1991	4	-	3	-	7
1993	-	-	6	1	7
Total	41	22	22	3	88

Table 3. Reaction of varieties/ hybrids screened against YLD from 1976-1993

Varieties/ Hybrids	Total screened	Disease incidence (%)			
		100	50-99	25-49	Below 25
Varietal hybrids	41	23	9	0	9
Hybrids involving tolerant palms	22	11	4	4	3
Inter-se	22	11	2	4	5
Self	3	0	1	1	1
Total	88	45	16	9	18

VTL-11 x Thirthahalli, VTL-13 x VTL-17 and VTL-17 x Thirthahalli (100%) and minimum in VTL 12 X Thirthahalli (63.9 %). The hybrid combinations between Hirehalli dwarf mutant and promising cultivars (VTL-3, VTL-11, VTL-13, Mohitnagar and Thirthahalli) planted in 1976 exhibited certain degree of tolerance in the initial years (Anon., 1981). However, all succumbed to YLD within a period of 6-8 years (Table 5). The disease incidence was highest in Thirthahalli x Dwarf (62.9 %) and least in Dwarf x VTL-11 (18.1%).

The most promising results were obtained from the trial laid out in 1981 at CPCRI Research Centre, Palode with field tolerant palms. Even though all the progenies of Saigon x Mangala

Table 4. Reaction of diallel cross combinations to yellow leaf disease.

Hybrids	No. of palms tested	No. of palms diseased	Per cent of incidence	Mean disease index
VTL-3 x VTL-11	12	11	91.7	25.90
VTL-3 x VTL-12	15	10	66.7	14.60
VTL-3 x VTL-13	8	8	100	21.40
VTL-3 x VTL-17	11	10	90.9	20.10
VTL-3 x Mohitnagar	13	10	76.6	11.80
VTL-3 x Thirthahalli	15	13	86.7	20.40
VTL-11 x VTL-12	12	10	83.3	18.50
VTL-11 x VTL-13	12	12	100	23.40
VTL-11 x VTL-17	14	13	92.9	17.60
VTL-11 x Mohitnagar	10	7	70.00	13.00
VTL-11 x Thirthahalli	20	20	100	25.60
VTL-12 x VTL-13	23	19	82.6	21.70
VTL-12 x VTL-17	11	10	90.9	21.40
VTL-12 x Mohitnagar	18	16	88.90	24.40
VTL-12 x Thirthahalli	11	7	63.90	15.30
VTL-13 x VTL-17	13	13	100	31.30
VTL-13 x Mohitnagar	8	6	75.00	8.70
VTL-13 x Thirthahalli	19	17	94.10	23.00
VTL-17 x Mohitnagar	12	10	83.30	16.90
VTL-17 x Thirthahalli	2	2	100.	32.50
Mohitnagar x Thirthahalli	17	13	84.60	21.20

Table 5. Incidence of yellow leaf disease on arecanut hybrids after 8years of planting (planted in1984).

Hybrids	No. palms	No. palms contracted disease	Disease incidence (%)	Mean disease index
Mangala x Hirehalli dwarf	21	9	42.8	9.3
VTL-13 x Hirehalli dwarf	30	14	46.6	15.4
Mohitnagar x Hirehalli dwarf	27	11	40.7	15.5
Thirthahalli x Hirehalli dwarf	27	17	62.9	23.8
Hirehalli dwarf x VTL-11	11	2	18.1	15.0
Mangala	16	7	43.7	21.6
Hirehalli dwarf	31	16	51.6	10.3

did not show resistance to the disease, hybrids between two palms No. 300 (Saigon) and No.125 (Mangala) exhibited high level of tolerance. The disease index in this combination was only 2.8 per cent (averaged over nine years) with an average yield of 9.19 kg/palm/year (Table 6). One of the palms belonging to this combination did not show any symptom even after 13 years. Since the yield of this palm was also high (14.3 kg), it can be considered as a very promising breeding material and can be successfully used in future breeding programme for YLD tolerance.

A field trial involving nine varietal hybrids and Mangala and South Kanara as control initiated during 1984 at CPCRI Research Centre, Palode indicated that all of them contracted the disease within a period of three years except VTL-12 x South Kanara combination (Table 7). Later, this combination also succumbed to the disease. Another experiment laid out at Kannara

Table 6. Reaction of hybrids, planted in 1981,to yellow leaf disease and their yield potential.

Hybrids	Mean no. of nuts/ palm	Fresh weight of ripe nuts (Kg)	Disease index
300 Saigon x 108 Mangala	159*	5.43	2.3
300 Saigon x 125 Mangala	251	9.19	2.8
28 Aryankavu x 125 Mangala	192	4.97	4.9
159 Peechi x 122 Mangala	83	2.87	3.6
105 Mangala x 299 Saigon	206	6.04	4.7
105 Mangala x 108 Mangala	123	3.57	8.1
28 Aryankavu x 28 Aryankavu	107	2.81	9.5
SE	28.8	1.00	1.1
CD (5%)	88.7	3.10	3.5

* Mean for 9 years (1985-1993)

Table 7. Reaction of varietal hybrids, planted in 1984, to yellow leaf disease

Cross combination	No.of palms	No.of palms diseased	Percentage[1] of disease incidence	Mean disease index
Hirehalli dwarf x VTL-3	27	2	7.4	4.0
VTL-3 x Hirehalli dwarf	27	1	3.7	5.0
South Kannara x VTL-12	26	3	11.5	1.3
VTL-12 x South Kannara	27	0	0	0*
VTL-12 x VTL-3	16	2	12.5	7.5
VTL-12 X Hirehalli dwarf	25	4	16.0	2.5
VTL-12 x Sreevardhan	20	2	10.0	17.5
VTL-3 x South Kannara	19	1	5.3	17.0
Hirehalli xVTL-17	27	2	7.4	3.5
Mangala	25	4	16.0	11.0
South Kannara	27	2	7.5	17.5

[1] Data recorded in 1987 * Succumbed to disease in 1990

in 1986 involving hybrids from disease escapes and Mangala and South Kanara local as check showed that more than 50 per cent of palms in all combinations were susceptible to the disease (Table 8). The hybrids 96-M x 260 and 172 x 71 M gave satisfactory yield of 5.42 and 6.15 kg nut weight respectively with 217 and 268 mean number of nuts. All other combinations were poor yielding with a mean weight of 2.38 kg and less than 80 nuts/palm.

Table 8. Reaction of hybrids derived from disease escapes to yellow leaf disease.

Cross combinations	Percentage of disease incidence	Mean disease index	Mean no. of nuts	Mean yield (Ripe fresh nut in Kg)
8 M x 25 A	91.60	32.40	75	1.978
31 M x 260	75.00	18.80	79	2.260
96 M x 260	83.30	22.70	217	5.418
414 x 34 M	95.80	32.90	28	0.758
172 x 71 M	95.80	28.90	268	6.151
149 X 177	100	40.70	40	1.143
Hirehalli dwarf x VTL 13	50.00	5.70	35	1.400
Mangala	54.10	10.50	79	2.381
South Kanara	95.80	29.80	14	0.462

Among the exotic types and species planted in 1968 at Kannara, only two genotypes (Indonesian II and British Solomon Islands I) have remained disease free. In the experiment in which "true" Mangala and segregants were planted to study the intensity of YLD, 24 per cent segregants contracted the disease in the fourth year after planting compared to four per cent in true Mangala (Anon., 1993). Even after18 years of field experimentation, none of the hybrids or varieties were completely resistant.

Field tolerant elite palms

As no variety or hybrid was found to be disease tolerant, it was appropriate to search for field tolerant elite palms in 'hot spot' of YLD affected areas in Kerala State.

The criteria for selection of elite disease escape palms were :

- More than 90 per cent of the surrounding palms should be affected by YLD.
- The palms should have a minimum age of 20 years
- Disease free nature of palms should be confirmed by light microscopic tests.
- Selected palms should yield a minimum of 200 nuts/palm/year under neglected conditions (Farmers neglect the gardens when YLD incidence is very high)
- Selected palms should be generally free from major pests and diseases.

From an intensive survey in 'hot spot' areas conducted during 1985-1987 in 13 districts of Kerala involving 1,32,750 palms, 70 healthy/disease escapes were identified. They were further subjected to light microscopic examination and six of them were disease free (Table 9). A recent survey conducted in 1998 led to identification of five disease free elite palms in Thrissur and 10 palms in Ernakulam districts. Further, an arecanut garden consisting

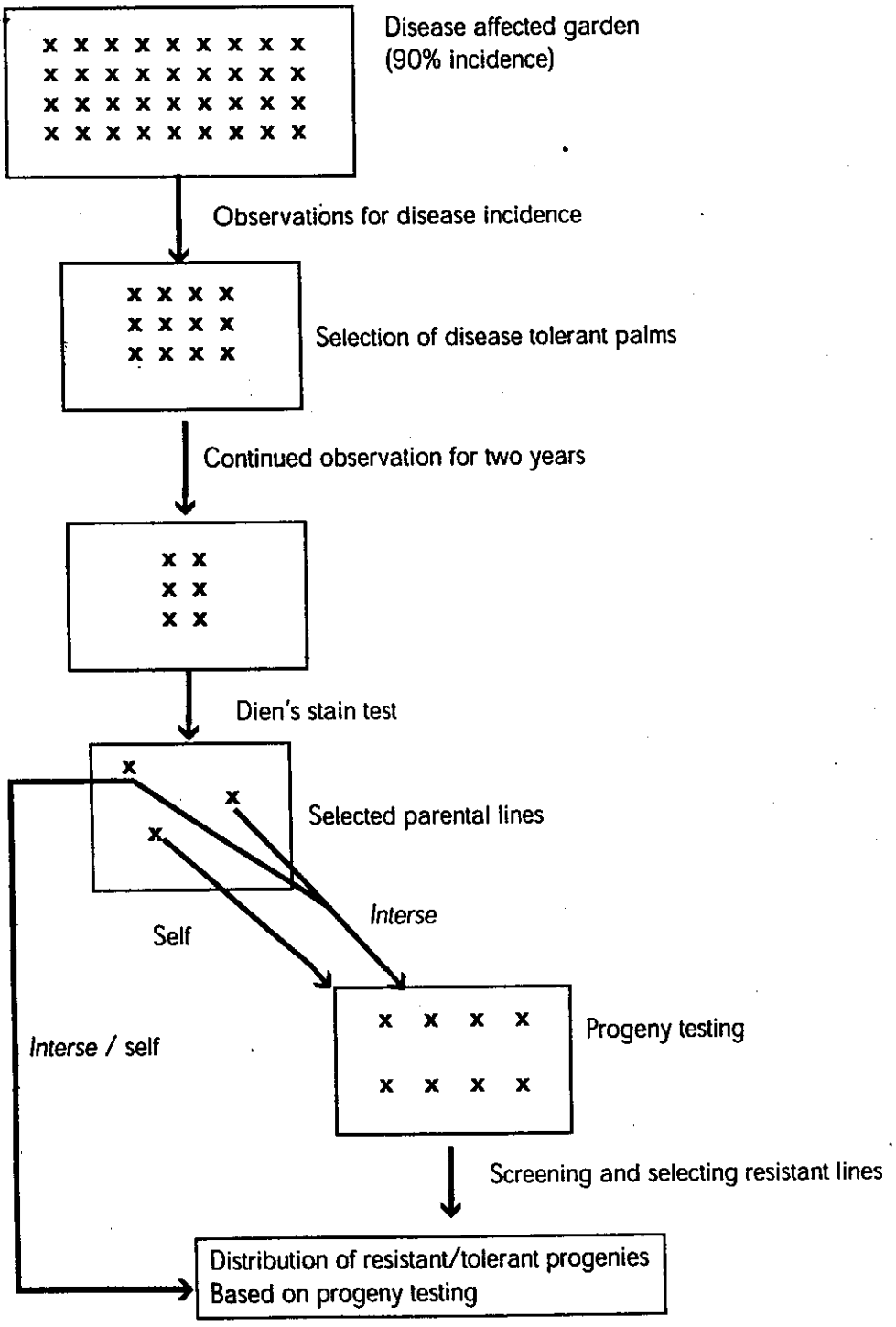
Table 9. Details of 'hot spot' survey conducted in 13 districts of Kerala

District	Year of Survey	No. gardens visited	Total no. of palms	No. of disease free palms	No. of tolerant palms identified
Thiruvanathapuram	1985	28	12,678	0	—
Kollam	1985				
Pathinamthitta	1985				
Kottayam	1986	13	11,994	3	1
Alappuzha	1986	7	17,857	2	0
Ernakulam	1986	29	12,071	3	0
Idukki	1986	20	14,433	5	0
Thrissur	1986	13	11,310	11	4
Palaghat	1986	11	11,875	1	0
Malappuram	1986	10	8,967	0	0
Kozhikode	1986	10	8,950	36	0
Wynad	1986	8	9,615	0	0
Kannur	1987	25	13,000	9	1
Total		174	1,32,750	70	6

of 52 palms, raised by the farmer using the seed nuts collected from a single YLD free high yielding palm of about 30 years old, occurring in middle of all other YLD affected palms, was also identified in the 'hot spots' of Ernakulam district during the survey. These 52 palms are now more than 20 years old. Though they were raised from open pollinated seed nuts of YLD symptom free elite palm, none of these palms were showing symptoms of YLD except three palms exhibiting kernel discolouration. Thus, there were 49 palms (second generation) without any symptoms of YLD. None of the palms exhibited any YLD symptom so far. All the 67 palms (52 palms of second generation and 15 disease escapes from Ernakulam and Thrissur districts) were subjected to histological staining using Diene's stain (Deelay *et al.*,1979). Based on reaction to Diene's stain, the disease escapes identified in 'hot spots' were categorised into healthy and infected palms. The 10 YLD symptom free elite palms in Ernakulam district were negative in their reaction to Diene's stain. Out of the 5 palms identified in Thrissur district, one palm was negative to staining reaction. Among the 52 second generation YLD free palms in Ernakulam district, 33 palms exhibited negative reaction to Diene's stain. Of these 33 palms, 24 palms were identified and marked as elite palms based on yield evaluation. Thus, 34 palms in Ernakulam district and one palm in Thrissur district were selected as YLD free elite palms in Kerala state for production of seed nuts by selfing and *inter-se* mating. These palms would be monitored every year for disease expression and disease free palms will be confirmed by light microscopic technique.

Seedlings raised from open pollinated seed nuts of second generation YLD free elite palms identified in Ernakulam district are being evaluated for their reaction to YLD by interplanting them in arecanut gardens with more than 90 per cent of YLD affected palms. Selfing of inflorescences of these 24 second generation elite palms is also in progress. A schematic diagram depicting breeding for YLD tolerant arecanut palms is given in Fig. 1 (Chandra Mohanan and Nampoothiri, 2000).

Fig. 1 Evolving YLD tolerant arecanut lines



Future strategy

Identification of disease resistant/tolerant palms and screening of these progenies should be a continuous process in the search for tolerant genotypes for YLD. As breeding for resistance in tree crops like arecanut is a slow process, early predictive tests for resistance are needed to accelerate the breeding process. Assessing resistance to YLD using biotechnological tools can be tried to shorten the breeding cycle. Screening the materials against the disease with dodder and insect vector and early disease detection aids using ELISA would accelerate the identification of resistance. PCR based molecular fingerprints can be exploited for determination of genetic diversity in arecanut germplasm and tagging resistant genes. Pathogen derived resistance mechanisms need to be employed to produce transgenics to resolve this stalemate.

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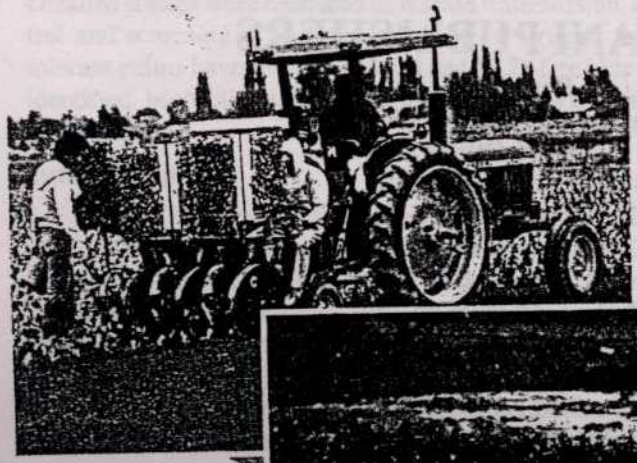
ROLE OF RESISTANCE IN INTENSIVE AGRICULTURE



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Chapter-9

Possibilities of Evolving an Arecanut Variety Tolerant to Yellow Leaf Disease

R.Chandra Mohanan and K.U.K. Nampoothiri

ABSTRACT

Yellow leaf disease (YLD) is the most serious malady affecting arecanut in Kerala and Karnataka States. The disease causes qualitative and quantitative loss. Phytoplasma is the causal organism of YLD and the plant hopper, *Proutista moesta* is the vector. Detailed studies were conduced on disease transmission, antibiotic therapy, vector control and screening of varieties and hybrids. Criteria for effective screening of field tolerant palms have been formulated and YLD-free elite palms in hot spots have been identified. Multiplication of YLD-free elite palms to establish nucleus seed gardens is in progress.

Introduction

Yellow leaf disease of arecanut (*Areca catechu* L.) is the most serious problem of areca growers in Kerala and Karnataka states. Though the disease first made its appearance as early as in 1914 in Central Kerala (Nambiar, 1949), there is no solution to tackle this malady till today. Now, yellow leaf disease (YLD) is prevalent in all districts of Kerala, five districts of Karnataka and some parts of Tamil Nadu and Maharashtra causing heavy economic loss to the growers . Yellod leaf disease affects the normal growth and vigour of palms. Reduction in yield upto 50 % within a period of three years after the onset of the disease has been observed (Nair, 1994).

Symptoms

As the name of the disease indicates characteristic yellowing of leaves is the most important symptom. Initial symptom of yellowing occurs on one or more leaves of the outermost whorl .Yellowing starts from the tips of leaflets on either side of the leaf and gradually extends to the base. At this stage the foliar yellowing is characterised by abrupt demarcation between green and yellow region. When the yellowing extends from the tip to the basal portion of leaflets there will be a clear band of green tissue adjacent to the mid rib. During dry periods, the tips of the chlorotic leaf lets become necrotic and eventually dry up. In the advanced stage of the disease, the leaves become reduced in size, stiff, closely bunched and abnormally puckered. Thus the crown becomes very much reduced in size. Immature nut fall, kernel discolouration and extensive root rot are the other major symptoms of the disease. Blackish discolouration of the kernel (endosperm) of immature and mature fruits is a common symptom of the disease. As a result the whole kernel becomes unfit for chewing. On drying, the chali

(dried nut) is shrivelled and of poor quality. Thus the disease causes qualitative and quantitative loss (Rawther, 1976; Chadra Mohanan, 1979; Nair, 1994). Some anatomical changes in the leaves, stem, inflorescence and roots due to YLD were also reported (Nair and Aravindakshan, 1970; Nair, 1976).

Etiology

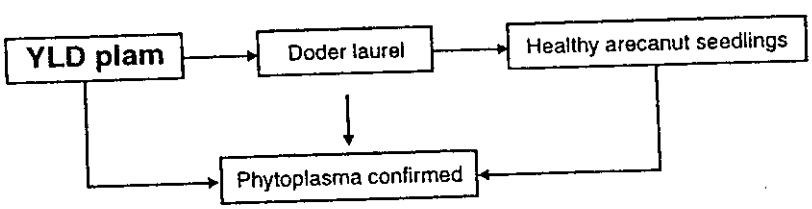
Extensive studies conducted on the role of fungi, bacteria, nematodes, viruses and nutritional disorders in causing this malady clearly revealed that none of these can cause YLD.

Electron microscopic studies showed the presence of Phytoplasma in the young sieve elements of YLD affected palms (Nair and Seliskar, 1978). This has been confirmed by further detailed studies. E.M . Examination of root tissues of YLD affected palms invariably showed the presence of Phytoplasma whereas they were totally absent in the roots of healthy palms from disease free area. Protozoan flagellates, viruses, fungi or bacteria were not observed in the tissues examined (Anonymous, 1985 and 1986).

Phytoplasmas are generally transmitted by leaf hoppers and plant hoppers. Detailed investigations on possible putative vectors of the disease have revealed the constant association of a plant hopper *Proutista moesta* (Westwood) (Homoptera : Derbidae) with arecanut palms. The ability of the plant hopper to acquire and sustain the mollicutes was assessed. On E.M. examination, Phytoplasmas were observed in the salivary gland tissues of plant hopper subjected to 30 – 41 days acquisition and incubation period on YLD affected palms while Phytoplasmas were totally absent in the salivary glands of laboratory reared plant hoppers as well as the insects collected from healthy area. Transmission of the disease and vector role of *P. moestsa* were confirmed by observing YLD symptoms on arecanut seedlings inoculated with *P. moesta* which was given 5 days acquisition access to diseased palms and 25 – 36 days incubation period (Ponnamma *et al.*, 1991 & 1997). These results lend further support to Phytoplasma etiology.

The presence of Phytoplasma and its transmission were established also by dodder transmission (Anonymous, 1991)

E. M. Examination of plants subjected to dodder transmission
(Dodder laurel – *Cassytha filiformis)*



Antibiotic therapy against YLD was carried out in two localities. Disease index tabulated after 2 years of initiation of the antibiotic therapy revealed marked improvements in the foliar condition in neomycin, ledermycin, oxytetracycline (OTC), gentamycin and hostacycline treated palms. Contrastingly, palms in the penicillin treatment showed increase in disease intensity. Thus the antibiotic therapy further confirmed the phytoplasmal etiology (Anonymous, 1990 and 1991)

Antibiotic therapy : at two locations

Antibiotics	% improvement in disease conditions (After two years)
*1. Neomycin 0.5 g a.i.	90
*2. Lederrnycin 2 g a.i.	89
3. O.T.C. 1 g a.i.	80
4. Gentamycin 2 g a.i.	80
5. Hostacycline 2 g a.i.	60
6. Pencillin 20 lakh units	Increase in D.I.

* Phytotoxic

As YLD was found to be transmitted by a planthopper, attempts were made to control the insect vector, *P. moesta* and thereby checking the fresh incidence and spread of YLD. But, even monthly application of insecticides like endosulfan and monocrotophos could not prevent the incidence of the disease (Anonymous, 1990). The reasons for this may be attributed to the large scale multiplication of the plant hopper and its occurrence in arecanut garden throughout the year.

Effect of insect control on fresh incidence of YLD

Treatments

1. Endosulfan	0.1 %	monthly spray
2. ..	..	quarterly spray
3. Monocrotophos	0.1 %	monthly spray
4.		quarterly spray
5. Untreated control		

[Phorate 10G @ 2g/sachet in leaf axils, Phorate 10G @10g/plant for soil application in all treatments]

Even monthly application of insecticides could not prevent the incidence of YLD

Screening of varieties

Since phytoplasmal diseases are not amenable to control by conventional plant protection measures, a lasting solution to this malady is to evolve disease tolerant/ resistant variety. Though studies on varietal reaction to YLD was initiated as early as in 1960, more emphasis was given to this line of investigation with the confirmation of phytoplasmal etiology. Earlier studies indicated that all the 52 germplasm collections (both exotic and indigenous) succumbed to YLD though in varying degrees of intensity (Nampoothiri, 1982). Therefore, 88 varietal hybrids of different cross combination were screened against YLD. They were also susceptible to the disease (Anonymous, 1985, 1988, 1990 and 1994).

Identification of field tolerant elite palms

As no positive result on disease tolerance was obtained even after screening 140 genotypes, it has been decided to identify field tolerant/resistant palms, which are high yielding. Hence, the present investigations were undertaken to identify field tolerant/ resistant elite palms in hot spots of YLD affected areas in Kerala state.

The criteria for selection of elite disease escape palms were :

1. More than 90 % of the surrounding palms should be affected by YLD
2. The palms should have a minimum age of 20 years.
3. Disease free nature of the palms should be confirmed by light microscopic tests.
4. Selected palms should yield a minimum of 200 nuts/palm/year under neglected conditions (Farmers neglect the garden when YLD incidence is very high)
5. Selected palms should be generally free from major pests and diseases.

A survey was conducted in hot spots of Thrissur and Ernakulam districts of Kerala State to identify disease escape palms. The disease escape palms identified were monitored for disease incidence and yield for two years. Thus, a total of 5 palms in Thrissur dist. and 10 palms in Ernakulam dist. were identified as YLD symptom free elite palms. An arecanut garden consisting of 52 palms, raised by the farmer using the seed nuts collected from a single YLD free high yielding palm of about 30 years old, occurring in the middle of all other YLD affected palms, was also identified in the hot spots of Ernakulam dist. during the survey. These 52 palms are now more than 20 years old . Though they were raised from open pollinated seed nuts of YLD symptom free elite palm, none of these palms were showing symptoms of YLD except three palms exhibiting kernel discolouration. Thus, there were 49 palms (second generation) without any symptoms of YLD. These 49 palms were also monitored for disease incidence for two years. None of the palms have exhibited any YLD symptom, so far.

All the 67 palms (52 palms of second generation + 10 disease escape palms in Ernakulam dist. and 5 disease escapes in Thrissur dist.) were subjected to histological staining techniques using Dienes' stain (Deeley *et al.*, 1979). For this, three root samples with root tip were collected from each palm and fixed in FAA. Simultaneously root samples were collected from 5 healthy palms in a YLD free area and 5 palms with typical YLD symptoms occurring in hot spots of Ernakulam dist. Seed nuts of 3 arecanut varieties (Mangala, Sumangala and Dakshina Kannada local) were collected from a disease free area and seedlings were raised under insect proof cages. Root samples were also collected from these seedlings. All the samples collected were fixed in FAA.

Transverse sections of all the samples fixed in FAA were taken and stained with 0.2% solution of Dienes' stain for 10 min. Then the sections were washed in distilled water, mounted in D.W. and examined under a microscope. Thus, the reaction of root tissues of YLD symptom-free palms in hot spots to Dienes' stain was compared with that of YLD affected palms and healthy palms/seedlings. The phloem of root sections of all YLD affected palms exhibited a distinct blue colour but the phloem of healthy root sections remained unstained. Based on such reaction to Dienes' stain the disease escapes identified in hot spots were categorised into healthy and infected palms.

The 10 YLD symptom free elite palms in Ernakulam dist. were negative in their reaction to Dienes' stain. Out of the 5 palms identified in Thrissur dist. only one palm was found to be negative to staining reaction. Out of the 52 palms identified as second generation YLD symptom free palms (including 3 palms with kernel discolouration) in Ernakulam dist., 33 palms were negative in their reaction to Dienes' stain. Among these 33 palms, 24 palms were identified and marked as elite palms based on yield evaluation. Thus, 34 palms in Ernakulam dist. and one palm in Thrissur dist. were selected as YLD free elite palms in Kerala state for production of seed nuts by selfing and interse mating. These palms will be monitored every year for disease incidence and disease free nature will be confirmed by light microscopic test.

Seedlings raised from open pollinated seed nuts of 'second generation' YLD free elite palms in Ernakulam dist. are being evaluated for their susceptibility to YLD by interplanting them in arecanut gardens with more than 90 % YLD affected palms. Selfing of inflorescence of these 24 second generation elite palms is also in progress.

Future thrust

Identification of more disease free elite palms in hot spots of Kerala and Karnataka states and their utilization in breeding programmes will be undertaken to evolve disease tolerant/resistant high yielding population. The YLD free elite palms available in hot spots will be multiplied by selfing and interse mating. The seedlings raised from these palms will be planted in large areas in the disease prevalent tracts of Kerala and Karnataka states to utilize them as nucleus seed source, after screening against YLD. Concurrently, the YLD tolerant/resistant palms can be used for future disease resistance breeding programmes by utilizing selected palms in the nucleus seed gardens to evolve a high yielding variety fully resistant to YLD. It will be a boon to farmers in Kerala and Karnataka states to have YLD tolerant/resistant high yielding arecanut variety to alleviate the loss due to yellow leaf disease.

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