RESEARCH ON CASHEW IN INDIA

by

V. K. Damodaran
T. Vilasachandran
P. K. Valsalakumari

Kerala Agricultural University
Directorate of Extension Education
Vellanikkara, Trichur—680651.
1979

FOREWORD

There is need for intensifying research into different aspects of many of the important horticultural crops in Kerala. The scarcity in the supply of raw cashewnuts to the cashew processing industry in the State highlights the urgent priority cashew deserves in our research efforts. A review of work so far done will help to determine the programmes to be undertaken immediately. This technical bulletin is intended to serve such a purpose.

Sri V. K. Damodaran has long years of research experience in cashew. He has done a very good job with limited facilities made available to him in preparing this bulletin. The Kerala Agricultural University commends his services.

It is hoped that this publication will serve as a useful base for building up the research programmes in cashew in a way that will help in meeting the felt problems of the cashew growers.

Kerala Agricultural University,
Vellanikkara — 680 651,
Dated 19th February, 1979.

N. KALEESWARAN
Vice-Chancellor.

PREFACE

Cashew (*Anacardium occidentale* L) is an important crop in the agricultural, industrial and commercial economy of the country—more particularly of the state of Kerala, where the cashew processing industry is concentrated, employing about a lakh and a half persons. The export of cashew kernels and cashewnut shell liquid have earned over 100 crores of rupees annually in recent years. But the internal production of raw nut meets only about a third of the requirements of the processing industry, which is passing through a crisis due to the non-availability of adequate raw nut consequent on the setting up of mechanical processing units in the African countries, which were hitherto supplying raw nuts to our country.

In spite of its importance in the economy of our country, cashew is a neglected crop and the present level of productivity is extremely low. Eventhough research on cashew in India is over 25 years old, the major part of the results obtained so far remain unpublished in the annual reports of the respective Cashew Research Stations. It was in this context that the Vice-Chancellor of the Kerala Agricultural University, Sri N. Kaleeswaran, I. A. S. suggested to me to collect the details of research on cashew so far done in India and make it available to the research workers and others, interested in this field.

Subsequently, the meeting of the Vice-Chancellors and Officers of the Regional Agricultural Universities held in April, 1977 decided to prepare abstracts of literature on important crops and topics by the Universities of the region. The responsibility of undertaking the above work on cashew was assigned to the Kerala Agricultural University. The present publication is the out-come of the above decisions. It is hoped that this bulletin will give a correct appraisal of the status of cashew research so far done in the country and help in the drawing up of the future line of work. The future developments in this field will be covered by an abstract service as contemplated in the meeting of the Vice-Chancellors.

I am extremely grateful to the Vice-Chancellor of the Kerala Agricultural University, Sri N. Kaleeswaran for assigning this task to me and for sanctioning its publication as a technical bulletin of the Kerala Agricultural University.

CONTENTS

CORRIGENDUM

Page No.	*para*	*line*	*as in the text*	*to be read as*
3	Table 4	11	5,05,401	50,401
5	2·9	5	these pests	this pest
7	5	1	6·1	5·1
9	6·1	14	Vridachalam	Vridhachalam
10	1·2	5	oral	oval
10	1·2	12	pistel	pistil
10	1·2	15	stamin	stamen
13	2·11	9	Fig (2)	Fig (6)
13	2·11	14	monocarpallate	monocarpellate
20	Table 14		Setting percentage	Shelling percentage
23	3·7	3	indentified	identified
30	Table 23	Caption line 2	CRRS	CCRS
32	4·10	1	gama	gamma
32	4·11	Caption	*CRR Vengurla*	*CRS Vengurla*
32	4·11	5	Venture 56	Veture 56
36	1·2	5	Evaluation	Evolution
38	4·1	6	¾—1⅛ inch	¾—1½ cm.]
39	4·2	7	Muthappa Rao	Muthappa Rai
42	4·8	3	Sand and saw dust (50 : 60)	Sand and saw dust (50 : 50)
43	Table 34	1	Little	Little damage to film
		2	damage to film	Some
		3	Some serious	Serious
46	4·14	1	has	have
49	6·2	1	Phadmis	Phadnis
50	6·4	2	buddings	buddlings
50	6·5	5 and 7	Spagnum	Sphagnum
57	Table 46	Caption line 2	M_3	M3
64	Para No.		7·6	1·6
64	1·6	4	*Gleosporium*	*Gloesporium*
66	1·10	2	*P· Obesus*	*P. obesus*
70	1·25	6	*Copticium*	*Corticium*
70	1·26	1	*Gloeesparium*	*Gloesporium*
70	1.27	1	*salmonocotor*	*salmonicolor*
75	4·7·2	7 & 8	Tanin	Tannin

CASHEW (ANACARDIUM OCCIDENTALE L)

1. The Crop and the Industry

1.1 Cashew, which is a native of Brazil was introduced into India in the 16th century, presumably in 1578 and today, it is one of the most important commercial crops in our country. During the past 400 years, it has spread to all the states in the western and eastern coasts of peninsular India. It is a hardy crop, growing in a semi-wild manner in the poorest of soils in the southern states. In the existing plantations, very little care and attention is paid in its culture. Besides India, other important cashew growing countries in the world are Mosambique, Tanzania, Kenya and Brazil. The total production of raw cashewnut in the important producing countries of the world during the years 1971-75 are given in Table 1 below :—

Table 1. Production of raw cashewnut in major producing countries

Year	India	Mozambique	Tanzania	Kenya	Brazil	Others
1971	2,12,000	1,78,000	1,17,000	23,000	15,000	2,000
1972	2,05,000	1,73,000	1,17,000	25,000	41,000	,,
1973	2,00,000	1,70,000	1,07,000	13,000	25,000	5,000
1974	1,40,000	2,10,000	1,35,000	25,000	30,000	5,000
1975	1,85,000	1,90,000	1,20,000	25,000 to 30,000	60,000	5,000

Source : Directorate of Cashewnut Development, Ernakulam.

Area and Production in India

1.2 Kerala is the premier cashew, growing state in India; other important producing states being Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Orissa and Goa. Accurate statistics of area and production of cashewnut in the different states are not available. However, according to the statistics reported by the Directorate of

Table 4. District-wise area and production of cashew in Kerala in 1974-75.

District	Area (hectares)	Production (tonnes)
Trivandrum	4,468	5,013
Quilon	8,692	9,752
Alleppey	3,617	4,058
Kottayam	1,334	1,497
Idikki	1,938	2,174
Ernakulam	3,974	4,459
Trichur	6,794	7,623
Palghat	9,051	10,155
Malappuram	14,249	15,987
Kozhikode	5,867	6,560
Cannanore	44,921	5,05,401
Total	1,04,885	1,17,679

Source : Bureau of Economics and Statistics, Trivandrum.

2. Cashew Cultivation

2.1 In Kerala, cashew is grown mostly in poor soils, where no other crop can be profitably grown. A major part of the cashew plantations in the state are located in hill-slopes, where the soil is largely lateritic. It is a humid tropical crop, highly drought resistant and hardy. It is grown as a rainfed crop in almost all the cashew-growing states in India. It is grown upto an elevation of about 700 metres.

2.2 The existing plantations are almost entirely raised from seed and most of the trees are genetically poor. Consequently, the production in the existing plantations is extremely low. Except for dibbling the seed with little care, practically no other orchard management practices are followed. In recent years, however, more attention is paid in the selection of seed materials, planting and aftercare. A few high yielding varieties have been identified in the Cashew Research Stations and these are being multiplied under pre-release multiplication programme.

2.3 The seeds may either be dibbled in prepared pits or seedlings may be raised in polythene bags in a nursery and planted in the main field

2.9 There are a number of pests affecting cashew, the most serious among which is the Tea mosquito (*Helopeltis antonii*). It attacks the inflorescences and tender shoots, which dry up as a result. It is estimated that 25 — 50% of the crop is lost as a result of the attack of these pests. Recent researches have shown that this pest can be effectively controlled by timely sprayings of insecticides.

2.10 The processing of cashewnut involve roasting, shelling, peeling, grading and packing. The cashew shell contains a phenolic compound which find use in several industries. If this oil is to be extracted, special types of roasting machines are necessary. The peeled kernels are separated into a number of grades depending upon the number of kernels required to make a pound. The recognised grades for whole kernel are 210, 240, 280, 320, 400 and 450. The graded kernels for export are packed in 4 gallon tins and sealed under inert gas (carbondioxide).

3. Cashew Industry

3.1 The cashew processing industry, was started in Kerala about 50 years ago and until recently India had almost a monopoly in the international trade in cashew kernal. There are at present about 250 cashew processing factories in Kerala giving direct employment to a lakh and a half persons. These factories require about 4.5 lakh tonnes of raw cashewnuts for working throughout the year. However, we are producing only about 1 lakh tonnes of rawnuts at present and we are depending upon the African countries for the remaining quantities of raw material. With the establishment of cashew processing units in some of the major producing countries, it has become difficult to import the rawnuts required for our processing factories.

3.2 Besides cashew kernels, cashew shell liquid is an important by-product, finding use in several industrial products. At present, only a very small part of the capacity for the production of cashew shell liquid is utilised, as there is only limited demand for it in other countries, where the industries based on this product are established.

3.3 Recent researches have shown that the papery covering over the kernel (testa) contains significant quantities of 'tannin' which can

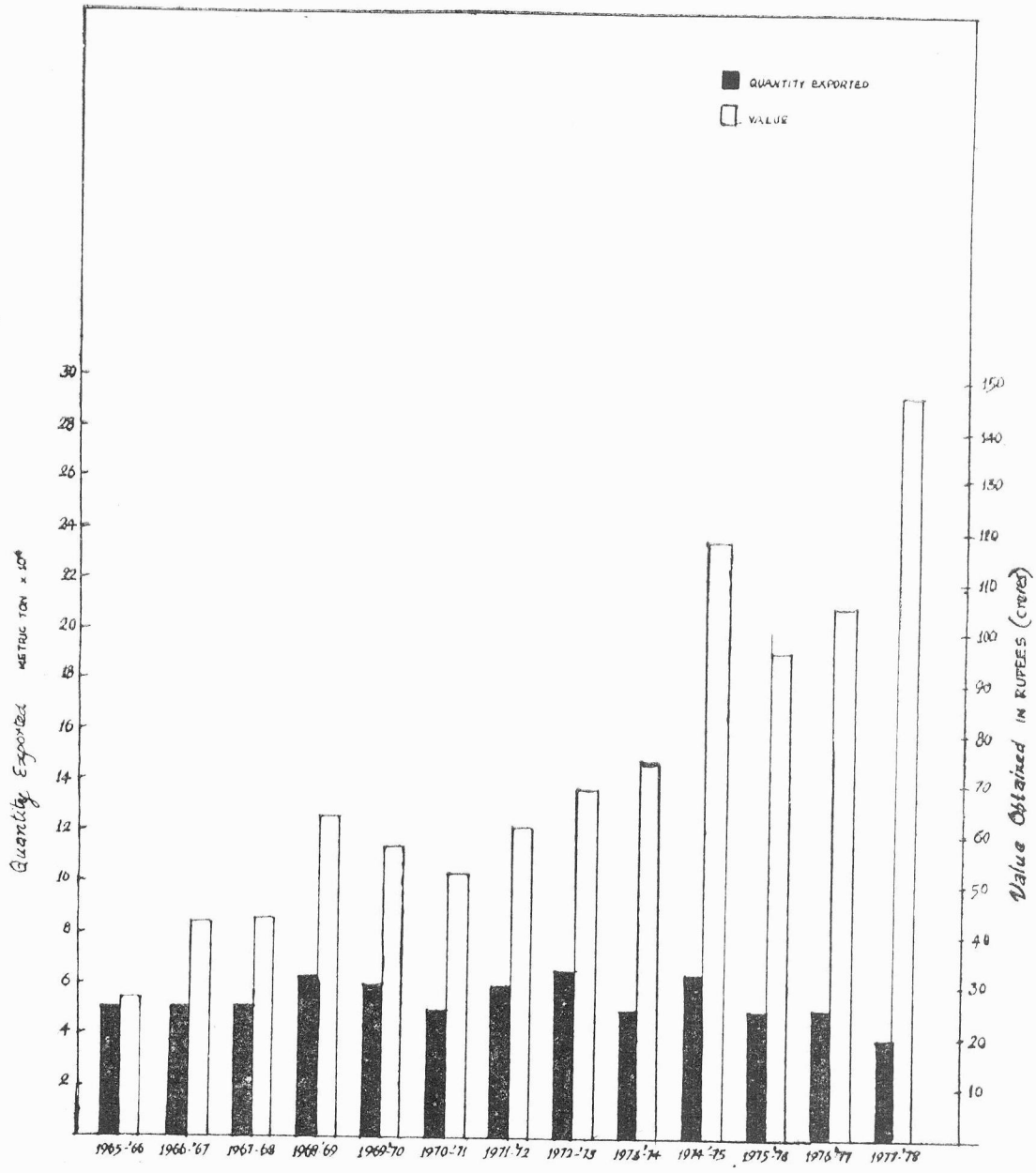

Fig. 1

Export of cashew kernels from India during 1965—'66 to 1977—'78

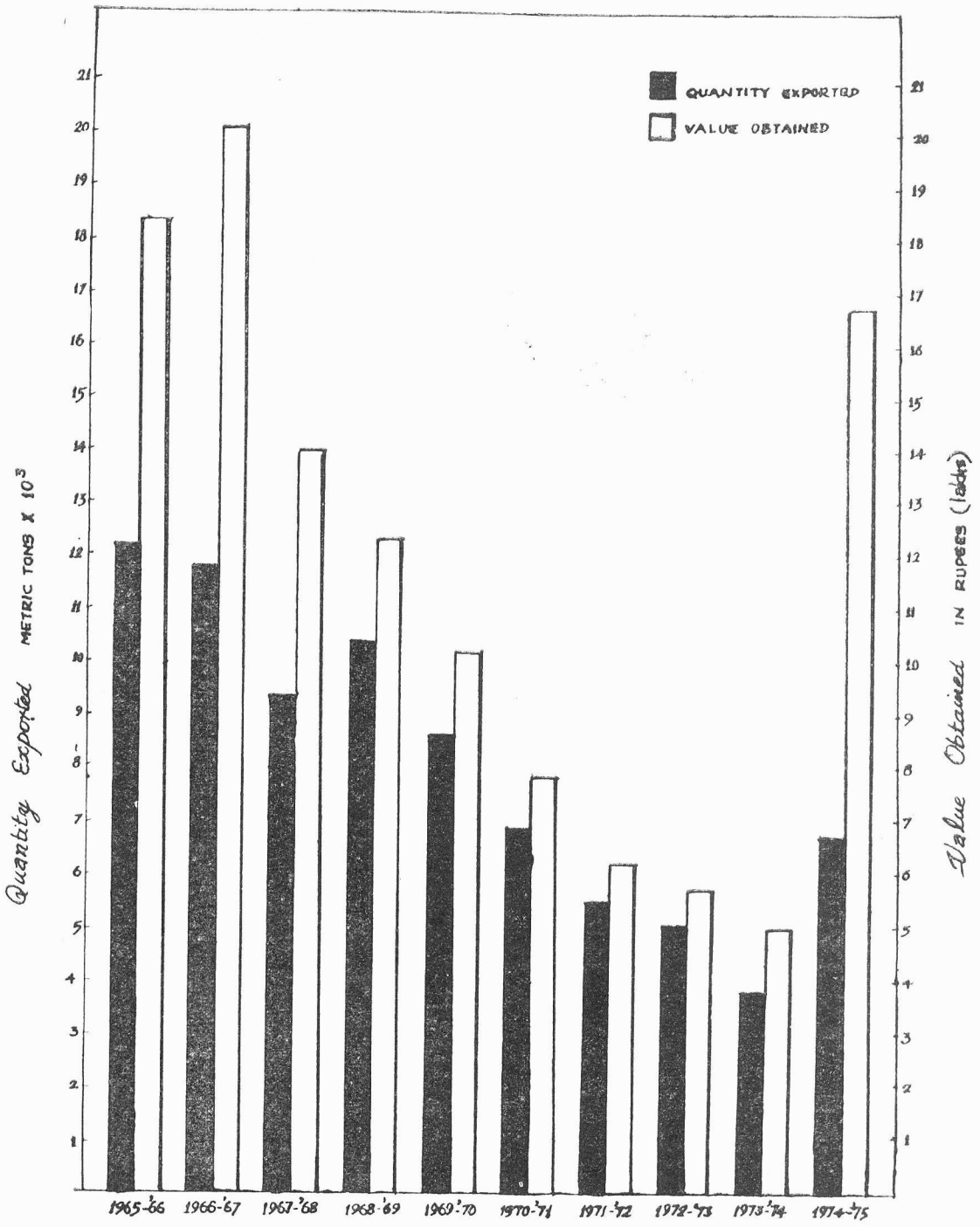

Fig. 2

Export of cashew shell liquid from India during 1965—'66 to 1974—'75

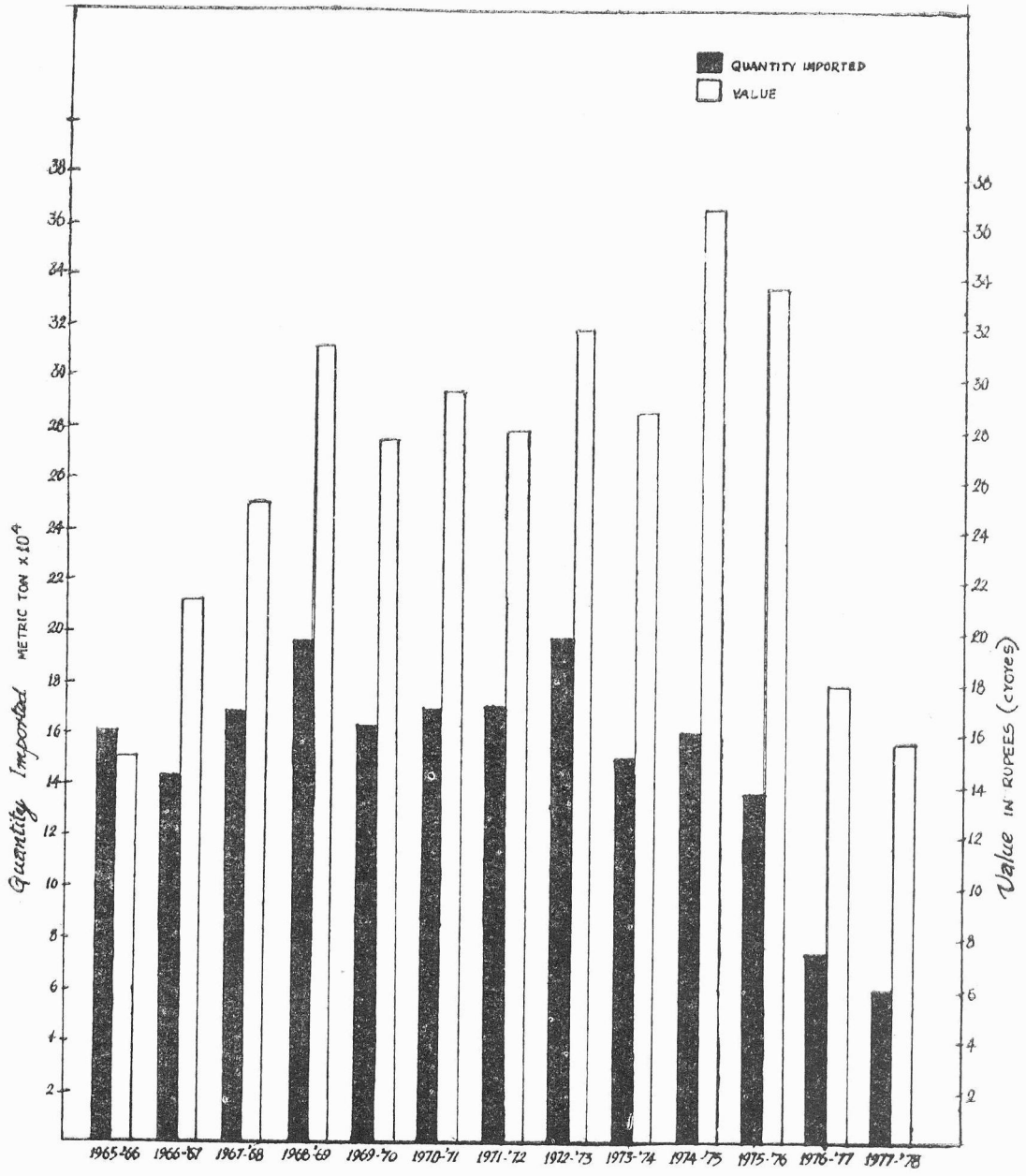

Fig. 3

Imports of raw cashewnuts to India during 1965—'66 to 1977—'78

Table 6. Import of raw cashewnuts to India during 1965-66 to 1977-78.

Year	Quantity in metric tonnes	Value in Rs. (000)
1965—66	1,60,636	1,50,603
1966—67	1,41,021	2,12,432
1967—68	1,68,218	2,50,837
1968—69	1,95,528	3,13,767
1969—70	1,63,426	2,75,994
1970—71	1,69,359	2,94,076
1971—72	1,69,985	2,79,060
1972—73	1 97,938	3,18,093
1973—74	1,50,249	2,87,985
1974—75	1,60,358	3,66,043
1975—76	1,37,196	3,35,578
1976—77	74,131	1,80,800
1977—78	60,194	1,57,189

(Source : Cashew Export Promotion Council, Ernakulam.)

It may be seen from the above tables that the internal production of rawnuts is only about one-third of the requirements of the processing industry. Import of rawnuts from other countries, apart from being a serious drain of our foreign exchange resources, is decreasing gradually with the development of the processing units in those countries and may completely cease in the course of the next few years.

5. The Present Position of Cashew Nut Production

6.1 Eventhough cashew is grown extensively in a number of states in India and occupies a pre-eminent place in the economy of Kerala, very little attention was paid until recent years in its culture. Infact, it is grown in the poorest of soils where nothing else can be grown. It is not treated as a crop requiring any attention in its culture and management. As a result, the present level of productivity of the existing cashew gardens is extremely low. A sample survey conducted by the Institute of Agricultural Research Statistics during 1960-61

6. Research on Cashew in India

6.1 It is apparent from the fore-going that there are several problems to be tackled, if the vital cashew industry is to survive. The first attempt in this direction was initiated by the ICAR in 1951 when it sanctioned an adhoc scheme for research on cashew with a central station at Ullal in Karnataka state and regional stations at Kottarakkara in Kerala state and at Vengurla in Maharashtra state. Another station was started at Bapatla in Andhra Pradesh and in Assam in 1955. Subsequently in 1962, the participation of the ICAR in financing the regional station at Kottarakkara was terminated when the State Government started a research station at Anakkayam in Malappuram district. In 1970, the All India Co-ordinated Spices and Cashewnut Improvement Project was sanctioned by the ICAR under which a co-ordinating centre was established at the CPCRI, Kasaragod with participating centres at Anakkayam / Mannuthy in Kerala, Vridachalam in Tamil Nadu, Vengurla in Maharashtra and Baptala in Andhra Pradesh. The results of research on cashew done during the past years under the above schemes are summarised in the following pages.

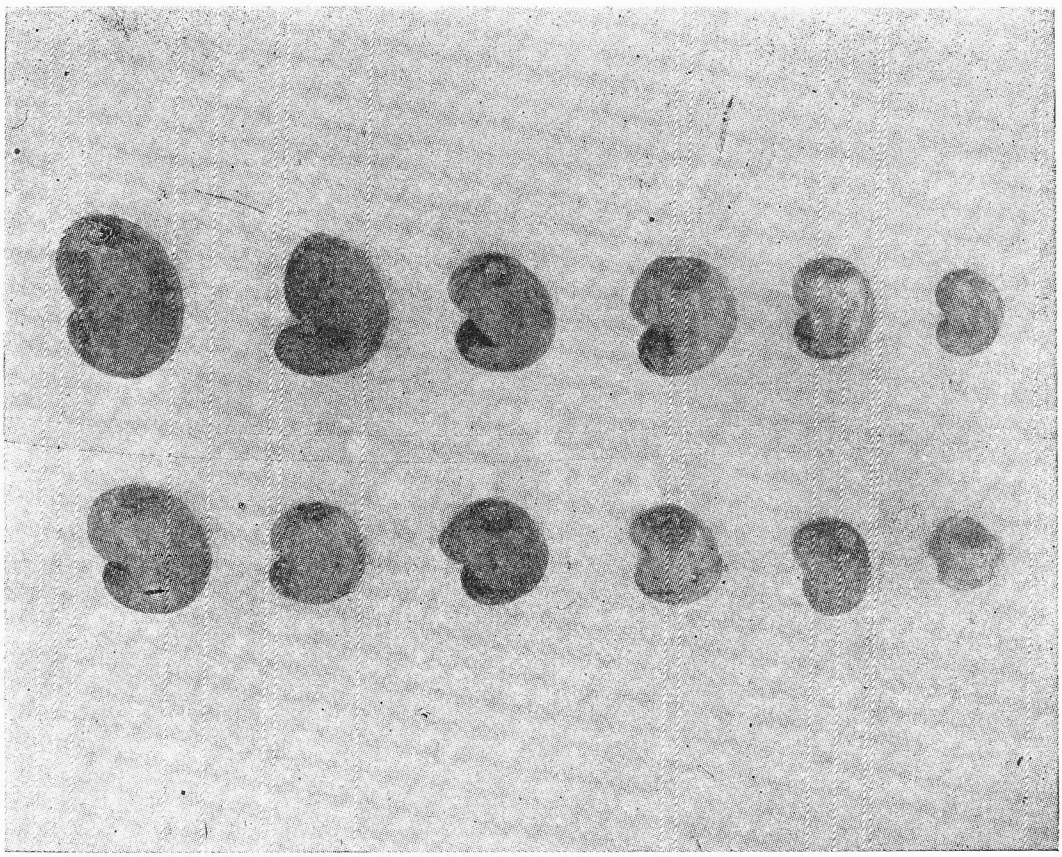

Fig. 4 (a) Nuts of different sizes and shapes

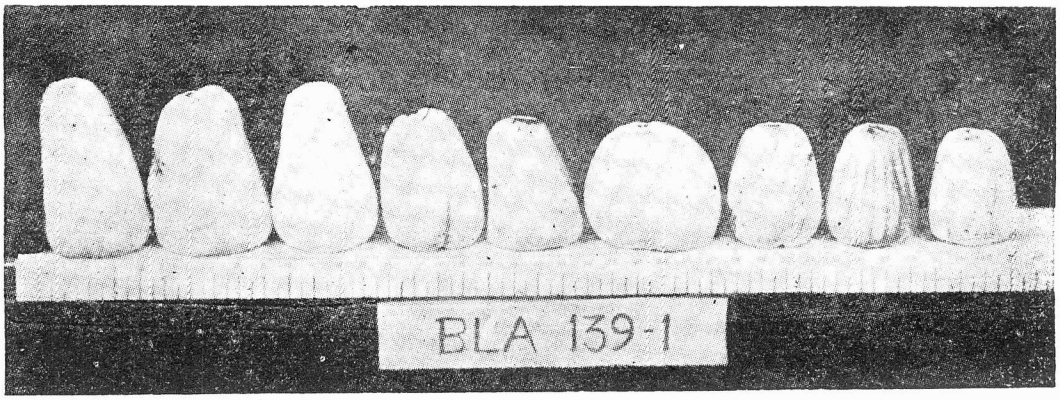

Fig. 4 (b) Cashew apples of different size and shape

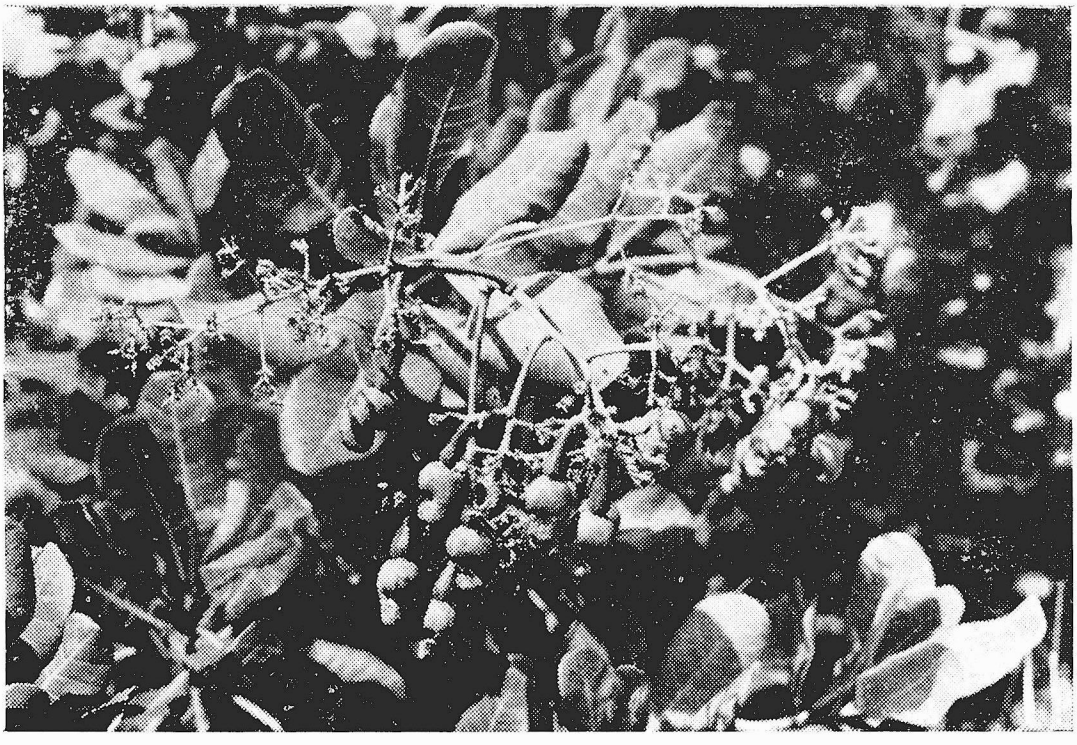

Fig. 5

Cashew inflorescence

between 9 a.m. and 11 a.m., while bisexual flowers opened between 2 p.m. and 4 p.m. They have also reported that it took 55 — 85 days from flowering to the maturity of nut.

2.2 Detailed floral biological studies were carried out by Madhava Rao and Vazir Hassan (1957) at Ullal (Karnataka state) in 1954—55. The main observation made by them are summarised below :--

2.3 There are mainly two active phases of growth—one from October to January and another between March and May. 84% of the shoots flowered between December—February while the rest did not flower. On an average, it took 32 days for the completion of flowering in a tree. The maximum flower production was between the later halves of December and January. On an average, a shoot produced 329 flowers. Nearly 96% of the flowers were staminate. Staminate flowers are produced throughout the blooming period of the tree, while 88% of the hermaphrodite flowers appeared between the second half of January and the first fortnight of March.

2.4 Panicles are produced on the terminal ends of the current season's growth, 45% of the panicles were conical, 40% irregular and 15% pyramidal. Colour of the panicles were a mixture of pink, white and green. The hermaphrodite flowers are slightly larger than the staminate flowers and there are indications of a better fruit set when the distance between the stigma and the anther is short.

2.5 The peak anthesis was between 9—11 a.m. Hermaphrodite flowers started opening from 9—10 a.m. and continued till 1 p.m. Staminate flowers opened from 9 a.m. and continued till about 3 p.m. Stigma was receptive throughout the day but looses it on the next day. Anther dehiscence commenced from 10—30 a.m. and pollen grains remained viable for a period of 48 hours. It took nearly 60 days from flowering to fruit maturity. The fruit set was only 3% of the hermaphrodite flowers. Spraying of water on panicles indicated some response to fruit set. Except black and red ants, no other insect was seen to visit the flowers.

2.6 Damodaran *et al.* (1965, 1966) carried out detailed studies on the floral biology of cashew at Kottarakara (Kerala) during 1961-62 season. Observations made by them are reproduced below :

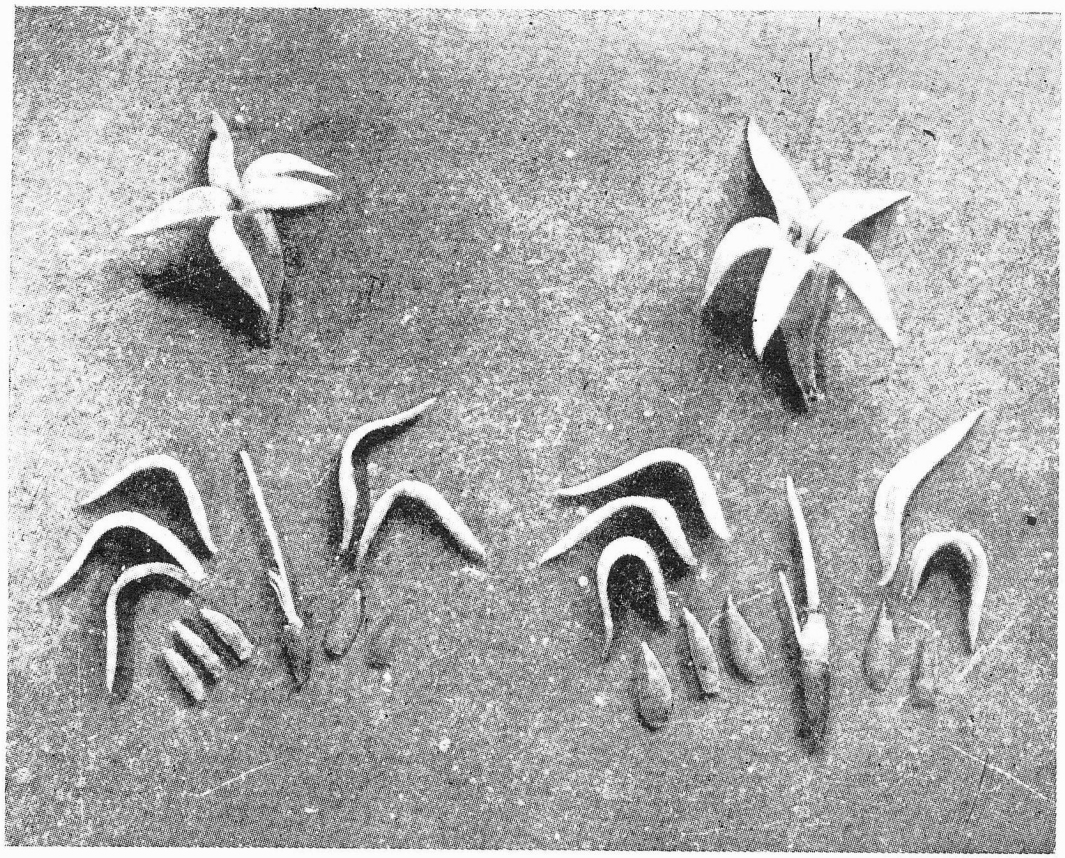

Fig. 6

Left: Male flower and its parts *Right: Bisexual flower and its parts*

2.11 The calyx has five free sepals, green in colour and oval in shape. There are 5 free petals, linear to lanceolate in shape white or creamy white in colour at the time of opening. Pink stripes appear on the petals, a few hours after opening and on the following day these become so pronounced that the whole flower appears to be pink. The petals become recurved within a short time after anthesis. The androecium consists of one fully developed stamen and 7 — 9 staminodes. The developed stamen has a pink anther with two lobes (Fig. 2). In one tree introduced from Tanganyika the colour of the anther was yellowish white. The staminodes have only short filaments and are concealed in the lower half of the open flower. The developed stamen in the hermaphrodite flower has only a short filament and its anther is far below the level of the stigma. The ovary is superior, reniform in shape and monocarpallate. The style is thick, tapering towards the end with slightly flattened stigma.

2.12 *Sex ratio.* The proportion of perfect flowers was found to vary considerably even between panicles on the same tree. However, some of the trees consistently produced a higher proportion of perfect flowers as compared to some other trees. The percentage of perfect flowers in the case of 26 trees varied from 0.45 to 24.9.

2.13 In order to find out whether there is any correlation between the sex-ratio and the yield of nuts, these were compared in the case of 18 trees which yielded during 1961—62. The data are given in table 8.

Table 8. Proportion of perfect flowers and yield of nuts in 18 trees.

Sl. No.	Tree No.	Mean percent of perfect flowers	Gross yield of nuts in grams	Sl. No.	Tree No.	Mean percent of perfect flowers	Gross yield of nuts in grams
1.	27 A	0·45	720	10.	11 A	7·9	2030
2,	19	0·75	805	11.	29	8·6	1580
3.	13 A	1·4	170	12.	28 A	11·3	420
4.	18	1·9	925	13.	8 A	12·3	1160
5.	12	2·1	986	14.	10 A	12·8	392
6.	14 A	2·2	2020	15.	7	14·8	1215
7.	9 A	4.1	512	16.	33	19·7	190
8.	15 A	5·0	605	17.	31 A	19·8	1442
9.	32	7·6	1580	18.	30 A	24·9	4059

Coefficient of correlation +0.39

Table 10. Intensity of dehiscence of anthers at different times of the day.

	Mean per cent of flowers with dehisced anthers.									
8·00	8·30	9·00	9·30	10·00	10·30	11·00	11·30	12·00	1·00	2·00
8·30 AM	9·00 AM	9·30 AM	10·00 AM	10·30 AM	11·00 AM	11·30 AM	12·00 AM	1·00 PM	2·00 PM	3·00 PM
Shady side	2·4	7·2	22·4	18·0	23·6	23·2	8·8	1·2	0·4	2·0
Sunny side	5·2	13·6	24·4	26·4	18·0	8·8	2·0	0·4	0·4	0·4

It is apparent from table 10 that the peak period of dehiscence of anthers was between 9-30 a. m. and 11-30 a. m. The rate of dehiscence was slightly higher on the sunny side till about 10-30 a. m. as compared to that on the shady side.

Receptivity of stigma

2.16 Receptivity of stigma was studied by carrying out controlled pollination at specified time before and after anthesis and finding out the extent of fruitset in each case. The number of flowers pollinated in each stigmatal age group, the number which set fruit and the percentage of fruit set are given in Table 11.

Table 11. Period of receptivity of stigma.

Stigmatal age group	No. of flowers pollinated	No. which set fruit	Percentage of fruit set
One day before anthesis	11	2	18·2
At 12 N of the day of anthesis	12	9	75·0
At 3 p. m. on the day of anthesis	60	27	45·0
One day after anthesis	14	3	21·4
Two days after anthesis	16	2	12·5
Three days after anthesis	15	Nil	0·0

The data show that the stigma of the cashew flower was receptive even one day before anthesis and continued to be so for about 48 hours after

day of opening of the flower. However controlled pollination did not indicate any degree of self-incompatibility in cashew. Wind seems to be the predominent agency for pollination, as insect visitors were found to be few and far between.

d) *Staminodes*

The staminodes were found to contain some viable and normal pollen grains, but their role in pollination under natural conditions was found to be practically nil.

2.18 *Fruit set and fruit drop*

In about 7 days after pollination, the ovary swells and attains the size of a 'Pea'. A large proportion of the perfect flowers drop off before 'Pea' stage either due to lack of pollination or due to natural drop. In order to study the extent of fruit-set and fruit drop, in trees with high and low sex ratio, five panicles each were labelled on two trees and data were collected on fruit set and fruit drop which are presented in Table 13.

Table 13. Fruit set and fruit drop in cashew.

Tree No.	No. of flowers			No. of flowers set fruit	No. of fruits dropped			No. of mature fruits harvested
	Panicle No.	Perfect	Staminate		Fruits below 5 mm length	Fruits between 5–10 mm	Fruit above 10mm	
28	1	24	978	7	2	2	1	2
	2	73	1418	32	17	9	1	5
	3	31	950	13	5	4	1	3
	4	18	848	1	1	1	–	–
	5	26	810	12	8	2	1	1
Mean per panicle	34·4			13	6·6	3·4	0·9	2·2
Percentage				37·8				6·4
38	1	85	595	22	11	3	1	7
	2	59	504	23	13	7	0	3
	3	58	253	24	15	8	1	2
	4	49	253	3	7	1	1	0
	5	32	282	7	6	1	0	0
Mean per panicle		52·6	—	17	10·4	3·6	3·6	2·4
Percentage		32·3	—	—	—	—	—	4·3

2.23 Studies conducted by Pavithran and Raveendranathan (1976) at the Calicut University on the influence of Gibberellic acid at 50 ppm and IAA 100 ppm on sex expression in cashew indicated that foliar spray of GA influenced the production of staminate and hermophrodite flowers during the mixed phase of flower opening. It also influenced the sex ratio per penicle from 449 males : 1 hermaphrodite to 35 male : 1 hermaphrodite. IAA did not show any positive effect on these characters.

3. Improvement by selection

3.1 Cashew is a highly cross-pollinated crop and the existing plantations were almost exclusively raised from seeds. This accounts for the large variation in economic characters found in the existing gardens. In the sample survey conducted by the Institute of Agricultural Research Statistics on the production of cashewnut in Kerala, it was revealed that plants grown under the same environmental conditions exhibited wide variation in yield and other economic characters. Therefore, the first attempt in the improvement of this crop was to survey the existing cashew plantations, collect those possessing economic characters and evaluate them and select and mutiply them vegetatively. Collection of germ plasm and selection of superior types were undertaken in all the research stations.

3.2 Eightyeight types including some exotic types were under evaluation at the cashew Research Station, Anakkayam from 1963 onwards and on the basis of the yield and other economic characters, the following types have been indentified as superior. (7)

Table 15. Showing yield and other economic characters of promising types among the indigenous collections at the C.C.R.S. Ullal.

Sl. No.	Selection No.	Average yield per year (kg)	Average weight of fruit (g)	Colour of fruits
1	2/2	4·48	47·3	Blood Red
2	9/2	2·51	—	—
3	1/3	2·04	96·3	Reddish yellow
4	9/3	5·72	—	—
5	9/5	2·31	63·3	Yellow
6	5/23	2·61	—	—
7	9/39	2·40	—	Yellow with green streak
8	1/40	5·04	81·1	Red with green streak
9	5/57	2·25	36·3	Blood red
10	3/61	2·03	46·5	Blood red
11	1/63	2·49	—	—
12	2 65	5·78	—	—
13	6/65	2·86	45·8	Yellow with green streak
14	7/65	3·18	50·3	Yellow
15	9/66	2·84	—	—
16	3/67	3·68	—	—
17	2/97	3·13	—	—
18	3/108	3·13	—	—
19	7/108	2·71	—	—

It may be seen from the above data that the mean yields of the selections are not high when compared with the yields obtained in Kerala. Selection No. 2/97 (Kottarakara Type) gave a yield of 11.9 kg nuts, followed by 10.15 kg from selection No. 3/108 (Gubbi) during 1971. Selection No. 61 (Alangudi—Madras), 103 (Sonepat—Andhra) and No. 46 (Taliparamba) are superior among the indigenous types.

3.5 Among the 30 clonal selections, planted in 1956, the following fifteen have been found to be promising and the economic characters of these are given below. (17).

Table Mo. 17. Economic characters of promising selections from the germplasm collections at the Cashew Research Station, Bapatla.

Sl. No.	Selection No.	Place of collection	Age of tree	Mean yield (kg)	Average of nuts (grams)	Colour of of apple	Shelling percentage.
1.	3/3	Simhachalam	12	15·1	6·3	Yellow	29·7
2.	9/8	Epurupalem	14	13·5	6·0	,,	30·7
3.	13/6	Chendiputtuka	12	13·3	6·3	,,	32·2
4.	13/14	Sanyasiputtuka	12	11·1	7·6	Crimson	27·3
5.	4/3	Araku	12	10·8	5·5	,,	27·3
6.	13/12	Sanyasiputtuka	12	10·8	5·0	,,	—
7.	9/3	Anakapally	13	10·7	7·3	,,	30·9
8.	13/2	Kodur	14	10·6	5·5	Yellow	28·3
9,	2/4	Nathavaram	13	10·4	5·6	,,	29·6
10.	9/10	Darivadakothur	14	10·0	6·2	,,	31·7
11.	12/16	Chendipottuka	12	10·0	5·8	,,	29·5

According to the Annual report of the station for 1977—78 type No. 9/8 Epurupalem and 3/3 Simhachalam are the best.

3.7 Besides the above, 51 types which gave yields ranging from 5 to 7.5 kg of nuts and possessing other economic characters have been indentified and are being studied further.

3.8 Among the 46 types raised from seeds obtained from other states in India and from exotic sources, the following types gave high yields:—

Type No.	Yield (kg)	Size of nut
4/2 Orissa	18·7	Medium
5/4 Orissa	15·7	Medium
3/5 Ceylon	10·6	Small

3.9 On the basis of the performance of the selection and hybrids so far studied at the station, the following varieties have been recommended for pre-release multiplication by the workshop of the All

3.12 *Central Plantation Crops Regional Research Station, Vittal.*

Eventhough, there are 63 accessions at the CPCRI, Regional Station at Vittal, no selections have been made so far here, as the plants are too young to be evaluated. At the recently started centre at Bhubaneswar the germplasm collection comprised of 47 types. These are too young to be evaluated (39)

3.13 *Comparative yield trials of high yielding types :*

Under the All India Co-ordinated spices and Cashewnut Improvement Project, a yield trial including four best selections or hybrids from each of the four Cashew Research Stations at Anakkayam, Vriddachalam, Bapatla and Vengurla have been laid out in all the Co-ordinating Centres. Seeds are used as the planting material. The varieties or types included in this trial are :—

Anakkayam	Vengurla	Vriddachalam	Bapatla
H—4 7	Ansur—I	M-10/4	Tree No. 1
K—10—2	Vengurla—37/3	M—6/1	,, 40
BLA—139—1	Vengurla—36/3	M-44/3	,, 56
BLA—256—1	Sawanthwadi	M-76/1	,, 273

The trial is in its early stage and the evaluation is in progress.

4. Improvement by Hybridization and Selection

4.1 Eventhough there is a wide range of variation in respect of most of the economic characters in the existing population, it is rather difficult to find a single tree, possessing all the desirable characters in a high degree. Breeding of perennial crops is laborious, time consuming and present many technical problems. The trees are highly heterozygous and the selection of parent trees for specific economic characters does not ensure that the progeny having the desired character can be obtained in the F_1 or F_2 with any degree of precision. However, since cashew can be propagated by vegetative means, selection can be made in the F_1 or F_2. The strategy in the breeding programme for cashew will be to make crosses involving as many parental combinations as possible, having the desired characters and make a rigorous screening in the F_1 or F_2 and multiply the selected progenies by vgeetative methods. Unlike in many

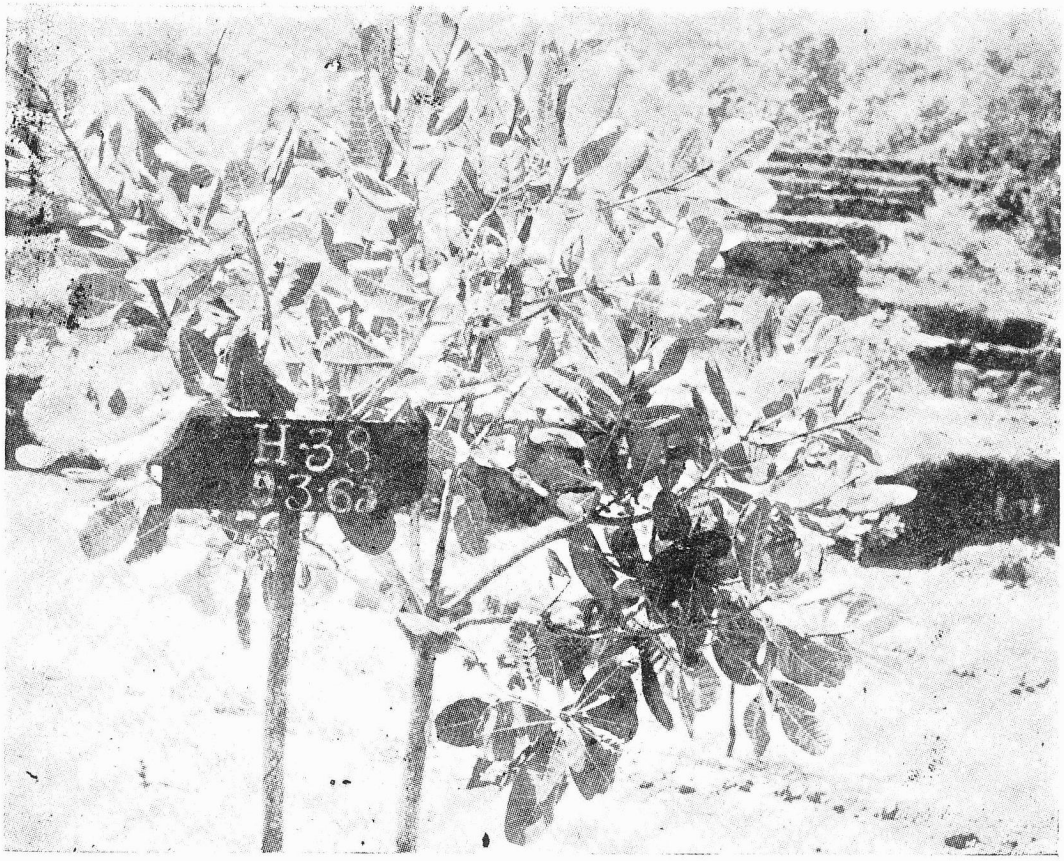

Fig. 7

H—3—8. Hybrid progeny which flowered in 18 months

4.2 Hybridization work at Cashew Research Station, Anakkayam.

Hybridization in cashew was started at Cashew Research Station, Kottarakkara in 1963. Crosses were made between 4 parental combinations, with a view to combine the prolific bearing characters of three types and the large nut size of three other types. The cross combinations and the number of F_1 progenies raised are given below:- (4).

Table No. 19. Characters of parent trees and cross combinations of the first set.

Female parent	Main character	Male parent	Main character	No. of F_1
1 Tree No. 12 A	Prolific Bearer; but small nuts	Tree No. 27	Large nut size	12
2. ,,		Tree No. 8	,,	8
3. Tree No 30	,,	Brazil-18	,,	19
4. Tree No. 30 A	,,	,,	,,	11

Among the 50 F_1 progenies, the following were good yielders, producing medium sized nuts:-

Table No. 20. Characters of the promising hybrids of the first set.

Hybrid No	Year of planting	Parental combination	Mean yield 5th—8th year (kg)	Highest yield so far (kg)
H — 3 — 17	1963	30 × Brazil 18	13·192	15·800
H — 1 — 4	,,	12 A × 27	7·600	10·850
H — 4 — 7	,,	30 A × BRZ-18	14·745	22·050
H — 3 — 13	,,	30 × BRZ-18	7·882	12·050

4.3 Some of the hybrid progenies flowered and set fruits when they were only 18 months old. The hybrid H—4—7 gave a yield of 22.050 kg of nuts in the 6th year of orchard life. Based on the yield and other economic characters of the above hybrids, H—3—17 and H—4—7 have been recommended for pre-release multiplication.

4.4 *Progeny performance :* Based on the initial evaluation of the types in the germplasm collection and of the hybrids, clonal progenies of

Fig. 8

ALGD—1—1. High Fruit-set

Table 22. Showing details of crosses made and F_1 progenies planted at Anakkayam / Mannuthy.

Cross No.	Year of crossing & planting	Female parent		Male parent		No. of F_1 progenies
		Type No.	Character for which selected	Type No.	Character for whieh selected	
H- 1	1963	12 A	Prolific bearing	27	Large nut size	12
H- 2	1963	12 A	,,	8A	,,	8
H- 3	1963	30	,,	Brazil-18	,,	19
H- 4	1963	30 A	,,	Brazil-18	,,	11
H- 5	1966	51	Nut size	22	Good fruit set	1
H- 6	1966	56	,,	22	,,	2
H- 7	1969	H-4-7	High yield	K-30-1	Giant nuts	24
H- 8	1970	T-20	,,	K-10-1	Large nut & good yield	19
H- 9	1971	T-20	,,	Brazil-18	Large nuts	8
H-10	1971	H-4-7	,,	,,	,,	6
H-11	1972	K-10-1	Large nuts	T-20	High yield	22
H-12	1972	K-10-2	,,	H-4-7	,,	10
H-13	1972	H-4-7	High yield	T-20	,,	14
H-14	1972	T-20	,,	H-4-11	High sex ratio	26
H-15	1972	T-20	,,	K-10-2	Large nuts	9
H-16	1972	K-30-1	Large nuts	H-4-7	High yield	1
H-19	1972	ALGD-1-1	High fruit set	K-30-1	Large nuts	10
H-20	1972	H-3-13	High sex ratio	K-30-1	,,	14
H-21	1972	BLA-139-1	Early, short flowering phase	K-30-1	,,	4
H-22	1972	BRZ-9-1	High shelling	K-30-1	,,	3
H-23	1972	ALGD-1-1	,,	H-3-13	,,	26
H-24	1972	ALGD-1-1	,,	BLA-139-1	,,	12
H-25	1972	ALGD-1-1	,,	BRZ-9-1	,,	19
H-26	1972	(BLA-139-1 (H-3-13)	,,	H-3-13 BLA-139-1	,,	8
H-27	1972	BRZ-9-1	,,	BLA-139-1	,,	12
H-28	1972	BRZ-9-1	,,	H-3-13	,,	6

1	2	3	4	5	6	7	8
15	Moz × 5/61	183	30·0	192	1·05	77	0·42
16	do	179	28·1	187	1·04	48	0·27
17	do	167	26·0	113	0·68	77	0·46
18	Moz × 9/65	153	29·3	155	1·01	118	0·77
19	do	120	28·0	73	0·60	67	0·56
20	Moz, × 9/65	153	29·5	89	0·57	97	0·62
21	Lindi × 1/10	205	20·6	56	0·27	107	0·52
22	do	200	26·6	125	0·63	78	0·39
23	do	100	31·9	42	0·42	43	0·43
24	do	163	30·3	90	0·55	125	0·76
25	Lindi × 1/40	163	29·0	71	0·43	35	0·21
26	do	143	29·0	64	0·44	59	0·41
27	Sindi × 5/16	159	26·5	76	0·48	43	0·27
28	Lindi × 5/61	183	24·5	226	1·23	256	1·39
29	do	220	30·0	280	1·27	471	2·14
30	Lindi × 5/61	250	29·7	348	1·39	702	2·81
31	do	210	28·6	278	1·32	176	0·83
32	do	166	30·6	87	0·52	—	—
33	Nairobi × 9/43	172	27·6	143	0·83	306	1·77
34	Nairobi × 9/61	164	28·8	208	1·27	73	0·44
35	do	215	29·0	122	0·56	48	0·22
36	do	205	28·0	229	1·11	374	1·82
37	do	185	24·5	175	0·95	96	0·34
38	Moz. × 1/63	178	25·6	88	0·49	127	0·71
39	do	174	31·9	72	0·41	154	0·88
40	do	144	29·4	104	0·72	173	1·20
41	do	230	23·0	47	0·20	92	0·45
42	Moz. × 1/61	145	28·3	75	0·52	48	0·33
43	Brazil — selfed	184	29·6	2	0·01	—	—
44	Pigmented--selfed	105	19.4	69	0·65	114	1·08

4.8 *Hybridisation work at C.R.S. Bapatla*

Hybridization between selected parents were taken up in 1957—'58 and 1958—'59 and 178 F_1 progenies derived from 61 parental combinations were under evaluation at this station. Among these, 44 types are very

Table 25. Important characters of the F_1 progenies derived from the different crosses:-

Sl. No.	Hybrids	No. of trees	% of perfect flowers	% of fruit set	Fruit set per panicle	Av. wt of apple in (g)	Av. wt. of nuts in (g)	Yield of nuts in kg (mean)	% of juice
1.	Midnapur red x Veture 56	9	21·12	5·11	7·6	56·26	6·35	10·782	72·00
2.	WBDC V x Ansur No. 1	9	23·94	4·76	7·8	60·08	6·90	6·667	75·95
3.	WBDC V x Veture 56	7	29·33	3·55	7·5	62·84	6·72	7·120	76·84
4.	Mysore Kotekar x Veture 56	7	25·63	3·71	6·5	53·09	5·96	6·561	75·52
5.	Ansur Early x Mysore Kotekar 1/61	4	29·12	3·38	5·6	39·64	4·19	8·190	79·05
6.	Ansur early x Mysore Kotekar 1/61	1	27·74	4·61	7·7	35·84	4·54	9·416	74·30
7	Mysore Kotekar 1/61 x Ansur Early	3	35·94	2·57	8·6	35·90	4·21	6·493	74·83
8.	Mysore Kotekar 1/61 x Ansur No. 1	3	14·95	8·31	6·8	38·06	5·04	5·775	72·25
9.	Ansur No. 1 x WBDC V	4	24·14	5·24	6·8	51·90	6·49	6·060	68·76
10.	Ansur Early x Midnapur Red	2	30·16	5·27	6·3	56·30	5·47	6·920	79·84
11.	Midnapur Red x Ansur No. 1	2	19·51	5·82	6·0	36·75	5·51	N. A.	71·95
12.	Veture 50 x WBDC VI	2	17·00	5·82	5·7	64·50	5·51	6·015	69·61
13.	Ansur No. 1 x WBDC VI	1	18·27	5·30	4·8	59·50	6·90	9·949	73·12
14.	Ansur No. 1 x Veture 56	1	26·60	3·13	5·2	77·76	9·66	9·959	77·36
15	Mysore Kotekar 1/61 x WBDC VI	1	29·75	5·52	7·6	49·44	6·00	5·704	76·54

4.13 *Hybridisation at C. R. S., Vridhachalam:-*

This line of work was started only from 1973 and 134 hybrid progenies, involving 5 parent trees and 10 parental combinations were planted in this station. They are under evaluation.

5. Hybrid Vigour

5.1 A trial to find out whether cashew exhibits hybrid vigour was laid out in 1968 at the Cashew Research Station, Anakkayam. For this, selfed, crossed and open pollinated nuts were collected from the same tree and sown in a replicated trial. Growth and yield data of the progenies derived from nuts of the above three categories were collected, which is given below: (24)

Table 28. Growth and yield data of trees raised from selfed, crossed and open pollinated seeds in cashew.

Treatment No.	Treatment	Girth (Mean/Tree)			Yield (kg) (Mean/Tree)	
		Girth of the trunk (cm)	Height (cm)	Spread (cm)	1971–72	1972—73
1.	Selfed progeny	40·00	395·42	345·06	0·550	0·627
2.	Hybrid progeny	50·83	442·83	412·08	1·263	2·391
3	Open pollinated progeny	47·75	432·50	382·92	0·500	1·116
	C. D. @ 0·5	8·11	NS	NS	0·578	1·147

It is apparent from the above data, that the hybrid progenies were more vigorous than selfed or open pollinated progenies eventhough there was no statistical significance, as far as growth parameters are concerned. In yield however, the hybrids are significantly superior to the selfed or open pollinated progenies. This indicates that cashew, like many other crops, exhibits the phenomenon of hybrid vigour.

3.2 At Kottarakkara, a study was conducted in 1959 to determine the period of viability of cashewnut under metallic bin storage. Monthly sowings were done during a period of 11 months. The data are given in Table 29. (20)

Table 29. Percentage of germination of seednuts stored for different period.

Month of sowing	Period of storage (months)	Germination %
May	1	84
June	2	82
July	3	80
August	4	73
September	5	60
October	6	36
November	7	26
December	8	10
January	9	0
February	10	6
March	11	6

The data show that there was progressive decrease in percentage germination of seednuts as the period of storage increased and that after the 6th month the germination was less than 50%.

3.3 Germination trial—heavy and light seednuts:

A trial was conducted with water-sinking and water-floating seednuts to find out the difference in germination and the time taken for the same. The results showed that 92% of the heavy nuts germinate within a period of 14 to 17 days while water-floating nuts recorded only 64% germination within a period of 14—22 days. (20)

3.4 *Transplantation trial of seedlings*

Transplantation of cashew seedlings generally results in the mortality of a good number of them and in order to find out whether the cutting back of the shoot and root results in a better degree of survival

Table 30. Percentage of success in air-layering done in different months.

Month	No of layers done	No. of established after separation.	Percent of success
March	10	9	90
April	10	9	90
May	10	7	70
June	10	3	30
July	10	4	40
August	10	2	20
September	10	5	50
October	10	5	50
November	10	8	80
December	10	7	70
January	10	8	80
February	10	10	100

It is clear from the above table that November to April is the best season for air-layering in cashew, giving 80 to 100 percent success. Layering done in February-March will enable detachment and planting of the layers in May and June. (20)

4.2 Trials at Kodur (Naik, 1948) showed that air-layering and inarching were the best methods of vegetative propagation for cashew, though side grafting, shield and patch budding were also possible. Hayes (1957) stated that air-layering was the best method of vegetative propagation of cashew. Similar results have been reported by Khan (1957) Rao (1958) Nair and John (1958), Kurup and Viswanathan (1970) and Muthappa Rao (1970).

4.3 The optimum time of layering varied from place to place. Rao (1958) obtained maximum success during the hot weather period.

4.4 Trials on the use of 'Alkathene' film for layering instead of gunny piece showed that the film reduced considerably the time taken for rooting, besides doing away with daily moistering of the layered shoots in the case of gunny wrappers.

4.5 Experience has shown that even though air-layering of cashew is quite easy and gave a high percentage of rooting a number of rooted

of rooting and subsequent sprouting of the layers, eventhough the differences were not significant. However, there were significantly larger number of roots per layer and the average length of roots was higher under the above treatment as compared to the rest. Besides, the number of days from layering to root emergence was also less.

(ii) Beneficial effects on increasing the rooting of air-layers by the application of plant growth regulators have been reported by a number of workers. Rao and Hassan (1957) found that the application of SeradixA increased the number of roots and better rooting of air-layers in cashew.

(iii) Acharya and Dash (1972) obtained 84.6% success in cashew layers by treating with IBA 800 ppm as compared to 46.2% in the control.

4.7 *Effects of age of parent tree and the type of shoot on rooting of air-layers:—*

Trees of 3 different age groups and two types of shoots viz., those which flowered during the season and those which did not, were included in the trial. A split plot design with the age of parent trees as main treatments and type of shoot as sub treatment was adopted. There were five replications. The percentage of rooted layers, the average number of roots per layer and the average length of roots per layer are given in Table 32 below:

Table 32. Effects of age of parent trees and type of shoot on the rooting of air-layers.

Treatment	Percent or rooted layers.	Average no. of roots per layer.	Average length of roots per layers
Main treatments			
Over 20 years	66	8·7	2·3
5 years	72	6·5	2·4
3 years	70	6·5	2 3
There was no significant difference betweer treatments.			
Sub treatments			
Flowered	58·7	7·4	2·5
Non-flowered	80·7	7·1	2.2
C. D. at 5% level	16·72	—	—

Sub treatment	Per cent of rooted layers	Average No. of roots per layer	Average length of roots per layer
Thick	68	6·0	2·6
Medium	67	5·0	2·5
Thin	58	4·5	2·4
C. D. at 5% level		0·51	

The results indicate that there was no significant differences between the 4 media tried. Among shoots of different thickness, thick shoots produced a larger number of roots per layer. The layers produced from thick shoots were found to be more vigorous in the first year of its growth in the field (20).

Effect of different grades of polythene film on the rooting of air layers.

4·9 Polythene film of 200, 150 and 100 gauge thickness were compared in this trial, in a randomised block design with 5 replications. Besides collecting data on the extent and intensity of rooting, observations were made on the damage to film from birds insects etc. and also on the penitration of roots through the film. The results are presented in table 34.

Table 34. Effects of different grades of polythene film on the rooting of air layers.

Treatments	Percentage of rooted layers	Percentage of sprouted layers	Average No. of roots/layer	Av. length of roots per layer	Remarks
200 g film	74	62	9·95	4·28	Little damage to film.
150 g.	72	52	6·95	3·58	
100 g.	74	58	5·29	3·06	Some serious.
C. D at 5%			2·23	0·50	

The results of the trial show that 200 gauge film is superior to others in respect of the average length of roots per layer. Film of 150 gauge and 100 gauge are easily damaged by birds, insects etc. A minimum thickness

Table 35. Shoot and root-growths of seedlings and air-layers of different age-groups.

Particulars	6 months		1 year		2 year		3 year	
	Seed-lings cm	Layer cm	Seed-lings cm	Layer cm	Seed-lings cm	Layer cm	Seed-lings cm	Layer cm
Shoot								
Ht. of shoot from collar	35	40	94	76	174	181	215	172
Shoot spread	—	—	22×11	33×15	66×39	129×61	165×108	195×139
Branching order	1st	2nd	2nd	2nd	2nd	3rd	4th	4th
Girth at collar	3	3·8	6·5	6·0	12·3	11·5	22·5	20·5
Root								
Depth of root	7	6	12	22	12	38	38	39
Thickness of main root	2·5	2	4	3·4	6·5	9·0	9·0	6·1
Length of main root	16·5	15	22·4	59·0	59·0	60·0	60·0	96
No. of secondary roots	3·0	3	2	4	4·0	10·0	10	15
Branching order of roots	1st	1st	1st	2nd	2nd	2nd	2nd	3rd
Root spread		...	4·5×2	17·5 × 1	33×5	50×34·5	100×90	98×92

The above data indicate that the layers have a better root system than the seedling plants of same age. The shoot growth also is better in the case of layers than the seedling plants except in respect of height. (20)

4.13 A comparative study of the root system of air-layersl seedlings and grafts upto 4 years of age was made at Ullal and the details of the root-system of 4 year old plants are furnished below : (Persona, correspondence).

Table 36. Comparative development of the root system of 4 years old layers, grafts and seedlings of cashew.

Type of planting material	Spread E. W. × N. S.	Depth cm	Length cm	No. of main roots	No. of secondary root
Layers	334·75 × 251·65	270	188	7	26
Inarch grafts	197·79 × 91·29	316	146	5	17
Seedlings	203·88 × 211·18	316	155	6	14

plants, rooting commenced within 22 days and these could be separated within 35 days. Cincturing at the node was found to induce quicker rooting than cincturing of shoots half an inch above or below the node. Application of Seradix A (a proprietory product containing NAA as active principle) gave indications of higher success, larger number of roots and better rooting in the months of June and July when the rooting was poor without treatment of Seradix. Among the 8 different rooting media tried, wood shavings, coconut husk, dust and sand were the best. (48)

4.16 A trial to study the effects of foliar spray of plant growth regulators on the rooting of air-layers was taken up in the Cashew Research Station, Ullal. Two chemicals, Naphthalene acetic acid and Indole-butyric acid were used separately and in combination as detailed below :—

Table 38. Showing the effects of plant regulator sprays on the rooting of air-layers.

Sl No.	Treatments	Average No. of roots	Average length of roots
1	NAA, 260 ppm	4·25	2·8 cm.
2	NAA, 520 ppm	1·5	2·57 ,,
3	NAA, 260 ppm + Sugar	3·0	2·00 ,,
4	NAA, 520 ppm + Sugar	8·0	4·97 ,,
5	IBA 560 ppm	8·5	3·35 ,,
6	IBA 520 ppm	9·25	4·62 ,,
7	IBA 260 ppm + Sugar	8·75	4·42 ,,
8	IBA 520 ppm + Sugar	10·5	3·72 ,,
9	(NAA + IBA) 280 ppm	3·5	3·32 ,,
10	(NAA + IBA) 280 ppm + Sugar	7·5	5·75 ,,
11	(NAA + IBA) 520 ppm	4·25	3·32 ,,
12	(NAA + IBA) 520 ppm + Sugar	7·0	5·10 ,,
13	Control	11·25	3·22 ,,

The data show that the plant regulator sprays were not effective in increasing the number of roots per layer but the average length of root was heighest in the treatment No. 10 (NAA+IBA—280 ppm+Sugar). (16)

as root stock. Month-war trials were conducted to standardise the best time to do the grafting. The results of this trial are given in the table below :—

Table 40. Percentage of success in the different months.

Month	No. of grafts done	No. survived after separation	Percentage of survival
August	10	8	80
September	10	10	100
October	10	8	80
November	10	6	60
December	10	8	80
January	10	10	100
February	10	8	80
March	10	6	60
April	10	6	60
May	10	6	60
June	10	4	40
July	10	8	80

The data of this trial indicate that July to October is the best period for this method of propagation. Considering the fact that June-July is the best season for planting, it will be better to do the grafting in January—February (20).

6. Veneer Grafting,

6.1 At the Cashew Research Station at Mannuthy, veneer grafting, side grafting, and budding trials were conducted during 1974-78 at monthly intervals. Maximum success was obtained during June to September, the percentage being 56% in veneer grafting and 84% in patch budding in June.

6.2 At Vengurla, Phadmis (1971) found patch budding was successful on one year old root stock and veneer grafting on 5 months old stock plants. The most suitable period for veneer grafting (60%) was

Table 41. Effects of plant regulators on the rooting of cashew air-layers.

Treatments	Percent of successful air-layers.	Average no. of roots / layer.	Average length of long roots per year	Average no. of days taken for rooting
IBA 100 ppm	61·5	12·1	6·8	37·5
,, 200 ,,	76·9	17·1	8·0	35·0
,, 300 ,,	84·6	19·5	8·9	32·0
NAA 100 ,,	46·2	7·5	3·9	40·0
,, 200 ,,	61·5	10·8	5·1	40·0
,, 300 ,,	61·5	11.9	5·1	38·0
Control ,,	46·2	6·3	3·4	42·0

It may be seen from the above data that the highest percentage of successful layers was obtained from the treatment 300 ppm of IBA. In the number of roots and length of roots also, the above treatment gave good results. The time taken for rooting was also reduced from 42 days in the case of control to 32 days in the case of IBA treatment. (21)

7.1 *Side grafting*

Rao *et al.* (1957) have reported that side grafting was successful to the extent of 70% during the period from February to May. The soil conservation Department in Orissa tried side grafting on a fairly large scale and obtained 50% success in July.

8.1 *Propagation by cuttings*

Propagation by cuttings was not successful in the trials conducted at the different cashew Research Stations in India. However, successful results have been reported by Coester and Ohler from the Royal Tropical Institute at Amsterdam. Three types of cuttings were tried (1) Green Shoots, about 4 months old, having a diameter of about 0·5 cm. (2) Maturiug shoots, with the bark turning from green to brown (about 8 months old) and (3) Mature shoots (about 12 months old). Three kinds of rooting medium and two growth regulators — IBA and NAA were used. The basal portion of the cuttings were split to a length of about 1 cm. before placing them in the rooting medium. Day temperature was maintained at 25—28°C and humidity at 90—95%. 83% rooting was obtained when Perlite was used as the rooting medium. Maturing shoot

Table 43. Growth and yield of different types of planting material at the Cashew Research Station, Vengurla.

Sl. No.	Type of planting	Average volume per tree in cm.	Av. yield of nuts per tree in kg 1978	Av. cumulative yield per tree in kg 1967-78
1.	Seedlings	525·5	15·220	86·142
2.	Air-layers	425·2	19·471	109·355
3.	Inarched grafts	489·5	19·875	93·816

Eventhough there was no significant differences in growth and yield of the different types of propagation materials used, the mean yield for the year and the cumulative yield were consistently higher in the case of layers as compared to the seedlings. (39)

9.3 At the Cashew Research Station, Bapatla, a trial to compare trees raised from seeds, stumped seedlings and air-layers was laid out in 1962 and the mean yield obtained during the period 1969—'71 were as follows : — (12)

Type of propagation material	*Mean yield for the period 1969 — '71*
Layers	6·5 kg
Stumps	4·2 kg
Seedings	4·11 kg

9.4 The trial on the performance of clones and seedlings laid out at Vridhachalam showed that clones registered the highest yield of 5·655 kg in the 8th year as compared to 2·885 kg in the case of seedling. (39)

The results are in conformity with the results obtained in other centres.

Shoot and root development in different types of propagation material.

10.1 A comparative study of shoot and root growth of four different types of plant materials was undertaken in the Cashew Research Station, Bapatla during the period 1965—'67. The four types of planting materials compared were (i) seeds sown in-situ, (ii) seeds

CHAPTER IV

PLANTING — CROP NUTRITION — ORCHARD MANAGEMENT

1.1 Almost all the existing cashew plantations were raised in the most casual manner without adopting any scientific principles of crop production. Very little research have been done so far on the pit size, planting distance, manuring, and the orchard management practices. Dibbling seed behind the country plough was a practice in many cashew growing areas in Tamil Nadu. Sowing seeds in small pits of 15—23 cm was the practice followed in raising the majority of cashew plantations in the state. However, observations made on these aspects clearly indicate that adequate sun-shine and providing congenial conditions for root development in the initial stages of plant growth are of vital importance for good growth and crop production in cashew. Very little research work has been done so far on these aspects. The results of a few trials, conducted in the different centres are briefly summarised below:—

1.2 A spacing-cum-manurial-cum mulching trial was laid out in the Cashew Research Station, Vengurla in the year 1958-59. The different treatments involved are the following.

Spacing	4.8m × 7.2m, 7.2m × 7.2m, 9.6m × 7.2m.
F. Y. M.	0, 2.8mt/ha., 5.6mt/ha.
Nitrogen	0, 25 kg/ha., 50 kg/ha.
Mulching	No mulching, Mulching with dry leaves.

The summarised yield data over the period 1970—74 are presented below:—

Table 44. Cumulative yield produced by cashew trees under spacing cum manurial experiment under different treatments since 1970-74.

Nitrogen		(N_0)				(N_1)				(N_2)			
Spacing	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean	C_0	C_1	C_2	Mean
S_1	111	109	456	225	197	443	262	284	110	427	361	299
S_2	99	102	108	103	166	189	274	210	258	389	732	460
S_3	104	93	258	152	159	302	258	239	222	308	293	274
Mean	105	101	274	160	174	311	265	244	197	374	465	344

Treatment	Mean yield (Kg/tree)
Control (no manure)	0·149
FYM 25 kg/tree	0·431
FYM + N 600 g/tree	3·475
FYM + K 580 g/tree	0·815
FYM + P 480 g/tree	0·271
FYM + N + P	2·597
FYM + N + K	2·660
FYM + N + P + K	2·362
FYM + P + K	0·908

There was significant increase in yield in the case of application of 600 g N along with 25 kg of FYM, while there was no response to treatments without Nitrogen. (38)

2.2 Fertilizer trials conducted in the bearing plantation at Kasargod during 1972-75 consisted of the following treatments.

N 100, 300, 500g per tree per year
P 75, 150, 225g per tree per year
K 100, 300, 500g per tree per year

The results showed that there was no difference among the levels of P and K, but N_2 and N_3 treatments gave higher yields than N_1. (38)

2·3 A fertilizer trial, initiated in 1969 at the Cashew Research Station, Vengurla, had the following treatments and the yields obtained during the 1973-75 season are given in table below:-

Table 46. Fertiliser experiment at Vengurla—Effect of N, P and K fertilization on the volume M_3 of trees (data for 1974-75).

		N_1	N_2	N_3
P_0	K_0	27	57	22
	K_1	45	90	59
	K_2	36	61	98
P_1	K_0	94	124	48
	K_1	69	140	118
	K_2	72	125	175
P_2	K_0	113	200	114
	K_1	77	99	185
	K_2	63	90	241

1. Control
2. Endosulfan 0·05% — 2 sprays of 3% urea
3. Endosulfan 0·05% — 3 sprays ,, ,,
4. Urea 3% + Endosulfan — 2 sprays ,, ,,
5. Urea 3% + Endosulfan — 3 sprays ,, ,,

Due to the failure of the monsoon and long drought the yield was extremely low and was not comparable.

2.6 However, the same trial conducted at Bapatla during 1975 indicated following trends.

Spraying Endosulfan 3 times was most effective followed by treatment (2), viz., spraying Endosulfan, two times. There was no response to the foliar application of urea. (38)

2.7 An observational trial to find out the effect of foliar spray of urea was conducted in 1967 at the Cashew Research Station, Bapatla. The treatments consisted of :—

1. Spraying 1% urea once in July
2. Spraying 1% urea once in November
3. Spraying 1% urea in two splits – once in July and second in November
4. Control

Growth data showed that treatment 3 showed maximum increase in girth and height, but this was not reflected in yield. (11)

Effects of plant regulator sprays on fruit-set, fruit drop and yield.

3.1 In the trial with three plant regulators conducted during the bearing season of 1973—74 at Anakkayam, it was found that two sprayings of Indole-acetic-acid at 50 ppm or Napthalene-acetic acid (Planofix) at 10 ppm significantly increased the fruit set and the number of mature nuts harvested. (5)

3.2 The same trial was repeated during the 1974—75 season. The plant regulators used in the trial were IAA—50 ppm, NAA—10 ppm and

Table 49. Mean yield of nut from trees sprayed with Plant Regulators at Cashew Research Station, Vridhachalam.

Treatment No.	Plant Regulator	Concentration	No. of nuts	Weight of nuts (kg)
1	IAA	10 ppm	445	2·340
2	,,	30 ,,	946	4·300
3	,,	50 ,,	1756	6·430
4	,,	70 ,,	2206	6·500
5	NAA	10 ,,	897	3·200
6	,,	30 ,,	2118	6·075
7	,,	50 ,,	1667	6·850
8	,,	70 ,,	516	2·760
9	IBA	10 ,,	274	1·600
10	,,	30 ,,	908	3·780
11	,,	50 ,,	1796	8·180
12	,,	70 ,,	5479	13·200
13	Planofix	10 ,,	1143	5·150
14	,,	30 ,,	1876	9·150
15	,,	50 ,,	866	4·630
16	,,	70 ,,	133	0·650
17	Ethrel	50 ,,	129	0·820
18	,,	100 ,,	558	3·245
19	,,	150 ,,	1831	6·500
20	,,	200 ,,	456	2·200
21	Control	,,	865	3·640

The highest yield of 13.200 kg was obtained from treatment No. 12 (IBA : 70 ppm) followed by treatment No. 14 (Planofix : 30 ppm) which yielded 9.150 kg as compared to 3.640 kg in the case of control. (18)

3.4 During 1974-75, a trial was conducted at Vridhachalam with the following treatments, giving two sprayings:—

Treatment		Yield
1) IAA	50 ppm.	Nil
2) IAA	100 ,,	2.250
3) IBA	50 ,,	0.275
4) IBA	100 ,,	0.075
5) NAA	10 ,,	0.075
6) NAA	20 ,,	Nil
7) 2, 4-D	5 ,,	0.400
8) 2, 4-D	10 ,,	2.600
9) Water spray		Nil
10) Control		Nil

CHAPTER V

PESTS — DISEASES & THEIR CONTROL MEASURES

1.1 Eventhough cashew is a hardy tree, which grows with practically no attention, it is subjected to the attack of a large number of pests and diseases. Among pests, the tea mosquito (*Helopeltis antonii Sign.*) is the most serious, causing heavy damage to the new flushes of growth and the inflorescence. The loss of crop due to the attack of this pest on the inflorescence is as much as 25—50%. Both adults and nymphs of this pest puncture the tender shoots and inflorescences and suck the sap. It also injects its saliva which is toxic to the plant tissue, as a result of which the tissues around the pierced branches become necrotic and the tender branches and inflorescences dry up completely. (Fig. 9)

1.2 Studies on this problem were undertaken in the different Cashew Research Stations and remedial measures have been evolved. But, even today most of the growers attribute this drying up to severe drought or adverse whether conditions like cloudiness during the flowering season.

1.3 Investigations carried out at the Cashew Research Station, Kottarakkara in 1962 clearly established that the drying up of the cashew inflorescences (Blossom Blight) and tender shoots (Die-back) were due to the attack of this pest. There was no fungal association in causing these conditions, atleast during the bearing season in Kerala.

1.4 Trials on insecticidal control of this pest were conducted at the Cashew Research Station, Anakkayam during 1964-65 and 1965-66 seasons, in which the following 11 insecticides were tried:-

DDT	0·2%
BHC	0·2%
Endrin	0·05%
Trichlorophon	0·1%
Carbaryl	0·1%
Phosphamidon	0·02%

actively moving. Pupation took place inside cocoons formed at the base of the jars.

iii) Tea-mosquito (*Helopeltis antonii S.*)

Studies indicated that the eggs required 15 to 17 days for hatching during November and December, whereas in the months of January and February the eggs hatched out within 12 or 13 days. Further, the nymphs collected during the month of April and May did not survive in the laboratory conditions. Field observations showed that during the month of May and June the population of both male and female tea-mosquitoes was less.

iv) Leaf miner (*Acrocercops syngramma.* M)

This pest was found to be severe in most of the private gardens during the period of new flush i.e., October and November. Caterpillar is white in colour and very active in nature. It mines into the green parts of the leaves. In some cashewnut plantations the extent of damage was 20 to 25 per cent. Studies showed that pupation period was 6 to 7 days. The hatched moth is tiny and white in colour.

v) Flea beetle (*Monolepta longitarsus*):—

Attempts to breed the flea beetles were not successful.

vi) *Caterpillar damaging inflorescence and shoot tips:-*

The moth is small and pale green in colour. Pupation period lasts for 9 to 10 days. The affected shoots dry up eventually.

vii) *Minor pests*:—

Ash weevils, leaf webber (*Orthaga sp.*) Hairy caterpillar (*Metanastria hyrtica.* C.). Thrips and mealy bugs were commonly found in the Research Station. However, the damage caused by these pests was negligible. These minor pests could be controlled by spraying BHC 50% WP (7.5 gms/litre of water). (15)

1.7 Studies were undertaken at CPCRI, Kasaragod to find out the exact role of *Helopeltis antonii* and fungi in causing inflorescence blight in cashew. These studies confirmed the earlier finding at Kottarakkara that the pest was primarily responsible for the inflorescence scorching

infested trees. Based on symptoms manifested by infested trees, viz., gummosis, extrusion of frass, presence of holes, yellowing and shedding of leaves, drying of twigs and final mortality of the tree, intensity of infestation has been grouped into mild, medium and severe categories. The intensity of incidence in a few tracts of Kerala, Karnataka and Tamil Nadu ranged from 1—62.4%.

1.11 *Plocaederus ferrugineus* lays eggs deeply inserted into the fresh tissues in the crevices of loose bark of the collar region of tree. Under a temperature range of 26—35°C and 47—100% R. H. the incubation period lasts for 4—6 days and grub phase 6—7 months. Biology of different species of stem borers is under study. No indigenous parasite or predator affecting the stem borer grubs has been recorded. However, laboratory tests carried out with the nematode *cum* bacterium culture DD-136 (*Neoaplectona carpocapsae* and *Achromobacter nematophilus*) revealed that an inoculum dose of 100 mgs per gram body weight of host grub, 60% mortality was obtained within 24 days. Trials have been taken up with the green muscardine fungus, *Metarrhizium anisopliae* (isolated from *Oryctes rhinoceros* grubs) the "milky disease bacterium' *Bacillus popilliae Dutky* (isolated from white grub, *Holotrichia serrata* received from S. B. I., Coimbatore) and *Bacillus thuringiensis Berl.* (culture obtained from CFTRI, Mysore).

1.12 Studies on the biology of the defoliating caterpillar, *Metanastria hyrtaca* Gram. (Lasiocampidae) have been completed. The incubation period was 9 days under a temperature range of 26—35° and R. H. range of 41—100%. The number and duration of larval instars have been found to vary depending on the sex on the moths emerging from them. The caterpillar phase of males comprising five instars is completed in 32.8 days and that of females in 35.4 days within 6 instars. The pupal period lasts for 12 days. Longevity of the unmated males was 3—5 days and the mated ones lived for 2—4 days. Mated females lived for 3—6 days and unmated ones for one day. Fecundity ranged between 189—330 eggs with an average of 249 eggs per femlae moth. In a brood there was preponderance of males over females, the ratio being 1:3 (female : male).

1.13 Studies on the parasites associated with the pests of cashew are in progress. Twelve species of parasites have been recorded so far

Carbaryl
Pyrethrins
Piperonyl butoside
Fenitrothion
Dimethoate
Trichlorophan
Phorate granules
Aluminium Phosphide tablets.

1.18 Out of the 56 trees treated, 28 were cured, 18 were dead and the remaining 10 were still under observation. If the infestation is detected in the early stage, treatment with 0.1% BHC suspension is effective. (38)

1.19 A prophylatic control trial with the following treatments was conducted in Karnataka Forest Plantations:—

Cashewnut shell liquid (CNSL)
Coal-tar
CNSL + 1% Aldrin
Coal-tar + 1% Aldrin

The above chemicals were applied to the trunk over a portion of 60 cm. from the ground, twice in April—May and October—November. Observations showed that treatments containing CNSL contracted more attack, while plots in which the affected trees were cut and removed showed least incidence and intensity of attack. (38)

1.20 An exhaustive review of the insect pests of cashew and their control has been published by Pillai *et. al.* (1976).

1.21 *Pachypeltis maesarum* (Miridae: Hemiptera) has been recorded in company with *Helopeltis antonii* causing almost similar damage to the shoots and inflorescence, in the Cashew Research Station, Vellanikkara during August—September 1976. The percentage of *P. maesarum* individuals in the mixed population ranged from 22.29 to 51.85 as revealed from random samples. (49)

1.22 Very serious incidence of the mealy bugs (*Planococcus* sp. on the shoots and foliage has been noted during February 1976 at the Cashew Research Station, Vellanikkara. Field trials on the relative field efficiency of insecticides revealed the superiority of quinalphos

CHAPTER VI

HARVESTING — PROCESSING & GRADING OF NUTS — MARKETING CASHEW APPLE & ITS UTILIZATION

Harvesting

1.1 Cashew trees flower during the summer months, commencing from October and continues till April—May. The peak period of flowering in the state is December—January and that of harvesting is April—May. Since the flowering and fruiting extends over a period of 3—4 months, harvesting is very expensive. Harvesting involves mainly the collection of nuts from fallen fruits. A long bamboo pole is also used to pluck mature nuts on the tree. There is also the practice of picking immature nuts and dry it in the sun just to turn the colour of the nuts into ash-brown and then market it. Even though this may weigh slightly higher than nuts collected from fully ripe apples, it is not a healty practice as the quality of the kernel of such nuts are inferior.

1.2 A study was undertaken in the Agricultural Research Station, Nileshwar to find out the optimum stage of harvesting of nuts, in relation to the ripeness of apple. Harvesting was done at the following stages :

i) Apple green, nut sightly ash coloured
ii) Apple fairly ripe, nut ash coloured
ii) Apple fully ripe, nut ash coloured.

1.3 One hundred nuts of each of the above categories were collected and the drying percentage, shelling percentage, and germination percentage of each of the above catagories were determined. The data are presented below :—

Category	*Original weight*	*Weight after drying*	*Shelling percentage*	*Germination percentage*
i)	27.0	20.5	27.7	82
ii)	24.0	21.0	28.9	96
iii)	23.0	21.9	29.1	97

2.4 Grading is done manually by experienced workers who first separates and remove shrivelled, discoloured and insect affected kernels. The graded kernels are packed in 4 gallon capacity tins under inert gas and sealed air-tight. This method of packing is known as 'Vita Pack'.

2.5 There is quality control arrangements for the kernel intended for export.

Shell Oil

3.1 The shell oil finds application in the manufacture of several products like paints and varnishes, protective for fishing nets, water proofing materials etc. However, the above industries are set up in foreign countries and in recent years, the demand for shell oil has dwindled considerably.

Testa Tannin

3.2 Tannin is an important material needed for the leather industry. We are importing this material at present. The 'testa' of cashew kernel contains substantial quantity of tannin. Recent researches have shown that this 'tannin' can be extracted commercially. A pilot plant for this has been set up recently in Kerala.

Cashew Apple

4.1 The cashew apple, which is botanically the swollen pedicel, contain about 12% sugar, high amount of Vitamin C and fair amounts of minerals like calcium, phosphorus and iron. But the major part of the apple is now practically wasted in Kerala. In Goa, almost the entire production is utilised for the manufacture of a liquor known as 'Feni'.

Physico-chemical composition of cashew apple.

4.2 Several workers have analysed the composition of cashew apple and reported considerable variation between different types. Sastri *et al.* (1962) found sharp decrease in tannin content and progressive increase in ascorbic acid, as the fruit ripened.

4.3 Chakraborty *et al.* (1962) reported that steam-treatment of fruits for 10 minutes at 10 lb pressure/sq. inch reduced the tannin content to traces. Another method to remove the astringent principle in the

by means of a screw type juice extractor or by a basket press. The juice is strained through a 30 mesh stainless steel sieve and then treated with a calculated quantity of gelatin solution (0.5 per cent) till tanins and acrid principles are completely precipitated. The clear liquid is filtered.

4.7.2 The average composition of the apple juice which has a pale yellow colour and which forms 50—60 per cent by weight of the apple is as follows :—

Total soluble solids	%	12.0
Total sugars	%	10.0
Acidity (malic)	%	0.46
Tanins	%	0.32
Tanins after gelatin treatment	%	0.03
pH		4.3

4.7.3 It is then inoculated with a fermenting starter of pure wine yeast. After about seven days the fermentation is almost complete and the yeast settles down. The clear portion can be decanted, bottled and pasteurised. The alcohol content of the wine will be about 4 per cent. This wine can be fortified with the brandy distilled from the cashew wine. Another method to raise the alcohol content to about 10 is to increase the level of sugar to about 20 per cent by adding cane sugar before fermentation.

4.7.4 The composition of the wine obtained after fermentation of the juice in the manner described above is given below :—

Total soluble solids	%	3·0
Acidity (malic)	%	0·27
Alcohol	%	5·0
pH		3·7

4.7.5 The vitamin C content of the fruit does not get lost in the course of processing.

4.7.6 The cashew apple wine can further be distilled to get higher content of alcohol and thus used as brandy. The product can find its way into the pharmaceutical industry or can even be exported. Samples

CHAPTER VII

PROBLEMS AND PROSPECTS

The research on cashew in India is nearly 28 years old ; but there are several problems in cashew growing which calls for urgent solution. The cashew processing industry is facing a serious crisis for want of adequate raw cashewnut. With the development of mechanical cashewnut processing units in the major cashew growing countries, the supply of rawnuts from those countries is decreasing rapidly and may even cease completely in the next few years. Programmes of rapid development of cashew growing have to be drawn up and implemented rapidly. The major problems which calls for research are indicated below.

1. Genetic improvement

The low level of productivity in the existing gardens is largely due to the poor genetic stock. The superior selections of hybrids already identified in research stations have to be multiplied vegetatively. These vegetative progenies may be planted in large blocks in isolation from other cashew gardens to serve as seed gardens. These seed gardens may be of single clone or poly-clonal. After meeting the requirements of new plantings, the seed produced in the seed gardens may be utilised for replanting in the existing areas under a planned phased programme.

The research programme on varietal improvement has to be intensified with emphasis on selections from existing variations. However, the chances of getting an ideal plant type with all the desirable characters from a selection programme are rather slim. Therefore a planned programme of hybridisation and selection is essential for this. The ideal type would be a dwarf bushy plant with intensive branching, regular bearing, early and short flowering phase, high sex ratio and good setting percentage and producing medium sized nuts, giving high shelling percentage. Being a highly cross-pollinated crop, the strategy in the breeding programme will be to select plants possessing most of the above attributes, make crosses between many parental

4. *Nutritional studies:*

Information on the nutritional requirements of the crop under varying soil conditions is lacking at present. Based on the indications available from the fertilizer trial in progress under the co-ordinated project, trials are to be conducted in cultivators' gardens as well. It is also necessary to find out the deficiency symptoms of major and minor nutrients and effective methods of curing the deficiencies.

5. *Inter-cropping :*

The best inter-crop that can be grown in the first three or four years of orchard life need investigation. The possibility of growing suitable inter crops in fully developed gardens also need study.

6. *Plant protection :*

Eventhough recommendations for the control of major pests like *Helopeltis sp.* are available, further researches are needed in this field. Stem borer is another major pest against which effective control measures are yet to be determined. Diseases like stem bleeding needs detailed studies.

7. *Utilisation of Cashew Apple :*

The possibility of utilising cashew apples for soft drinks or for liquor needs study on pilot plant level.

The above are the major problems which need intensive research during the next 3—6 years. Only by finding out suitable remedies for the problems indicated above it will be possible to increase the production of cashewnut and thereby solve the crisis facing the cashew industry in the country particularly in Kerala.

11. *Size of leaf lamina*				
Length	11.5 cm	11.6 cm	8.3 cm	14.3 cm
Breadth	6.6 cm	7.0 cm	5.9 cm	8.2 cm
12. Texture of leaf	Leathery	Leathery	Leathery	Leathery
13. Colour of mature leaf	Dark green	Dark green	Dark green	Dark green
14. Venation	Prominent	Prominent	Prominent	Prominent
15. Flowering season	Early	Mid-season	Mid-season	Mid-season
16. *Inflorescence*				
Shape	Conical	Slightly pyramidal	Pyramidal	Conical
Length	15.1 cm	20.9 cm	19.7 cm	15.7 cm
Basal spread	15.5 cm	9.3 cm	25.7 cm	21.9 cm
Compactness	Open	Open	Open	—
17. Per cent of perfect flowers	11.1	13.3	12.3	8.38
18. *Apple characters*				
Colour at 'pea' stage	Pink	—	Greenish pink	Greenish pink
Colour of ripe fruit	Pinkish yellow	Yellowish pink	Yellowish pink	Yellowish pink
Shape	Oblong ovate	Long conical	Conical	Conical
Weight	67.5 g	—	—	—
Percentage of juice	—	—	—	—
Total soluble solids	—	—	—	—

		gave a mean yield of 6·947 kg of nuts during	yield of 2·266kg of nuts during 1974—75	yield of 4·038kg during 1974-75
23. Reaction to major diseases	Stem bleeding (gum exudation) and pink disease caused by *Pellicularia salmonicolor* are the two major diseases of cashew in Kerala state. The above diseases have not so far affected this tree. Whether it is due to resistance or merely an escape cannot be stated at this stage.	No disease incidence noted so far	One of the main branches of the tree is affected by the 'Pink disease' caused by *Pellicularia salmonicolor*. However, none of the 10 clonal progenies of this type are affected by the disease	No major diseases noticed so far
24. Reaction to major pests	Tea mosquito (*Helopeltis antonii*), apple and nut borers, leaf rollers and thrips are the serious pests of cashew. No resistance to any of the above pests has been noticed.	No resistance to major pests.	No resistance to the major pests under field conditions	Observations made so far do not indicate any resistance to major pests.

REFERENCES

1 Acharya, N. and Dash, P. C. 1972. Effect of plant growth substances on cashew air layers. *Curr. Sci.* **41** : 534—35.

2 Aiyadurai, S. G. and Koyamu, K. 1957. Variation in seedling trees of cashew. *South Ind. Hort.* **5** (4) : 153—156.

3 Ayyanna, T., Narayana, K. L. and Krishnamurthy Rao, B. H. 1977. Insect pests of cashew in Andhra Pradesh and their control. APAU. *Tech. Bull.* **7** : 29.

4 Ann. Prog. Report of the Cashew Research Station, Anakkayam/ Vellanikkara for the year 1971—72.

5 Ann. Prog. Report of the Cashew Research Station, Anakkayam/ Mannuthy for the year 1972-73.

6 Ann. Prog. Report of the Cashew Research Station, Anakkayam/ Mannuthy for the year 1974—75.

7 Ann. Prog. Report of the Cashew Research Station, Mannuthy for the year 1977—78.

8 Ann. Prog. Report of the Cashew Research Station, Vengurla for the year 1966—67.

9 Ann. Prog. Report of the Cashew Research Station, Vengurla for the year 1974 –75.

10 Ann. Prog. Report of the Cashew Research Station, Vengurla for the year 1977 — 78.

11 Ann. Prog. Report of the Cashew Research Station, Bapatla for the year 1967—68, 68—69.

12 Ann. Prog. Report of the Cashew Research Station, Bapatla for the year 1970—71.

13 Ann. Prog. Report of the Cashew Research Station, Bapatla for the year 1977—78.

14 Ann. Prog. Report of the Central Cashew Research Station, Ullal for the year 1965—66.

15 Ann. Prog. Report of the Central Cashew Research Station, Ullal for the year 1967—68.

30 I. A. R. S. 1964. Consolidated report on the pilot sample survey for the study of cultivation practices and for the estimation of yield and the extent of cultivation of cashewnuts in Kerala, Page 7.

31 ICAR. 1976. Report of the Committee on cashew cultivation.

32 Johnson, D. 1973. The Botany, origin and spread of cashew (*Anacardium occidentale* L) *J. Plant. Crops*, **1** (1 and 2) : 1—7.

33 Khan, K. F. 1957. Let us produce more cashewnut *Ind. Fmg.* **7** (7) : 36—37.

34 Kurup, K. R. and Viswanathan K. 1970. The cashew in Kerala. *Intensive Agriculture*, 11—16.

35 Moorthy, K. N., Kumaran, P. A. and Nayar, N. M. 1975. Increasing fruit-set in cashew by hormonal spraying *J. Plant Crops*, **3** (1) : 81—82.

36 Mukherjee, S. K. and Majumdar, P. K. 1973. Vegetative propagation of tropical and sub-tropical fruit crops. *ICAR Tech. Bulletin.* (Agri.) No. 45.

37 Muthappa Rai. 1970. Cashew through Vegetative propagation. *Intensive Agriculture*, 17—19

38 Nambiar, M. C. 1975. Progress Report of the All India Co-ordinated Spices and Cashewnut Improvement Project for 1973—75.

39 Nambiar, M. C. 1978. Progress Report of the All India Co-ordinated Spices and Cashewnut Improvement Project for 1977—78.

40 Nambiar, K. K. N., Sarma, Y. R. and Pillai, G. B. 1973. Inflorescence blight of cashew. *J. Plant Crops*, **1** (1&2) : 44—46.

41 Naik, K. C. 1948. *South Indian Fruits and their Culture.* P. Varadachari & Co., Madras.

42 Nayar, T. G. and John, J. P. 1958. Cashew grafts and layers excel seedlings. *Ind. J. agric. Sci.* **28** (2) : 129—32.

43 Palaniswamy, V. and Hameed, A. S. 1976. Study of propagation of cashew (*Anacardium occidentale* L) by patch budding. *South Ind. Hort.* **23** (1) : 24—25.

44 Patel, J. S. 1932. A note on cashewnut cultivation. Leaflet No. 4. Department of Agriculture, Madras.