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1996-'97

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(Indian Council of Agricultural Research)

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KARNATAKA

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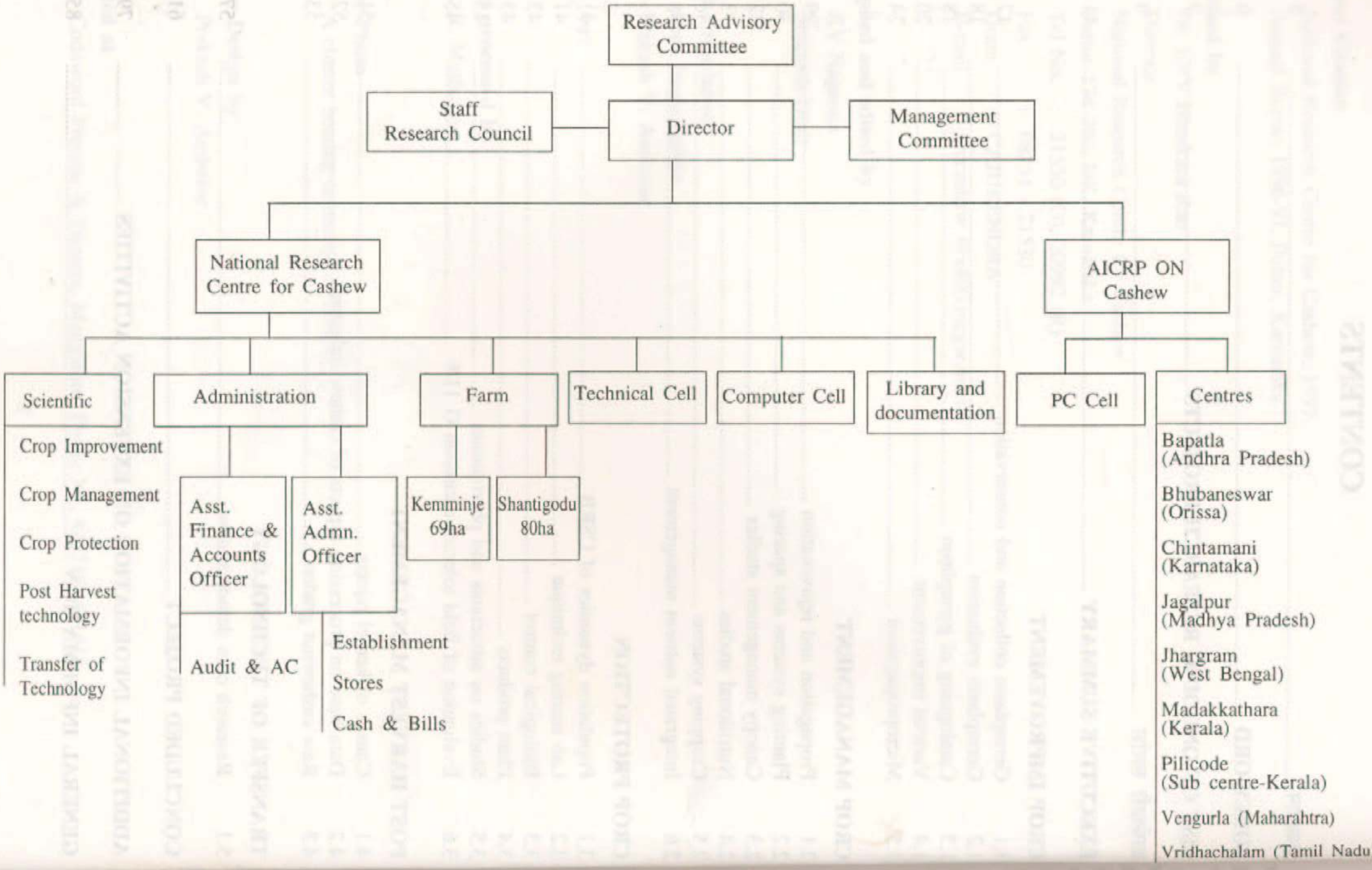
CONTENTS

ORGANOGRAM


Research Advisory Committee
Staff Research Council
Director
Management Committee
National Research Centre for Cashew
AICRP ON Cashew
Scientific
Administration
Farm
Technical Cell
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Centres
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Crop Management
Crop Protection
Post Harvest technology
Transfer of Technology
Asst. Finance & Accounts Officer
Asst. Admn. Officer
Audit & AC
Establishment
Stores
Cash & Bills
Kemminje 69ha
Shantigodu 80ha
Bapatla (Andhra Pradesh)
Bhubaneswar (Orissa)
Chintamani (Karnataka)
Jagalpur (Madhya Pradesh)
Jhargram (West Bengal)
Madakkathara (Kerala)
Pilicode (Sub centre-Kerala)
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प्राक्कथन

सन् 1986 से राष्ट्रीय काजू अनुसंधान केन्द्र देश में काजू की पैदावार प्रौद्योगिकी के बढ़ावे पर भरसक प्रयास कर रहा है । इस केंन्द्र में फसल सुधार, फसल प्रबंध, फसल सुरक्षा, कटाई उपरान्त प्रौद्यौगिकी एवं स्थानांतरण में शोध पर प्रयासरत हैं ।

क्लोनल जननद्रव्य का अभिलक्षण एवं वर्गीकरण आई पी जी आर आई डिस्क्रिप्टर के आधार पर किया जा रहा है और 56 एक्सेशन का डिस्क्रिप्टर तैयार हो चुका है । इस वर्ष के दौरान संकरण कार्यक्रम में गुठली आकार में सुधार एवं इच्छुक गुण सहित नई किस्में तैयार करने का प्रयास किया गया है । सूक्ष्म संचरण में निस्पंद संवर्धन द्वारा पौधे *इन विट्रो* में तैयार पौध से प्राप्त किए गए । इन पौधों को हरित गृह में ट्टढकर खेतों में लगाने के किए तैयार कर लिया है । पिरपक्व पेड़ के एक्स प्लान्ट से कुछ हद तक जड़ प्रेरित करना संभव हो पाया है । परिपक्व पेड़ के एक्स प्लान्ट से संदूषित रहित संवर्धन संभव हो सका है ।

उच्च घनत्व रोपण के फायदे भलीभांति निरुपरित है । चालु वर्ष में इस पद्धति पर कृषकों के क्षेत्र में खेत परिक्षण किए जाने वाले है । हालाँकि काजू वृष्टी भरण फसल है, लेकिन ग्रीष्म के महीनों में सिंचाई से उपज में बढ़ोतरी देखी गयी है ।

वर्ष के दौरान भीषण टी मस्किटो ग्रसन से पैदावार में काफी कमी पायी गई, जो कि शोधकर्ता के लिए गंभीर सोचनीय विषय है । इस विषय में यह कहना उचित होगा कि गोवा 11/6 में सामान्य अनुक्रियता मध्य मौसम पुष्पन गुण के कारण टी मस्किटो बग का कम ग्रसन देखा गया है । पिछले छह सालों से इस एक्सेशन में अच्छी निष्पादन देखी गयी है इसलिए संकरण कार्यक्रम में इसे इस्तेमाल किया जाना चाहिए। इस जननद्रव्य को अब संकरण कार्यक्रम में दाता स्वरुप प्रयोग में लाया जा रहा है ।

देश में रोपण सामग्री के तैयारी में परिघटनात्मक वर्धन हुआ है । काजू विकास निदेशालय द्वारा स्थापित निजी नर्सरी एवं क्षेत्रीय नर्सरी, शोध केन्द्रों से 67.0 लाख कलमें तैयार की जा चुकी है । रा.का.अ.के. द्वारा स्थापित क्षेत्रीय नर्सरी को अति उत्तम नर्सरी घोषित कर काजू विकास निदेशालय ने प्रमाणपत्र और मेमेंटो, उच्च रोपण सामग्री प्रदान करने के लिए दिया है । नौवीं पंचवर्षीय योजना के लिए लक्षित विकास कार्यक्रम, कृषको से तैयार की गई प्रौद्योगिकी पुनर्भरण हेतु शोध केन्द्र में वार्षिक काजू दिवस मनाया गया।

इस वर्ष के दौरान भा.कृ.अनु.प.ने पहली बार केन्द्र के लिए अनुसंधान सलाहकार समिति स्थापित की। इसकी पहली बैठक एक बार हुई, इसमें शोध परियोजना के प्रगति पर विचार कर भविष्य में शोध संबंधित अग्रिम क्षेत्रो पर कार्य का सुझाव दिया गया । मासिक सेमिनारों का आयोजन इस वर्ष के दौरान किया गया और वैज्ञानिकों द्वारा 7 सेमिनार प्रस्तुत किए गए । इस वर्ष में प्रबंध समिति की दो बैठकों द्वारा केन्द्र के शोध एवं प्रगति कार्यक्रम पर प्रकाश डाला गया ।

मैं इस अवसर पर केन्द्र के सभी शोध कार्यक्रम में पूर्ण मदद देने हेतु सभी वैज्ञानिक, तकनीकी, प्रशासनिक एवं सहायक कर्मचारियों को हार्दिक धन्यवाद देता हूँ । संपादन सहायता में डा. के.वी. नागराज एवं डा. श्रीनाथ दीक्षित को विशेष आभार अभिलिखित करता हूँ ।

ई वी वी भास्कर राव

(ई.वी.वी. भास्कर राव)
(निदेशक)

FOREWORD

National Research Centre for Cashew has been striving towards developing technologies for the improvement of cashew production in the country since 1986. This Centre has been pursuing research in the areas of crop improvement, crop management, crop protection, post-harvest technology and transfer of technology.

Attempts have been made to characterise the clonal germplasm and catalogue them as per IPGRI descriptors and the descriptor for the 56 accessions has been brought out. Hybridization programme for the improvement of nut size and developing varieties with desirable characters was pursued during the year. In micro-propagation, plantlets could be obtained from nodal cultures from *in vitro* grown seedlings. These plantlets have been hardened in the green house and are ready for field planting. Limited success has been achieved in inducing rooting from explants of mature trees. It has been possible to get contamination free cultures in explants from mature trees.

Profitability of high density planting has been amply demonstrated. It has been proposed to take up field testing of this technology in farmers' plots during the current year. Although cashew is a rainfed crop, irrigation in summer months has been shown to enhance the yield.

During the year, severe infestation of tea mosquito resulted in considerable loss of yield which is of serious concern for researchers. In this regard it is worthwhile to mention the performance of a field tolerant accession, Goa 11/6, which escapes the peak infestation of TMB due to its flushing behaviour. This accession has been performing well for the last six years and it could be a promising line for breeding programmes. This accession is presently being used as one of the donors in hybridization programme.

Interms of generation of planting material, a phenomenal growth was achieved in the country by producing over 67 lakh grafts by research centres, private nurseries and regional nurseries established by Directorate of Cashewnut Development. Regional nursery established at NRCC was adjudged as one of the best Regional Cashew Nurseries in the country by DCD and was awarded with a merit certificate and memento for sustained supply of quality planting material. Annual Cashew Day was conducted at the research centre to get feedback from the farmers on the technologies developed and to create an awareness regarding the developmental programmes envisaged during 9th Plan period.

Research Advisory Committee for the institute was constituted for the first time by ICAR during the year. It met once and deliberated on the progress made in research projects and suggested priority areas of research to be undertaken further. Monthly seminars were held during the year and seven seminars were presented by scientists. Management Committee of the institute met twice during the year and deliberated upon the R & D activities of the centre.

I take this opportunity to express my sincere thanks to all the scientific, technical, administrative and supporting staff for the support rendered during the year for all the research activities of the centre. I also place on record my sincere appreciation to Dr. KV Nagaraja and Dr. Sreenath Dixit for their editorial assistance.

EVV Bhaskara Rao

(EVV BHASKARA RAO)
(Director)

LIST OF ONGOING RESEARCH PROJECTS

Project No.	Project	Project leader/associate
	1. CROP IMPROVEMENT	
1.1	Collection, conservation, cataloguing and evaluation of cashew germplasm	KRM Swamy MG Bhat D Sundararaju
Ad-hoc scheme	Collection of cashew germplasm from forest plantations in Karnataka	KRM Swamy Thoyajaksha
1.2	Varietal improvement of cashew.	MG Bhat KRM Swamy
1.3	Tissue culture studies in cashew for micropropagation and somaclonal variation.	Thimmappaiah Shirly R Anil
	2. CROP MANAGEMENT	
2.1	Propagation and rejuvenation studies in cashew.	KRM Swamy
2.2	Planting systems and planting density trials in cashew.	N Yadukumar
2.3	Canopy management studies in cashew.	KRM Swamy
2.4	Comparative efficacy of slow release nitrogenous fertilizers for cashew.	N Yadukumar
2.5	Economic feasibility of drip irrigation and graded doses of NPK on the productivity of cashew.	N Yadukumar
2.6	Development of suitable cashew based cropping systems.	N Yadukumar
2.7	Organic farming for sustainable cashew production.	N Yadukumar
	3. CROP PROTECTION	
3.1	Formulating IPM schedules for stem and root borers infesting cashew.	TN Raviprasad D Sundararaju
3.2	Evaluation and mass multiplication of bio-control agents against TMB.	D Sundararaju TN Raviprasad
3.3	Devising eco-compatible plant protection measures against TMB.	D Sundararaju TN Raviprasad
	4. POST HARVEST TECHNOLOGY	
4.1	Investigations into the causes of nut rejects during harvest, storage and processing.	KV Nagaraja D Balasubramanian

4.2	Developing data base on processing aspects of cashew industries in India.	D Balasubramanian
4.3	Design, development and evaluation of raw cashew nut grader.	D Balasubramanian

5. TRANSFER OF TECHNOLOGY

5.1	Research cum demonstration plots.	Sreenath Dixit

कार्यकारी सारांश

राष्ट्रीय काजू अनुसंधान केन्द्र की स्थापना सन् 1986 में काजू की उत्पादन व उत्पादकता बढ़ाने के उद्देश से की गयी । केन्द्र के संशोधित उद्देश-मिशन लक्षित काजू से संबंधित सभी शोध, पैदावार बढ़ावा एवं स्तर विशेषतः निर्यात के दृष्टी से, काजू जननद्रव्य राष्ट्रीय निक्षेपस्थान, एवं शोध संबंधित जानकारी के बँटवारे प्रशिक्षण केन्द्र, प्रौद्योगिकी बढ़ोतरी एवं समन्वित राष्ट्रीय शोध परियोजना, परामर्श, पौध सामग्री का बँटवारा, और राष्ट्रीय एवं अंतर्राष्ट्रीय एजेन्सियों के साथ समन्वय करना है ।

बजट

केन्द्र का वार्षिक बजट 1996-97 में रु. 55.0 लाख योजनाधीन एवं रु. 37.5 लाख अयोजनाधीन था । इसके अलावा, भा.कृ.अनु.प. रिव्हॉलविंग फंड परिव्यय रु. 4.35 लाख एवं डी.सी.डी. रिव्हॉलविंग फंड रु. 7.35 लाख था । एड व्हॉक स्कीम का आबंटन रु. 0.97 लाख जबकि एन.ए.आर.पी. अधीनस्थ बजट रु. 5.0 लाख था ।

फसल सुधार

राष्ट्रीय काजू जीन बैंक (एन सी जी बी) में 320 देशज क्लोनल एवं 70 विदेशी नवोद्भिद मूलतः ब्राज़ील के, मोज़ाबिंक से प्राप्त हुए जननद्रव्य हैं। विदेशी जननद्रव्य ब्राज़ील एवं तन्ज़ानिया से आयात करने की प्रकिया शुरू कर दी गयी है । 56 जननद्रव्य की ग्रंथ सूची बना ली गयी है । इलीट जननद्रव्य मूल्यांकन में (14) उच्चतम वार्षिक उपज 3.5 कि.ग्रा./पेड इलीट जननद्रव्य वी.टी एच 59/2 में पाया गया। एम 44/3 (जाँच आधार) के अपेक्षाकृत, जिसकी उपज 1.88 कि.ग्रा./पेड था । वी.टी.एच 59/2 एवं वी.टी.एच. 539/2 दोनों में उच्च वार्षिक उपज पाया गया ।

कुल 24 ऊतक संवर्धित पौधों को हरित गृह में दृढ़ कर खेतों में लगाने हेतु तैयार कर लिया है।

फसल प्रबंध

अर्ध उच्च वायू स्तरीय पौध (वी टी एच 762/2, वी टी एच 762/4, एस 11/1, एस 11/2) और उच्च (सिलेक्शन-1) खेतो में लगाये गये । छह साल के अवधि तक, अंतराल एवं रोपण पद्धति से पेड की लंबाई, चौढ़ाई एवं प्रति पेड़ फैलाव में कोई अंतर नहीं पाया गया, जबकि निकटवर्तीय अंतराल में भूमि स्तर पर फैलाव ज्यादा पाया गया ।

उच्च घनत्व रोपण में 550 पेड़/हे. प्लाट में उच्चतम उपज 686 कि.ग्रा/हे. (13 साल रोपण के बाद एवं 5 साल 111 पेड़ से 555 पेड़/हे. घटाने पर) पाया गया । वितान प्रबंध शोध में भिन्न किस्मों एवं काटने के स्तर में कुल पत्तियाँ पार्श्व एवं पार्श्व लंबाई में सार्थक विभिन्नताएँ पाए गए । असिंचित प्लाटों के अपेक्षाकृत सिचिंत प्लाटो में नटधारण में बढ़ोतरी पाई गयी । इसी प्रकार अखादित एवं खादित प्लाटों में नट धारण में विभिन्नताएँ पाए गए । चेक (जाँच आधार) के अपेक्षाकृत उपज में 40 प्रतिशत बढ़ावा पाया गया जब असिंचित परिस्थितियों में उच्चतम दर का खाद डाला गया । सिंचन मात्र (60-80 लि./पेड़) बिना खाद 60-70% उपज में बढ़ोतरी, असिंचित एवं बिना खाद डाले पेड़ो में पाया गया।

रोपण उपरान्त पहले छह वर्षो में कैश्वारीना एवं अकेशिया के मध्यम वर्ति कृषि से उपज में असर पड़ा । कुल मुनाफा (रु. 26,605/हे.) पाया गया जब 2 पंक्ति में अकेशिया और 1 पंक्ति में कैश्वारीना लगाए गए ।

फसल संरक्षण

मृदा में मिलाने के 90 दिन बाद भी *मेटाराइज़ियम एनिसोप्ले* एक कवक रोगजनक जिंदा रह पाता है और इसकी उग्रता काजू स्टेम एंव रूट बोरर (सी.एस.आर.बी.) पर बरकरार रहती है । रोगित छाल में *प्लोसिडरस* स्पीसीस के अंडे अधिकतम पाए गए । खेत परीक्षण में गोवा 11/6 में टी मस्कीटो बग पर सामान्य अनुकीयता पाई गई । गोवा 11/6 में मध्य मौसम प्रधावन एवं पुष्पन होने की वजह से अति उग्र टी मस्कीटो बग आक्रमण से बचाव, उच्च उपज का कारण हो सकता है । इसमें पाँचवी कटाई में उच्चतम औसतम उपज, 7.2 कि.ग्रा./पेड़ भी पाया गया ।

कटाई उपरान्त प्रौद्योगिकी

कच्ची गुठलियों का 16 महीने तक संचयन करने से प्रारंभिक गुठली आद्रता 5-14 प्रतिशत, प्रक्रम से पूर्वचयन एवं भर्जन 5-20 मिनट से, प्रक्रम गुणता में असर नहीं पडता है । प्राप्त डाटा 133 काजू कारखानों के आधार पर डाटा बेस तैयार किया गया, प्रक्रम के दौरान काजू निराकरण के कारण फ्लोटर्स ही है । कच्ची काजू गुठली के श्रेणिकरण का डिज़ाइन व संविचरन कर लिया गया है ।

प्रौद्योगिकी स्थानांतरण

प्राप्त जानकारी के अनुसार डेमोन्स्ट्रेशन कृषकों के निकटवर्ती कृषको से पता चला है कि अनेकों के पास काजू की खेती के लिए समोचित पौध सामग्री का ज्ञान था । लगभग 40 प्रतिशत भागीदारों को कुछ काजु के किस्मों की जानकारी भी थी । किंतु चिंता का विषय था नाशक जीव नियंत्रण पद्धति व अपनाने के ज्ञान का अभाव ।

मानव संसाधन विकास

कृषि शोध में कम्पूटर उपयोगिता, कम्पूटर नेटवर्कीग एवं कृषि सूचना प्रक्रम के लिए वैज्ञानिकों को प्रशिक्षण पाठ्यक्रम हेतु प्रायोजित किया गया । साथ ही वैज्ञानिकों को राष्ट्रीय सेमिनार बागवानी फसल संबंधित एवं विकास कार्यशाला के लिए प्रतिनियुक्त किया गया । केन्द्र में कर्मचारियों के लिए राजभाषा कार्यान्वयन में बढ़ावा देने हेतु एक कार्यशाला एवं प्रशिक्षण कार्यक्रम का आयोजन किया गया ।

EXECUTIVE SUMMARY

National Research Centre for Cashew was established in 1986 with an objective of increasing the production and productivity of cashew. Revised mandate of the research centre includes conducting mission oriented research on all aspects of cashew for improving productivity and quality with special reference to export, serving as a national repository for cashew germplasm and acting as clearing house for research information, acting as centre for training, technology updating and coordinating national research projects, providing constancy, generating planting material and collaborating with national and international agencies.

Budget

The institute had an annual budget of Rs. 55.00 lakh under plan and Rs. 37.5 lakh under non plan heads for the year 1996-97. Besides, ICAR Revolving Fund Scheme had an outlay of Rs. 4.35 lakh and DCD Revolving Fund had Rs. 7.35 lakh. Ad-hoc scheme had an allocation of Rs. 0.97 lakh, while the budget under NARP was Rs. 5.0 lakh.

Crop Improvement

National Cashew Gene Bank (NCGB) at present has got 320 indigenous clonal accessions and 70 exotic seedling accessions of Brazil origin obtained through Mozambique. Process for importing exotic germplasm material from Brazil and Tanzania has been initiated. Cataloguing for 56 accessions of germplasm has been completed. In the evaluation of elite germplasm, (14 elite lines) highest annual yield of 3.5 kg/tree was recorded in VTH 59/2 compared to M 44/3 (check) which gave a yield of 1.88 kg/tree. Both VTH 59/2 and VTH 539/2 had superior annual yield.

Crop Management

A total of 24 tissue culture raised plant have been fully hardened in green house and ar ready for field planting.

Air layers of semitall (VTH 762/2, VTH 762/4, S 11/1, S 11/2) and tall (Selection - 1) have been field planted. Upto six years, spacing and system of planting had no effect on tree height, girth and spread of individual tree whereas, ground coverage was more in closer spacings.

In high density planting, plot with a population of 550 tree/ha gave the highest yield of 686 kg/ha (13 years after planting and 5 years after thinning from 1111 trees to 555 trees/ha). Under canopy management studies, significant variation for number of leaves per lateral and length of lateral was observed for both varieties and pruning levels. Nut retention has significantly increased in irrigated plots compared to unirrigated plots. Similar, differences in nut retention among fertilized and unfertilized trees were observed. An increase in yield by 40 per cent was observed when highest dose of fertilizer was applied under unirrigated conditions over check plot. Irrigation alone (60 to 80 l/tree) without fertilizer increased yield by 60-70 per cent compared to unfertilized and unirrigated trees.

Combination of casuarina and acacia affected the yield of cashew for the first six years after planting. Net profit realised, however, was maximum when two rows of acacia and a row of casuarina were grown as intercrops with cashew (Rs. 26,605/ha).

Crop Protection

Metarhizium anisopliae, a fungal pathogen survived and retained its virulance against the grubs of cashew stem and root borers (CSRB) even upto 90 days after mixing in the soil. It

was noticed that infested bark had highest oviposition of *Plocaederus* spp. Goa 11/6 having mid season flushing and flowering habit, escapes from severe attack of tea mosquito bug which could be responsible for its higher yield over the years. It also had higher mean yield of 7.2 kg/ tree in fifth harvest.

Post - Harvest Technology

Storage of raw nuts upto 16 months, initial raw nut moisture ranging between 5 and 14 per cent, grading before processing and roasting time varying between 5 and 20 min did not affect the processing quality. Floaters, however, are responsible for the kernel rejects noticed during processing. Based on the data collected from 133 cashew factories data base has been established. Raw nut cashew grader has been designed and fabricated.

Transfer of Technology

Information collected from neighbouring farmers of demonstration farmers was analysed and it was found that majority had favourably good knowledge regarding the ideal planting material of cashew. About 40 per cent of the respondents had even the knowledge of a few varieties of cashew. It was however, disheartening to note that their knowledge on pest control methods and its adoption was dismal.

Human Resource Development

Scientists were sponsored for training courses on computer application in agricultural research and computer net working and information processing in agriculture. Besides, scientists were also deputed to National Seminars, Workshops covering horticultural research and development. A Workshop cum - training - programme was organised for promoting use of official language for the staff of the centre.

CROP IMPROVEMENT

1. CROP IMPROVEMENT

1.1 GERMPLASM COLLECTION AND CONSERVATION

The objectives of the project are collection of both indigenous and exotic germplasm, conservation of germplasm in the National Cashew Gene Bank (NCGB), and evaluation and cataloguing of germplasm.

Scions sticks (@ 25 trees) collected from the 24 cashew trees which were identified from KCDC/Forest Plantations in Dakshina Kannada district during 1996 fruiting season were grafted on root stock seedings. The grafts are being maintained in the nursery for planting in NCGB.

Survey for germplasm collection was undertaken in Uttara Kannada district during 1997 fruiting season. The KCDC/Forest plantations in Bhatkal, Honnavar, Kumta, Ankola, Karwar, Sirsi and Siddapur units of Kumta Division were surveyed. A total of 12 trees were identified from these plantations for different characters (Table 1.1). Most of these trees are found growing in lateritic soils with open boul-

Table 1.1 Cashew germplasm identified from KCDC plantations of Kumta Division during 1997

Name of plantation	Collection no.	Tree growth	Season of flowering	Shelling %	Features
Mavalli - 1957	MA-1	Tall	Feb.	—	Cluster bearing, high yield
	MA-2	Semi-tall	Jan.-Feb.	24.4	Cluster bearing, high yield
	MA-3	Tall	Jan.-Feb.	25.8	Cluster bearing, high yield
	MA-4	Tall	Jan.-Feb.	25.3	Cluster bearing, high yield
	MA-5	Tall	Jan.-Feb.	24.8	Cluster bearing, high yield
	MA-6	Tall	Feb.-Mar.	—	Cluster bearing, high yield
	MA-7	Semi-tall	Jan.-Feb.	30.9	Cluster bearing, high yield
Gunavanthi Malkod-1969					
Malkod-1969	GM-1	Semi-tall	Jan.-Feb.	26.8	Cluster bearing, high yield, short internode length of twigs, thick leaves, green leaves.
	GM-2	Semi-tall	Feb.-Mar.	—	Late flowering, cluster bearing, high yield.
Gokarna-1964/65	GO-1	Semi-tall	Jan.-Mar.	27.5	Protracted flowering, cluster bearing, high yield.
Aghanashini-1953	AN-1	Semi-tall	Jan.-Mar.	29.9	Protracted flowering, cluster bearing, high yield.
Uluvare-1963	UV-1	Tall	Jan.-Mar.	27.9	Protracted flowering, cluster bearing, high yield.

All the collections had nuts of medium size except GM-2 which had small nuts.

GM - 1, a collection with short internodes

ders / sheeted laterite /rocks and in level to slopy lands without receiving any cultural treatments.

Exotic germplasm material for collection from Brazil (CCP. 06, 09, 76, 1001 ; FAGA-1, 3, 7, 11 ; *Anacardium gigantium, A. rhinocarpus, A. spruceanum)* and Tanzania (AC4) have been identified and process for importing the same has been initiated.

Sixteen seed samples (15 *Anacardium occidentale* and one *A. microcarpum* reported to be precocious, dwarf, and high yielding, received from Brazil through Mozambique, were sown in polybags (102 seeds) and the seedlings (77 no.) were planted in NCGB during August 1996. At present the NCGB has got 320 clonal accessions and 70 exotic seedling accessions got from Brazil through Mozambique.

1.2 GERMPLASM EVALUATION

Observations as per IPGRI cashew descriptors have been recorded on 30 accessions (1987 planted in NCGB). Correlation among ten economic characters, namely, plant height, canopy spread, leaf area, flowering intensity, duration of flowering, weight/nut, weight/apple, weight/kernel, shelling percentage and yield/plant, has been worked out for 56 accessions (1986 planted).

Leaf area had significant positive correlation with yield ($r = 0.223, R^2 = 0.049$). Weight/apple, however, had significant negative correlation with yield ($r = -0.293, R^2 = 0.086$). The multiple correlation (R) was 0.605 and the multiple regression fitted had a coefficient of determination (R^2) as 36.62 per cent. Therefore, the nine characters could determine the yield to an extent of 37 per cent.

1.3 CATALOGUING OF GERMPLASM

Observations recorded in IPGRI cashew descriptors on 56 accessions (1986 planted) have been characterised. Majority of the accessions had upright and open tree habit (98.2%), obovate leaves (60.7%), extensive type of branching (98.2%), red coloured young leaves (66.1%), mid-season flowering (Dec.-Jan., 69.6%), yellow coloured mature apple (50.0%), conical-obovate shaped apple (69.7%), loosely attached nut to apple (55.4%), non-uniform shell thickness (94.6%), loosely attached peel to kernel (100.0%) and rounded flanks of nut (58.9%) (Table 1.2). Statistically analysed data for seventeen quantitative characters is presented in Table 1.3. Variablity was the highest for sex ratio (42.7% CV), followed by apple to nut ratio (32.8% CV) and weight/apple (28.4% CV). Tree height, twig diameter, internode length, number of leaves/twig, leaf size, flowering intensity, shelling percentage, weight/kernel and yield/tree, exhibited CV of more than 20 per cent. Moderate variability was observed for tree spread (13.6%), twig length (17.7%), flowering duration (13.9%) and

Table 1.2 Variability for some of the qualitative descriptors of 56 accessions.

Descriptor	Descriptor State		% Accession
Tree habit	3.	Upright & Compact	0.0
	5.	Upright & open	98.2
	7.	Spreading	1.8
Leaf shape	1.	Oblong	16.1
	2.	Obovate (Club-Shaped)	60.7
	3.	Oval	23.2
Branching pattern	1.	Extensive	98.2
	2.	Intensive	1.8
Colour of young leaves	1.	Red	66.1
	2.	Yellow Red	30.4
	3.	Green Yellow	3.5
	4.	Purple	0.0
Season of flowering	3.	Early (Nov-Dec.)	21.4
	5.	Mid (Dec-Jan.)	69.9
	7.	Late (Jan-Feb.)	9.0
Colour of mature apple	1.	Yellow	50.0
	2.	Red	50.0
	3.	Yellow Red	0.0
	4.	Red Purple	0.0
Shape of cashew apple	1.	Cylindrical	10.7
	2.	Conical-Obovate	69.7
	3.	Round	10.7
	4.	Pyriform	8.9
Attachment of apple to nut	3.	Loose	55.4
	5.	Intermediate	10.7
	7.	Tight	33.9
Uniformity of shell thickness	0.	Not uniform	94.6
	+.	Uniform	5.4
Attachment of peel to kernel	1.	Loose	100.0
	2.	Tight	0.0
Flanks of nuts	3.	Flattened	39.3
	5.	Round	58.9
	7.	Bulging	1.8

Table 1.3 Quantitative characterization of 56 cashew accessions

DESCRIPTOR	Mean	Range Minium	Range Maximum	CV (%)
Tree height (m)	5.3	3.3	8.0	23.9
Tree spread (m)	6.0	4.3	8.4	13.6
Twig length (cm)	16.0	10.2	23.0	17.7
Twig diameter (mm)	4.6	3.5	10.0	20.4
Internode length (cm)	1.6	1.0	2.9	23.1
No. of leaves per twig	10.0	6.0	14.0	21.7
Leaf size (cm^2)	60.9	37.0	122.9	24.2
Duration of flowering (days)	96.6	74.0	128.0	13.9
Flowering intensity (%)*	56.5	28.6	83.0	21.3
Sex ration (Female : Male + Female)	0.1	0.03	0.2	42.7
Weight of apple (g)	57.2	20.0	101.6	28.4
Wt. of nut (g)	5.4	2.9	8.3	18.7
Apple to nut ratio	10.7	4.1	28.1	32.8
Shelling percentage	27.3	18.0	33.2	21.2
Shell thickness (mm)	2.9	2.2	3.5	10.7
Weight of kernel (g)	1.5	0.7	2.2	20.6
Cumulative yield/tree (kg)	10.5	6.8	19.8	22.9

$$* \frac{\text{No. of flowering laterals}}{\text{Total no. of laterals}} \times 100$$

weight/nut (18.7%). Variability was the least for shell thickness (10.7% CV).

1.4 VARIETAL IMPROVEMENT

Objectives of the breeding programmes are the genetic improvement of cashew for yield and other important characters such as nut weight (>7g), kernel weight (>2g), shelling percentage (>28%), resistance to tea mosquito bug and quality of cashew kernels (high protein and lysine). A total of 58 accessions/elite lines, eight selfs and 43 hybrids were evaluated in seven trials. Twentyfive new cross combinations were freshly planted in 1996 under nut size improvement programme. Details of the trials are as under:

(a) Elite germplasm lines/accessions.
(b) Evaluation of recommended varieties
(c) Evaluation of hybrids/selfs
(d) Improvement of nut size in released varieties
(e) Other trials - a trial on high shelling types, a trial on big apple types and a trial on comparative study of the performance of grafts versus seedlings.

1.4.1 Evaluation of elite germplasm lines/ accessions

Among the 14 elite germplasm lines/ accessions evaluated, VTH 59/2 and VTH 539/ 2 performed better in sixth harvest. Highest annual yield of 3.90 kg/tree was recordedd in VTH 59/2 as against 1.88 kg/tree in case of M 44/3 (107% increase over M 44/3 control) and with nut weight of 6.2 g, kernel weight of 2.0g and shelling percentage of 31.5 per cent. This was followed by VTH 539/2 with annual yield of 3.54 kg/tree which was 89 per cent higer over control. Highest cumulative yield of 7.37 kg/ tree was recorded in VTH 539/2 registering 70 per cent more than the control. Cumulative yield

of control M 44/3 was 4.34 kg/tree. VTH 59/2 had cumulative yield of 7.21 kg/tree. Both VTH 59/2 and VTH 539/2 had superior annual yield and cumulative yield over the grand mean of all 14 lines. Grand mean for annual and cumulative yield was 2.34 kg/tree and 5.05 kg/tree respectively. VTH 40/1 had nut weight of 8.1g which was the highest. Kernel weight was highest in VTH 194/12 (2.6g) followed by VTH 196/18 (2.5 g).

1.4.2 Evaluation of recommended varieties

Two trials with recommended varieties (Set-1 : 12 varieties planted in 1986 and Set-2 : 9 varieties planted in 1991) had a common control of M 44/3. Highest cumulative yield of 9.31 kg/tree was recorded in M 44/3 followed by EPM 9/8 with 8.36 kg/tree upto 8th harvest with grand mean of 5.99 kg/tree for all 12 variteies in Set-1 (Table 1.4). The highest nut weight (6.7g) and highest kernel weight (2.2g)

Table 1.4: Performance of recommended varieties

Variety	Yield (kg/tree)	Cum. Yield (kg/tree)	Nut wt. (g)	Kernel wt (g)	Shelling (%)	Hermaphrodite flower (%)
Set-1 (8th harvest)						
1. M 44/3	2.23	9.31	4.6	1.2	27.5	30.15
2. EPM 9/8(BPP-4)	2.81	8.36	6.7	2.2	31.4	17.52
3. T.No.1(BPP 5)	2.43	7.97	4.8	1.4	28.6	31.55
4. BLA 39-4	1.35	7.15	4.5	1.8	34.8	41.26
5. M 10/4	1.20	6.61	5.1	1.4	27.8	27.83
6. T.No.56(BPP-6)	2.16	6.58	4.9	1.5	31.2	28.07
7. H 2/12(BPP2)	1.85	6.41	4.3	1.3	29.9	7.70
8. Ullal-1	1.15	5.43	5.3	1.7	32.3	5.29
9. BLA 139-1	1.38	5.12	5.3	1.7	32.1	32.15
10. H 2/11 (BPP 1)	0.72	4.00	5.1	1.8	33.5	40.52
11. H 3-17	0.74	3.35	5.4	1.6	30.0	18.98
12. H 3-13	0.14	1.66	5.4	1.7	32.4	16.01
Grand Mean	1.513	5.99				
CD 5%	0.777	2.284				
Set-2 (3rd harvest)						
1. Vengurla-1	0.54	1.58	5.2	1.7	32.8	13.64
2. NDR 2-1	0.75	1.53	6.8	2.2	31.1	13.64
3. Vengurla-4	0.33	1.48	7.1	2.1	31.2	26.89
4. Ullal-2	0.31	1.47	4.2	1.3	27.6	11.50
5. NRCC Sel-2	0.25	0.99	7.6	2.4	30.7	17.94
6. M 44/3(VRI-2)	0.32	0.96	4.8	1.2	25.9	
7. BPP-3	0.13	0.72	5.2	1.5	28.6	21.45
8 K-22-1	0.26	0.68	5.6	1.8	30.5	7.40
9. NRCC Sel-1	0.13	0.60	6.1	1.8	28.3	12.65
Grand Mean	0.336	1.110				
CD 5%	0.371	0.670				

were recorded in EPM 9/8 in Set-1. Out of nine varieties evaluated in Set-2, highest cumulative yield of 1.58 kg/tree upto third harvest was recorded in Vengurla-1 as against cumulative yield of 0.96 kg/tree in M 44/3 and with grand mean of population being 1.11 kg/tree (Table 1.4).

Flowering phases were studied in 20 varieties from January to April 1997. Proportion of hermaphrodite flowers to total number of flowers and period of different flowering phases ie, male phase, hermaphrodite phase and mixed phase, were observed in each of the 20 varieties by counting the number of hermaphrodite and male flowers at interval of 3 to 4 days on tagged flower panicles. Proportion of the hermaphrodite flowers ranged from 5.29 per cent to 41.26 per cent among the different varieties, the lowest being in Ullal-1 and the highest being in BLA 39-4 (Madakkathara-1). H 2/11 (BPP 1) had also very high proportion of hermaphrodite flowers (40.52 per cent). Varieties having more than 30 per cent hermaphrodite flowers were BLA 139-1 (32.15%), H 2/11 (BPP 1) (40.52%), T.No.1 (BPP 5) (31.55%), M 44/3 (30.15%) and BLA 39-4 (Madakkathara-1) (41.26%) (Table 1.4).

Among the 20 varieties studied, mixed phase persisted throughout the flowering period in H 2/11 (BPP 1), M 44/3 (VRI-2), BLA 39-4 (Madakkathara-1), and Vengurla-4 (Table 1.4). Male phase predominated throughout the flowering period in Ullal-1, H 3-13, H 2/12 (BPP-2), Ullal-2, NDR-2-1 (Madakkathara-2), K 22-1 and NRCC Selection-1. There were only male flowers in the first one month in Ullal-1 while it was so in the last one month in the case of NRCC Sel-2. This predominance of male phase thus might have resulted in the lower yield levels of these varieties. Hermaphrodite phase was more pronounced during early period in T.No.1 (BPP-5). However, this has not resulted in increase in yield. The existence of mixed phase throughout the period of flowering might have also contributed for the highest cumulative yield observed in M 44/3.

1.4.3. Evaluation of hybrids/selfs

There are three sets of experiments under the evaluation of hybrids/selfs. In the first set 25 hybrids and 5 selfs were evaluated along with a check (M 44/3) in unreplicated preliminary evaluation trial planted in 1987. In the second set (planted in 1992), six hybrids and one selfed line and in the third set (planted in 1994) five hybrids and two selfed lines were evaluated in replicated trials along with NRCC Sel-1, NRCC Sel-2, VRI-2 and VTH 174.

In the first set (unreplicated trial) Tree No.46 of cross VTH 36 (Tr.No.56) x VTH 30 (A 18/4) performed well with annual yield of 2.25 kg/tree and cumulative yield of 13.16 kg/tree in 7th harvest (Table 1.5). The nut weight was 6.9g with kernel weight of 2g. Shelling percentage was 28.3 per cent.

Hybrid tree No.10 of cross VTH 59/2 (13/5 Kodur) x VTH 20/4 (M 37/3) and Hybrid tree No.41 of cross VTH 93 (13/12 Sanyasiputka) x VTH 36 (T.No.56) also performed well for yield and nut characters. Cumulative yield of these hybrids was twice the yield of check (M 44/3). Among the selfs,VTH 30 (A 18/4) self had one tree No. 88 which had medium cumulative yield of 8.87 kg/tree and with 6.75 g nut weight, 2.2 g kernel weight and 30.9 shelling percentage.

Table 1.5 Performance of promising hybrids in hybrid evaluation trial (Set-1).

Tree No.	Cross	Yield (kg/tree)	Cum yield (kg/tree)	Nut wt. (g)	Kernel wt. (g)	Shetting %
46	T.No.56 x A 18/4 (VTH 36 x VTH 30)	2.25	13.16	6.9	2.0	28.3
10	13/5 Kodur x M 37/3 (VTH 59/2 x VTH 20/4)	1.45	12.00	6.2	1.9	29.7
41	13/12 Sanyasiputka x T.No.56 (VTH 93 x VTH 36)	3.80	11.39	6.4	1.9	28.6
-	M 44/3 (VTH 12)	1.25	5.97	5.4	1.7	29.0

In second set (replicated trial), highest yield was recorded in hybrid 32/4 (0.73 kg/tree) in the first harvest as against yield of 0.23 kg/tree in M 44/3 (check). Nut weight and kernel weight of H 32/4 were 6.8 g and 1.8 g respectively. (This hybrid was selected from the hybrid trial conducted at Vittal). The hybrids/selfs in the third set are in the initial stage of plantation.

1.4.4 Improvement of nut size in released varieties

In order to combine the high yielding character with bold nut and kernel characters, crosses were made between released varieties and bold nut types since 1990. Over 800 hybrid plants were planted since 1991.

Six grafts each of NRCC Sel-1, NRCC Sel-2 and M 44/3 were planted along with the hybrid seedlings in the same trial for comparison of the performance of hybrids in relation to seedlings.

Performance of the selected hybrid plants in second harvest is given in Table 1.6. Thirteen hybrid plants were identified as promising ones out of over 250 bearing plants. Nut weight of two entries were 11.0 g (H-1200) and 10.0 g (H-1482). Kernel protein and lysine content were analysed in six selected hybrid trees. H 1185 had high protein (59.2%) while H 1310 had low protein (35.8%). Lysine content ranged from 31.7 to 43.4 µg/mg protein (Table 1.6). Based on field caging studies for TMB incidence, all six hybrid trees along with check were found susceptible to TMB. In crosses where bold nut genotype VTH 711/4 was used as donor parent, proportion of the hybrid plants having large nut size was higher as compared to the crosses where medium nut size genotype VTH 40/1 was used as donor parent.

1.4.5 Other trials

In a trial on evaluation of high yielding and high shelling types, seven genotypes along with a check (M 44/3) were evaluated. Cumulative yield of VTH 79/1 was 1.85 kg/tree, which was followed by VTH 57/1 (1.56 kg/tree) in third harvest. All genotypes had shelling percentage of more than 30.0 per cent.

A trial on evaluation of eight big apple and medium size nut types along with M 44/3 was conducted with the purpose of identifying dual purpose types. Highest apple weight was

Table 1.6 Performance of selected individual hybrid plants in nut size improvement programme

Tree No.	Parentage	Yield (kg/tree)	*Cum yield (kg/tree)	Nut wt. (g)	Kernel wt. (g)	Shelling %	Protein %	Lysine µg/ mg protein
H-1181	V5 x VTH 711/4	0.80	1.10	8.1	2.5	33.3	46.7	42.5
H-1185	BLA 139/1 x VTH 711/4	0.30	0.75	8.4	2.5	30.9	59.2	31.7
H-1191	M 44/3 x VTH 711/4	0.15	1.00	8.6	2.3	28.8	40.0	41.6
H-1200	M 44/3 x VTH 711/4	0.11	0.91	11.0	3.5	32.6	41.0	39.7
H-1226	BLA 139/1 x VTH 711/4	0.15	0.90	8.0	2.5	32.1	-	-
H-1247	BLA 139/1 x VTH 711/4	0.25	0.65	8.2	2.4	28.1	-	-
H-1299	BLA 139/1 x VTH 711/4	0.05	0.40	9.4	2.7	31.6	-	-
H-1310	V5 x VTH 711/4	0.10	1.00	8.1	2.2	29.1	35.8	42.6
H-1341	V5 x VTH 711/4	0.05	1.20	9.0	3.0	33.3	-	-
H-1356	V5 x VTH 711/4	0.05	0.60	8.9	2.4	27.9	-	-
H-1481	M 44/3 x VTH 711/4	0.16	0.76	9.0	3.0	33.3	-	-
H-1482	BLA 139/1 x VTH 711/4	0.20	0.20	10.0	3.0	30.0	-	-
H-1496	V5 x VTH 711/4	0.10	0.90	8.9	2.6	30.5	41.5	43.4
	M 44/3						53.8	36.5
	BLA 139/1						60.6	29.4

* for two harvests

recorded in VTH 146/1 with 67.3 g apple weight which was more than double the weight of apple of M 44/3. Cumulative nut yield in this genotype was 1.50 kg/tree in third harvest. Highest cumulative yield was recorded in VTH 146/4 (2.20 kg/tree). In a trial on comparative study of the performance of grafts versus seedlings, five genotypes were evaluated with one set originating from grafts and another set originating from seedlings from same mother tree. They were compared both for morphologfical characters and yield. The grafts and seedlings originating from same source (same mother plant of a genotype) did not differ for morphological, yield, nut and apple characters.

1.5 MICROPROPAGATION

This programme was initiated in 1989 with the objective of standardising micropropagation technique to multiply cashew elite lines.

1.5.1 Root stock micropropagation

1.5.1.1 Induction of multiple shoots

In vitro germination of immature nuts of dwarfing rootstocks was done on B5 (Gamborg's) medium supplemented with 2mg/l of NAA. Shoot tips excised from the *in vitro* raised seedlings on three-fourth strength MS medium supplemented with TDZ and NAA (0.1 mg/l each) showed multiple shoot induction. The hormones were withdrawn after 10, 20 and 30 days of incubation. A minimum period of 10 days in TDZ medium was sufficient to induce maximum number of buds (4.8 buds/explant).

1.5.1.2 Shoot bud elongation

Two media namely Raj Bhansali (1990) medium with casein hydrolysate and half-MS medium with glutamine 400 mg/l were tried for elongation of shoots. The former medium was found better with 84.2 per cent of the shoots showing elongation.

1.5.1.3 *In vitro* rooting

For rooting, a factorial experiment was laid out with 24 treatments involving two basal media (MS, WPM), two states of media (solid, liquid), two levels of sucrose (full strength, half strength) and three levels of hormones (0.5mg/l NAA, 2.5mg/l of IBA).

The results are presented in Tables 1.7 and 1.8. There was significant difference for the state of medium and auxin levels and the interactions between the treatments were not significant. Liquid medium (41.7%) was superior to solid medium (26.6%) and auxin medium was superior to hormone free medium. The best treatment was WPM liquid with 1% sucrose containing NAA and IBA (2.5mg/l each) which gave about 80 per cent rooting of shoots.

1.5.1.4 Hardening and establishment of tissue culture plants

Acclimatisation of rooted microshoots were tried in pots containing sand and soilrite mixture at varying proportion (2:1, 1:1 & 1:2). The survival of plants was found to be highest (50%) in 2:1 potting mixture. A total of 24 tissue

Table 1.7: Effect of basal medium, state of medium and sucrose level on in *vitro* rooting per cent.

Basal Medium	Solid			Liquid			Mean %
	Half sucrose	Full sucrose	Total	Half sucrose	Full sucrose	Total	
MS	26.6	26.6	26.6	40.0	46.6	43.3	34.9
WPM	40.0	13.3	26.6	33.3	46.6	40.0	33.3
Mean(%)	33.3	19.9	26.6	36.7	46.6	41.7	34.1

Predominance of single root in *in vitro* rooting

Table 1.8 Effect of hormone treatment on rooting.

Auxin levels	Rooting (%)
Zero	17.0
NAA (5mg/l)	34.1
NAA + IBA (2.5mg each/l)	48.8

Result: F test significant (at 5% level) for state of media and auxin levels.

culture plants have been fully hardened and established in green house and are ready for field planting.

1.5.2 Regeneration studies in mature trees

1.5.2.1 Control of contamination

For control of contamination and establishment of axenic cultures in cashew various measures in field and laboratory were under - taken. Trees were pruned, irrigated and sprayed with fungicides. The collected shoots were sterilized with various sterilants (mercuric chloride, bleach, chlorine tablet) with and without agitation in carbendazim (0.2%). Among the various treatments tried, a double sterilization procedure involving bleach (20%) for 20 min. and mercuric chloride (0.05%) for 10 min. was found best for nodal explants of field trees (VRI-2) with a contamination control of 60-70 per cent and a bud break percentage of 16 per cent. On the other hand, nodal explants collected from green house maintained young cashew grafts of (Ullal-2 and NRCC-1), control of contamination and bud break was much better. Sterilization following mercuric chloride (0.1%) for 5 min. gave over 75 per cent contamination free cultures with a bud break of 53.6 and 72.0 per cent respectively.

1.5.2.2 Induction of multiple shoots

A trial on multiplication experiment was initiated with three basal media (MS, WPM and SH) and two levels of TDZ (0.1 and 2 mg/l) with a common level of (0.1mg/l) of IBA using microshoots of Ullal-2. Multiple shoots (3 buds/explants) were induced in both Ullal-2 and NRCC-1 in about 4-5 weeks. The best medium for multiple shoot induction was MS with 0.1mg/l of IBA with 75 per cent of the microshoots in Ullal-2.

CROP MANAGEMENT

2. CROP MANAGEMENT

2.1 PROPAGATION AND REJUVENATION

The objectives of this programme are, finding out the possibility of increasing graft success during off-season, identification of dwarf/ semidwarf root stock and working out the economics of top working.

2.1.1 Off season grafting

Production of softwood grafts of cashew has been shown to be possible during off-season (Oct.-Feb.) with about two month old green scions and also decapitated scions. Mean graft success was 56 and 52 per cent, respectively.

Use of low cost humidity chamber/ polyhouse with mist makers during drier months was found to be advantageous though the graft success was at par with that of normal method (capping individual graft and keeping under shade for two weeks before shifting to nursery).

2.1.2 Root stock studies

Field planted air layers of semi-tall (VTH 762/2, VTH 762/4, S 11/1 and S 11/2) and tall (Selection-1) trees will be used as root stocks for grafting with the scions of tall type (Selection-1), in order to study the influence of root stock on the growth of scion variety.

2.1.3 Top working/rejuvenation

Mortality of the successfully top worked trees was encountered due to cashew stem and root borer infestation inspite of giving regular prophylactic treatments. The mortality was more in those plots which were surrounded by the stem borer infested plantations and in the older trees (Table 2.1).

The cost of establishment and maintenance of 0.2 ha each of top worked plot and replanted plot for the last seven years was Rs. 5882 and Rs. 5239 (Rs. 367/tree and Rs. 174/plant), respectively (Table 2.2).

In a large plot trial, 94 cashew trees of Vengurla-2 variety, aged seven years, were top worked with scions of Vengurla-1 variety during 1996 (beheading in May and grafting in July). A total of 532 shoots (@ 6-8 shoots/tree) were grafted, of which a total of 439 were successful with a mean graft success of 82.5 per

Table 2.1 Success of top working.

Loaction	Age of tree (years)	Year	Month of beheading	Month of grafting	Top worked trees (no.)	Graft success (%)	Mortality of trees (%)
Shanthigodu	11	1989	Apr-Sept.	July-Nov.	108	37-78	61-94
Shanthigodu	14	1990	June	Sept/Oct.	30	72	46.6
Kunthur	11	1991	May	July/Aug.	60	83	88.0
Vittal	12	1994	Aug.	Nov./Dec.	24	57	53.8
Shanthigodu	7	1996	May	July	94	82	1.0

Table 2.2 Cost of establishment and maintenance of top worked and replanted plots (0.2 ha eac during the last seven years.

Year	Amount spent (Rs.)		Yield (Kg)	
	Top worked	Replanted	Top worked	Replanted
1990-91 to 1995-96	5050.00	4216.00	125.70 (4 harvests)	47.69 (3 harvests)
1996-97	832.00	1023.00		
Total	5882.00	5239.00		
No. of plants	16	30		
Per tree	367.62	174.63		

cent. About 3-4 successful shoots/tree have been retained and others were removed. Regular prophylactic treatments were given at monthly intervals. So far, only one tree had died due to stem and root borer infestation. From 45 trees, a total of 198 eggs and 40 grubs of stem borer were extracted during June 96 - April - 97 and the stumps were treated. The cost of establishment and maintenance of 0.25 ha plot (94 trees) of top working during the first year was Rs. 3098 (Rs. 33/tree) (Table 2.3).

Table 2.3 Cost of establishment and maintenance of top worked plot (0.25 ha) during 1996-97.

Particulars	Amount (Rs.)
Beheading of trees (94 trees; 7 year old)	726
Maintenance cost	1020
Grafting of shoots, removal of sprouts etc.	660
Plant protection	1632
Total	4038
Quantity of fuel wood 4700 kg x Rs.0.20	940
Net expenditure	3098
Expenditure/tree	33

2.2 PLANTING SYSTEMS AND SPACING

2.2.1 Hedge and square systems

The study was initiated to understand th effect of systems of planting and spacing o growth and yield of cashew under both prune and unpruned conditions. The field experimen was laid out at Kemminje during the year 199 in a Split plot design with 3 replications. Main plot treatments.

Square system	Hedge system
5.0Mx5.0M-T1	5.0Mx4.0M-T4
6.5Mx6.5M-T2	6.5Mx4.0M-T5
8.0Mx8.0M-T3	8.0Mx4.0M-T6

Sub plot treatments.

1. Pruned 2. Unpruned

During the period the branches which were intermingling with neighbouring plants, criss cross branches and dry twigs were pruned in sub plot treatments. Rest of the plants remained unpruned.

Observations on growth parameters such as height of the plants girth of the trunk, canopy spread and grond coverage and soil temperature and moisture were recorded. Spacing and system of planting did not affect tree height, girth and

Table 2.4 Effect of spacing and system of planting under pruned and unpruned conditions on ground coverage(%),soil moisture and temperature.

Spacing (m)	Plant population per ha	Ground coverage (%)		Soil moisture (%)		Soil temperature (°C)	
		Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
Square							
T1 (5 x 5)	400	56.5	72.08	13.32	14.94	33.1	36.6
T2 (6.5 x 6.5)	236	33.2	29.20	10.98	12.09	34.2	37.1
T3 (8 x 8)	156	19.6	23.80	10.99	12.78	39.9	39.2
Hedge							
T4 (5 x 4.0)	500	83.1	100.0	11.23	13.23	35.0	33.4
T5 (6.5 x 4.0)	384	50.0	62.7	12.75	13.17	38.9	35.1
T6 (8 x 4.0)	312	37.5	38.6	11.63	10.36	38.4	35.5

spread of individual tree sinificantly whereas, it affected ground coverage/ha significantly.The ground coverage was maximum in 5mx4m spacing in both pruned (83.1%) and unpruned plot (100%). Lowest ground coverage was observed in 8m x 8m spacing both under pruned and unpruned conditions (Table 2.4)

Soil moisture tends to be on lower side when trees are widely spaced (T2 & T3) and high when trees are closely spaced (T1 & T4) indicating that competition for moisture is not existing when trees are closely spaced upto sixth year. Lower moisture content in case of plots where trees are widely spaced may be due to less ground coverage (19.6 to 33.2 %) compared to plots where trees are closely spaced (56.5 to 100 %).Slight increase in soil temperature in plots where trees are widely spaced (T2 & T3 - 34.2 to 39.2°C) compared to plot where trees are closely spaced (31.1 to 36.1°C) was observed (Table 2.4).

Table 2.5 Effect of spacing and system of planting under pruned and unpruned conditions on yield (six years after planting).

Spacing (m)	Density No./ha	Yield/plant (kg)		Yield (kg/ha)		Cumulative yield (kg/ha)	
		Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
Square							
T1 (5 x 5)	400	0.994	0.813	397.6	325.2	1220	1216
T2 (6.5 x 6.5)	236	0.680	0.627	160.5	148.0	508.3	489.6
T3 (8 x 8)	156	0.497	0.547	77.5	85.3	261.3	288.4
Hedge							
T4 (5 x 4.0)	500	0.880	0.590	440.0	295.0	1317.3	1263.0
T5 (6.5 x 4.0)	384	0.640	0.640	245.8	245.8	842.05	787.8
T6 (8 x 4.0)	312	0.573	0.413	178.8	128.8	658.4	570.25
SEM for Spacing (MP)		63.20					
CD for Spacing (MP)		198.54					
SEM for Pruning (SP)		31.22					
CD for pruning (SP)		25.92					

Though significant difference in yield/tree was not observed the yield/ha was significant among different spacing treatments. The nut tield in 5m x 5m and 5m x 4m spacing plots were significantly superior to other treatments viz; 8m x 8m, 6.5m x 6.5m spacings. The cumulative nut yield including fifth harvest also indicated that maximum yield was recorded in 5m x 5m and 5m x 4m spacing plots (Table 2.5). Though pruning has slightly improved yield it is not significantly superior to unpruned trees upto fifth harvest.

2.2.2 High density planting

This experiment was initiated during 1982 to assess the effect of different plant densities on growth and yield of cashew.

During this year also the plot with plant population of 555 trees/ha gave the highest yield 685.98 kg/ha (13 years after planting and five years after thinning from 1111 trees to 555 trees/ ha). Cumulative yield was maximum (5446.32 kg/ha) in the case of plot with 312 plants/ ha (originally 625 plants/ha) (Table 2.6).

Table 2.6 Effect of plant density on cashew nut yield(kg/ha)

Plant population/ha	Yield/ha after 13 years of planting	Cumulative yield (from 4-13 years after planting)
156	324.20	2599.20
278	610.97	3751.97
625 upto 10 years and 312 after thinning	502.32	5446.32
1111 upto 7 years and 555 after thinning.	685.98	5350.98
2500 upto 7 years and 625 after thinning	532.50	4880.50
SEM	12.2	
CD	51.62	

2.3 CANOPY MANAGEMENT STUDIES

Programme has been initiated to study the effect of pruning on canopy containment and dwarfing, flushing, flowering and yield of cashew.

General pruning along with leader shoot pruning in the case of trees, aged 11-13 years, was found to be beneficial. Pruning doubled the yield compared to unpruned trees and this trend continued for 2-3 years. In view of this, a field replicated trial on canopy management in cashew was laid out during 1992-93 with four varieties (VRI-1, Ullal-1, VTH 30/4 and Selection-1) and four levels of pruning (C1 = No pruning, C2 = Yearly pruning, C3 = Alternate pruning) in CRBD. The plot size consisted of 6 grafts planted at 8m x 8m spacing. All the plants have been trained to modified leader system. The pruning treatments were imposed starting from August 1995. Mean values for growth parameters, yield and leaf N and K content are presented in Table 2.7. Leaf area was recorded with the help of Laser Area Meter (CI-203) on fifth mature leaf from the terminal portion of a lateral shoot (all the four direction ; three trees/treatment). In the same way leaf samples were collected for NPK analysis. Tea mosquito infestation was observed in all the treatments. Variation due to varieties was significant for height of plant, trunk girth, canopy spread, leaf area, leaf N content and yield/tree. Variation due to both varieties and pruning levels were significant for number of leaves/lateral and length of lateral.

Table 2.7 Mean values for growth parameters.

Variety	Treatment	Flowering intensity per m^2 (%)	No. of leaves/ lateral	Length of lateral (cm)	Biomass pruned/plot (kg)
VRI-1	C1	32.1	11.5	28.0	0.00
(Intensive, Early)	C2	36.0	14.0	26.7	16.81
	C3	30.2	13.1	23.4	0.00
	C4	31.2	11.2	25.5	21.51
Ullal-1	C1	35.6	9.8	27.8	0.00
(Intensive, Late)	C2	29.5	11.7	23.8	10.01
	C3	31.3	10.5	22.3	0.00
	C4	26.4	11.5	23.8	8.16
VTH 30/4	C1	30.8	10.3	25.3	0.00
(Extensive, Early)	C2	29.5	11.4	23.8	23.51
	C3	31.1	11.3	24.1	0.00
	C4	24.5	10.3	24.9	10.23
Selection-1	C1	25.8	11.5	33.8	0.00
(Extensive, Late)	C2	34.7	14.2	31.5	21.60
	C3	25.9	12.8	28.4	0.00
	C4	28.7	13.8	30.2	10.23
CD (Var.)		NS	0.95	1.10	
SEM (Var.)		—	0.33	0.38	
CD (Prun.)		3.55	0.95	1.10	
SEM (Prun.)		1.23	0.33	0.38	

C1 - No pruning ; C2 - Yearly pruning, C3 - Alternate year pruning
C4 - Shape pruning

2.4 NUTRITIONAL STUDIES

2.4.1 Slow release nitrogenous fertilizers

Different forms of slow release nitrogenous fertilizers were compared for their efficacy with M 44/3 gtafts as plahting material. After four harvest, differences in leaf nutrients (NPK) and yield between different slow release nitrogenous fertilisers were not significant.

2.4.2 Irrigation and graded doses of NPK

Efficacy of drip irrigation coupled with graded doses of NPK on the productivity of cashew grafts is assessed in this programme which was started in 1989. The main plot treatments consisted of drip irrigation @ 20, 40, 60 and 80 litres per tree once in four days during dry months. Control (no irrigation) is also included. The sub-plot treatments are : (1) No fertilizder, (2) 250 g N, 62.5g each of P_2O_5 and K_2O/tree, (3) 500g N, 125g each of P_2O_5 and K_2O/tree, (4) 750g N, 187.5g each of P_2O_5 and K_2O/tree respectively. The experiment was laid out in split plot design with four replications. Here, apart from working out the irrigation requirements fertilizer use efficiency will also be studied.

Significant increase in nut retention was observed in irrigated trees compared to unirrigated trees (Table 2.8). Significant difference in nut retention was observed between plots receiving no fertilisers (M1) and high doses of fertiliser (M3 & M4).

Irrigating cashew at the rate of 80 litres/ tree once in four days resulted in annual yield of 2.77 kg/tree during the fifth harvest with a cumulative yield of 10.02 kg/tree. While in control plot the annual yield and cumulative yield were 2.121 kg/tre and 6.58 kg/tree respectively. Minimum difference among irrigation treatments (I2 to I5)was observed this year.

Highest annual yield (3.048 kg/tree) and cumulative yield (9.84kg/tree) were recorded in the plot receiving 750g N, 187.5 P_2O_5 and 187.5g K_2O. Lowest annual (2.09kg/tree) and cumulative (7.02kg/tree) yield was recorded from the check plot. Differences among graded doses of fertilizer were significant (Table 2.9).

Increase in yield by 40 per cent was observed when highest dose of fertiliser was applied under unirrigated conditions over check plot. Irrigation alone (60 to 80 l/tree) without fertlizers has increased yield by 60 to 70 per cent when compared with tree recieving no irrigation and fertilizer. Irrigating 60 to 80 l/tree once in 4 days with highest dose of fertilizer (750g, 187.5 P_2O_5 and 187.5g K_2O) increased yield by 122 to 129 per cent over check (no fertilizer and no irrigation Table 2.9 & 2.10).

Irrigation together with fertiliser increased yield substantially. Further, studies indicated that irrigation has also increased total yield by increasing harvest in the month of May (Fig 2.1 & Table 2.11).

Table 2.8 Nut retention percentage under different drip irrigation and NPK levels.

Treatment	Fertilizer treatment (g/tree)				
	M1	M2	M3	M4	Mean
0 l/tree*	35.93 (36.71)	41.49 (40.08)	44.09 (41.61)	50.35 (45.18)	42.96 (40.89)
20 l/tree	52.86 (46.66)	52.26 (46.30)	52.53 (52.280	59.65 (50.61)	56.82 (48.96)
40 l/tree	70.91 (57.48)	71.44 (58.43)	80.71 (64.73)	75.68 (60.71)	74.68 (60.33)
60 l/tree	75.55 (61.02)	72.96 (58.91)	73.30 (58.91)	76.58 (61.14)	74.60 (59.99)
80 l/tree	78.59 (62.84)	76.68 (61.20)	80.40 (63.93)	78.75 (62.57)	78.60 (62.63)
Mean	62.77 (52.94)	62.97 (52.98)	68.20 (56.29)	68.20 (56.04)	
CD for irrigation.	5.55				
CD for fertilizer.	3.51				

M1-0 : 0 : 0**
M2-250:62.5:62.5
M3-500:125:125
M4-750:187.5:187.5

* Once in four days through drippers. Figures in parentheses indicate transformed values.
** N : P_2O_5 : K_2O.

Table 2.9 Effect of drip irrigation and NPK doses on yield (kg/tree) seven years after planting.

Treatment	Fertilizer treatments (g/tree)				
	M1	M2	M3	M4	Mean
0 l/tree* (I_1)	1.72	2.20	2.28	2.29	2.12
20 l/tree (I_2)	2.21	2.50	3.11	3.12	2.74
40 l/tree (I_3)	1.99	2.27	2.69	3.10	2.52
60 l/tree (I_4)	2.31	2.81	2.76	3.35	2.81
80 l/tree (I_5)	1.90	2.57	3.26	3.38	2.78
Mean	2.03	2.47	2.82	3.05	
CD for irrigation	NS				
CD for fertilizer	0.346				

M1-0 : 0 : 0**
M2-250:62.5:62.5
M3-500:125:125
M4-750:187.5:187.5

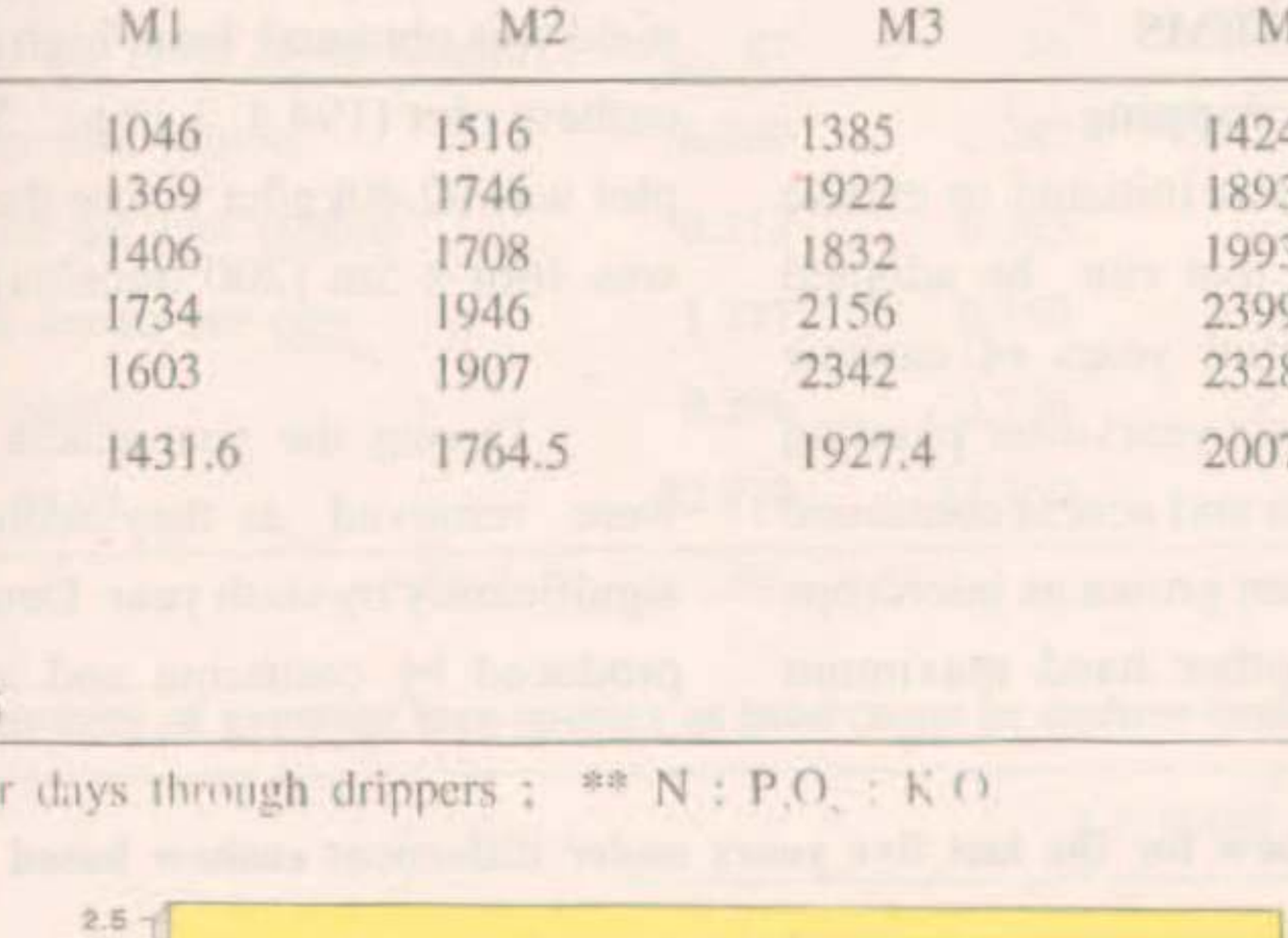
* Once in four days through drippers ; ** N : P_2O_5 : K_2O.

Table 2.10 Effect of drip irrigation and NPK doses on yield(kg/ha) up to seven years after planting.

Treatment	Fertilizer treatments (g/tree)				
	M1	M2	M3	M4	Mean
0 l/tree* (I_1)	1046	1516	1385	1424	1342.7
20 l/tree (I_2)	1369	1746	1922	1893	1732.5
40 l/tree (I_3)	1406	1708	1832	1993	1734.7
60 l/tree (I_4)	1734	1946	2156	2399	2058.7
80 l/tree (I_5)	1603	1907	2342	2328	2045.0
Mean	1431.6	1764.5	1927.4	2007.4	1782.7

M1-0 : 0 : 0**
M2-250:62.5:62.5
M3-500:125:125
M4-750:187.5:187.5

* Once in four days through drippers ; ** N : P_2O_5 : K_2O



Note:
I1 - I5 Irrigation treatments
M1 - M4 Fertilizer treatments

Fig. 2.1 Effect of irrigation and fertilizer on nut yield

Table 2.11 Effect of irrigation and fertilizer on distribution of nut harvest from Feb. to May.

	Irrigation (l/tree)					Fertilizers (N:P:K g/tree)			
	I_1	I_2	I_3	I_4	I_5	M_1	M_2	M_3	M_4
May	0.055 (4.70)	0.375 (20.25)	0.594 (28.98)	0.587 (29.35)	0.837 (37.03)	0.151 (10.87)	0.523 (27.19)	0.443 (21.80)	0.543 (25.95)
Apr	0.123 (10.50)	0.484 (26.14)	0.451 (21.99)	0.574 (28.70)	0.641 (28.36)	0.547 (39.38)	0.635 (33.02)	0.577 (28.39)	0.458 (21.89)
Mar	0.823 (70.00)	0.887 (47.80)	0.690 (35.65)	0.722 (36.10)	0.589 (26.06)	0.642 (46.22)	0.520 (27.04)	0.652 (32.10)	0.590 (28.20)
Feb	0.172 (14.80)	0.102 (5.50)	0.315 (15.56)	0.117 (5.85)	0.193 (8.54)	0.05 (3.60)	0.241 (12.53)	0.361 (17.76)	0.499 (23.85)

Note

I_1	=	0	M_1	=	0:0:0
I_2	=	20	M_2	=	250:62.5:62.5
I_3	=	40	M_3	=	500:125:125
I_4	=	60	M_3	=	750:187.5:187.5
I_5	=	80	M_4	=	750:187.5:187.5

Figuers in parantheses indicate percentage of total harvest

2.5 CROPPING SYSTEMS

2.5.1 Inter and mixed cropping

This programme was initiated to evolve suitable cropping system that can be adopted profitably during the initial years of cashew orchard life. For the first six years after planting combinations of casuarina and acacia continued to affect cashew yield when grown as intercrops (20.873 kg/ha). On the other hand maximum yield was obtained from high density (5m x 5m) cashew plot (194.4 kg/ha). Yield in the check plot was 92.40kg/ha where the spacing adopted was 10m x 5m (200 trees/ha) Table 2.12.

During the year acacia and csuarina trees were removed as they reduced cashew yield significantly by sixth year. Details of the biomass produced by casuarina and acacia in different

Table 2. 12 Yield of cashew for the last five years under differnent cashew based cropping systems.

Cropping system	Mean yield (kg/plot of 300 Sq. M)	Mean yield (kg/ha)	Cumulative yeld (kg/ha) (4-6 years after planting)
Cashew+acacia+casuarina	0.104	20.87	105.75
Cashew+casuarina+acacia	0.227	45.53	169.61
Cashew+ailanthus	0.367	73.40	238.27
Cashew + bamboo	0.543	108.95	274.82
Cashew high density	0.484	194.40	522.94
Cashew + subabul	0.430	85.67	258.69
Cashew alone	0.463	92.40	266.68
SEM		23.5	
CD		97.07	

treatments are given in Table 2.13. Acacia as intercrop produced maximum biomass (82.97 & 51.28t/ha). Casuarina as intercrop produced 37.76 & 31.22t/ha respectively in both treatments. Number of useful poles (4M length) were maximum in plot with cashew+acacia+casuarina.

Economics of growing tree species as intercrops for the first six years have been worked out and presented in Table 2.14. Total cost of production of growing tree species like two rows of acacia and a row of casuarina between two rows of cashew for the first six years was Rs 13900/ha and it was Rs 14300/ha in the case of growing two rows of casuarina and a row of acacia as intercrops between two rows of cashew. Net profit realised was maximum when two rows of acacia and a row of casuarina were grown as intercrops in cashew orchard (Rs 26605/ha).

Table 2.13 Biomass of acacia and casuarina produced in different cropping systems.

Parameter	Cropping system			
	1		2	
	acacia + (2 rows)	casuarina (1 row)	casuarina + (2 rows)	acacia (1 row)
	(Between two rows of cashew trees)			
No. of useful poles per plot (4 M Length)	82	54	39	77
Weight of poles per plot (t/plot)	6.360	2.280	2.050	3.590
Weight of fire wood per plot (t/plot)	0.212	0.065	0.057	0.114
Weight of twigs & leaves per plot	1.717	0.850	1.007	1.421
Total biomass per plot(t)	8.296	3.776	3.122	5.128
Total biomass per ha.(t)	82.970	37.760	31.220	51.280

Table 2.14 Economics of growing tree species as intercrops in cashew orchard for the first six years.

Parameter	Cropping system			
	1		2	
	acacia + (2 rows)	casuarina (1 row)	casuarina + (2 rows)	acacia (1 row)
	(Between two rows of cashew trees)			
Cost of poles/ha	19680 +	19440	14040 +	18480
Cost of firewood/ha	1060 +	325	285 +	270
Total income (Rs/ha)	20740 +	19765	14325 +	19050
	40505		33375	
Total cost of production (Rs)	13900		14300	
Net profit (Rs)	26605		19075	

2.6 INTEGRATED NUTRIENT MANAGEMENT

In order to explore the possibility of composting cashew wastes and to develop suitable organic manure for cashew the experiment was laid out at Shantigodu in 1996.

The details of treatments are as follows.

Main plot treatments (9)

- 100% NPK doses as existing practice
- 100% N in the form of poultry manure.
- 50% N in the form of poultry manure and remaining NPK in the form of inorganic fertilizers.
- 100% N in the form of composted coir pith.
- 50% N in the form of composted coir pith and remaining NPK in the form of inorganic fertilizers.
- 100% N in the forn of farm yard manure.
- 50% N in the form of farm yard manure and remaining NPK in the form of inorganic fertilizers.
- 100% N in the form of composted cashew wastes and weeds.
- Control-No fertilizer /organic manure.

Sub plot treatments.

- Spraying neem based insecticide-Limanool.
- No spray.

During the first year cashew grafts of NRCC selection 2 variety were planted in field after clearing existing tree growth. The treatments will be imposed from third year onwards. Different manures will be procured during the next season for composting.

CROP PROTECTION

3 CROP PROTECTION

3.1 POPULATION DYNAMICS OF CASHEW STEM AND ROOT BORER (CSRB)

The intensity of infestation of CSRB, *Plocaederus spp.* was recorded at the National Cashew Gene Bank at Kemminje campus from March 1996 to February 1997. Majority of infested trees showed initial symptoms during March-June (11 trees) followed by moderate infestation, upto November (10 trees) after which severity of infestation manifested (7 trees). This indicated that the population commenced during March and progressed during the later months (Table 3.1).

During the period under survey, 3 trees recovered, while 7 trees died despite curative treatment. This could be due to fresh infestation or infestation prevailing in the root zone.

An experimental plot at Shantigodu campus was observed for eggs laid, during the peak period of CSRB emergence viz. February to April. It was observed that healthy trees had eggs of both species of CSRB ; *P. ferrugineus* and *P. obesus* indicating co-existance of both species as primary pests of cashew.

3.2 LAB REARING TECHNIQUE

3.2.1 Young grubs of CRSB

The freshly hatched grubs of both species of CRSB were released on host bark pieces of 2cm x 2cm, which were placed in a covered petridish and was moistened daily by spraying

Table 3.1 Different stages of CSRB infestation during 1996-97.

	Initial		Moderate			Severe			Recovered			Dead		
	Existing	Fresh	Existing	Progr	Fresh	Existing	Progr	Fresh	Existing	Fresh	Existing	Progr	Fresh
Mar 96	7	-	2	-	-	-	-	-					
Apr 96	7	3	1	-	-	-		-		1			
May 96	10	1	1	-	-	-		-	1				
Jun 96	10	1	1	2	-	-		-	1				
Jul 96	9		3	2	-	-		-	1				
Aug 96	7		5	1	-	-	1	-	1				
Sep 96	6		6	1	-	1		-	1				
Oct 96	5		7	1	1	1		-	1				
Nov 96	2		5	3	2	1	4	-	1				
Dec 96	1		4	1	-	4	3	-	1	2	0	2	
Jan 97	-		3	1	-	3	1	-	3		2	4	
Feb 97	-		4	-	-	3	-	-	3		6	1	

water. The feed was changed once in 4, 6, 8 and 10 days interval. From the study it was observed that shorter intervals of feed change (4 & 6 days) caused maximum mortality during handling while delaying feed change upto 10 days, led to canibalism. Considering these aspects, the interval of feed change at 8 days was adopted for rearing of young grubs of CSRB upto 25 days after hatching.

3.2.2 Older grubs of CSRB

The 25 days old grubs of CSRB were reared further in individual rearing bottles containing host bark pieces of 4cm x 4cm. The intervals of feed change were evaluated at 6, 8, 10 and 12 days. In the above treatments, moistering of feed through water spray was undertaken daily and on alternate days with an unmoistened control. Fibrous frass was also added into individual bottles to retain the moisture content in all treatments.

The weight of CSRB grubs was recorded at 25 day intervals. The weight gain and survival were highest on 150 day after hatching in case of 10 days feed change with daily watering (4 - 726g ; 76.67% respectively). This has been adopted in all further rearings.

3.3 BIOLOGICAL CONTROL

3.3.1 Fungal pathogens

Studies on persistence of *M. anisopliae* indicated the survivability and virulence of the fungus upto 90 days after mixing into soil. The fungal virulence was more in case of the FYM amended soil. The fungus induced a higher mortality of the grubs of *P. obesus* compared to the grubs mortality of *P. ferrugineus* suggesting the fungal pathogen to be a strain of *P. obesus* (Table 3.2). The growth of the fungal pathogens *B. bassiana* and *M. anisopliae* was partially inhibited when these were inoculated onto jowar grains treated with Carbaryl (0.1%) and Chlorpyriphos (0.15%). This resulted in delayed spawn development for 45 days. The usage of *B. bassiana* and *M. anisopliae* as prophylactic treatment could not prevent infestation by CSRB.

3.3.2 Parasitoids

The egg parasitoid of TMB, *Telenomus* sp. was encountered in host eggs collected from the insecticide sprayed and unsprayed plots (Table 3.3).

Table 3.2 Persistence and virulence of *M.anisopliae* spores mixed with soil

Treatment	Percentage mortality					
	30 DAT		60 DAT		90 DAT	
	Pf	Po	Pf	Po	Pf	Po
Soil alone	0	0	0	0	0	10
Soil + *M.anisopliae* + neem cake	0	20	0	10	10	10
Soil + *M.anisopliae* + FYM	10	30	10	40	0	10

Pf = *P.ferrugineus*
Po = *P.obesus*
DAT = Days after treatment

Table 3.3 Occurrence of egg parasitoids of tea mosquito bug in plots treated with insecticides.

Month of egg collection	Egg parasitism (%) in		Maximum number of days taken for emergence of adult parasitoids	
	Treated	Untreated plots	Treated	Untreated plots
March	(6.8-11.7)	(7.0)	10-16	10
April	(0.0-5.3)	(0.0)	08	-
May	(0.0)	(0.0)	-	-
June	(0.0)	(3.3)	-	06
July	(7.5-12.2)	(30.3-39.3)	04-20	06-14
August*	50.2-55.7	40.0-59.0		
	(7.2-21.2)	(7.7-10.0)	19-32	03-16
September	25.4-38.4	46.0		
	(7.3-19.6)	(21.0)	30-50	50
October	44.6-56.6	I.S		
	(6.52-16.2)		10-48	I.S
November	36.8-59.8	I.S		
	(1.3-34.3)		23-35	I.S
December	39.7-57.9	I.S		
	(0.0-9.6)		12-68	I.S

* From August onwards % egg parasitism estimated by dissection method. Prior to that the data pertains to emergence. Figures in parentheses indicate % egg parasitism from which adults parasioids emerged. I.S. Inadequate Sample.

The laboratory rearing of *Telenomus sp.* was attempted in eggs of Mirids, *Helopeltis* spp., *Pachypeltis mesacrum* and on a lepidopteran *Coreyra cephalonica*. Oviposition activity of the parasitoid was observed only on *Helopeltis* eggs, whereas, it was absent on eggs of *P. mesacrum* and *C.cephalonica* indicating genus specificity of *Telenomus sp.*

In the case of parasitised eggs of *Helopeltis* spp., the adult parasitoid emergence was negligeble, because of the desiccation of plant parts bearing the host eggs. Thus, it was not amenable for mass multiplication due to its requirement of specific host condition.

3.4 PLANT PRODUCTS

3.4.1 Neem formualtions

In the prophylactic trials against CSRB, neem oil (5%), Limanool (1.0%), and nimbecidine (1.0%) were evaluated in comparison with

Table 3.4 Incidence of CSRB in different prophylactic trials.

Treatment	Mean % of attack on		
	30 DAT	60 DAT	90 DAT
Carbaryl (0.2%)	16.2 b	16.20 bc	16.20 a
Carbaryl(0.2%) in mudslurry	20.0 b	20.00 c	48.00 b
Limanool (0.5%)	8.6 a	8.60 ab	12.60 a
Neem oil (5%)	8.6 a	8.60 ab	8.60 a
Rakig Spawn of *B. bassiana* (250g)+ 500 g neem cake	8.6 a	4.80 a	20.20 a
Raking spawn of *M. anisopliae* + 500 g neem cake	8.6 a	4.80 a	20.20 a
Untreated check	8.6 a	16.20 bc	24.00 a
CD at 5%	7.36	8.14	16.09
Sem	-	-	-

Values with same letter do not differ significantly
DAT = Days after treatment

Carbaryl (0.2%). It was observed that infestation level in different treatments ranged from 8.60 to 24.0 and was found to be on par with untreated control on 90 days after treatment (Table 3.4).

The same treatments were evaluated for their oviposition deterrancy under free choice conditions. There was no variation in the number of eggs deposited on treated and untreated egg collection sticks, indicating the absence of oviposition deterrancy in all the treatments.

A field trial was conducted with neem oil (5%), Limanool (1.0%), Nimbecidine (1%) and Carbaryl (0.2%) as treated check. Observations on the pest population on 1 DAT, 2 DAT and 5 DAT and damage score were recorded.

The results indicated a reduction in pest population only in case of carbaryl treatment which also had the least damage score. The pest population and damage score in the neem formulations were on par with the untreated control (Fig.3.1).

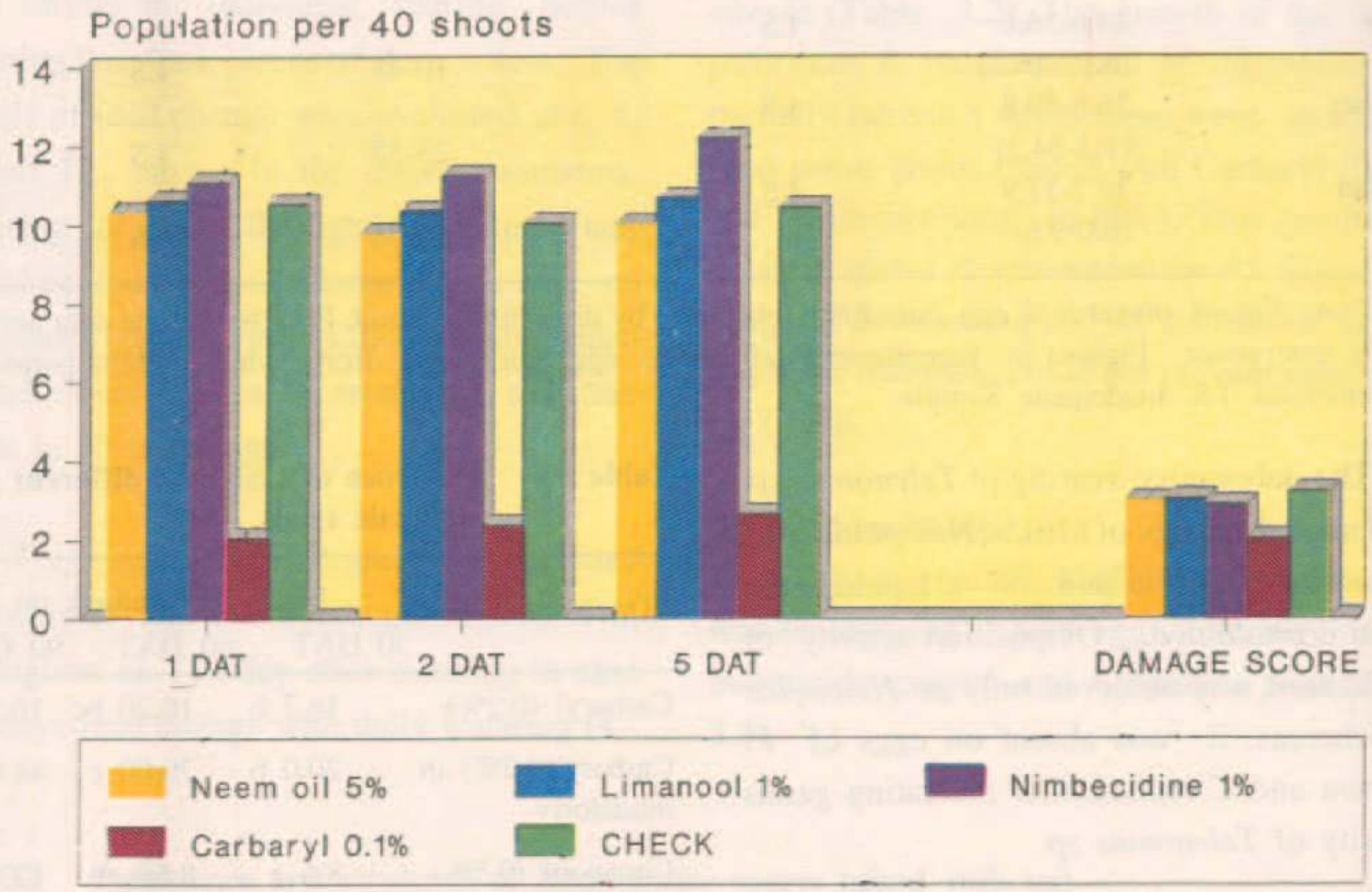


Fig. 3.1 Efficacy of neem products against TMB under field conditions.

3.4.2 Laboratory evaluation of neem and other plant products

The efficacy of neem oil, pongamia oil, Calophyllum oil, leaf extracts of *Adathoda vasica*, *Butea monospuma*, Annona extracts, Limanool and Nimbecidine were evaluated on cashew seedlings under laboratory conditions.

The results indicated that carbaryl had the least damage score (0.89) and mean mortality (2.50), while untreated control had the highest

Table 3.5 Effect of plants products on knock down activity and TMB damage under laboratory conditions.

Plant product/pesticide tested	Damage score (after 48 hrs)	Mean mortality (after 12 hrs)
Neem oil 5%	2.3	1.33 (1.36)b
Annona extract 5%	2.8 b	1.75 (1.47)b
Cotton seed oil 5%	2.8 b	0.41 (0.91)d
Butea frondosa leaf extract 5%	3.0 b	0.83 (1.06)c
Adathoda vasica 5%	2.3 b	0.58 (0.95)d
Pongamia oil 6%	2.7 b	1.33 (1.29)b
Pongamia oil 2% + lime	3.0 b	1.16 (1.24)c
Pongamia oil 4% + lime	2.6 b	0.83 (1.31)b
Limanool (1%)	2.9 b	1.00 (1.17)c
Nimbecidine (1%)	3.0 b	0.75 (1.01)cd
Carbaryl (0.1%)	0.9 a	2.50 (1.74)a
Calophylum 5%	2.8 b	1.25 (1.22)c
Check	3.7 c	0.37 (0.86)e
CD 5%	0.745	(0.22)

Values in parentheses are transformed values. Values with the same letter do not differ significantly.

damage of 3.66 with least mortality of 0.37. All other treatments did not vary significantly amongst themselves, indicating carbaryl to be the most effective treatment against TMB (Table 3.5).

3.5 STUDIES ON ATTRACTANTS/SEX PHEROMONES OF CSRB

The bark of imfested tree had the highest oviposition both in case of *P. ferrugineus* (30.33) and *P. obesus* (26.67) (Fig.3.2). Under olfactometer trials, the virgin female and unmated male as bait insect elicited the highest attraction from the unmated opposite sex in *P. ferrugineus*, while both mated and unmated beetles of opposite sex were attracted in case of *P. obesus*.

3.6 EVALUATION OF FIELD TOLERANT ACCESSION G 11/6

In the earlier laboratory screening trial one cashew accession (Goa 11/6) was found to be moderately susceptible (2.1 to 3.0) to tea mosquito bug and it was again confirmed by raising it in

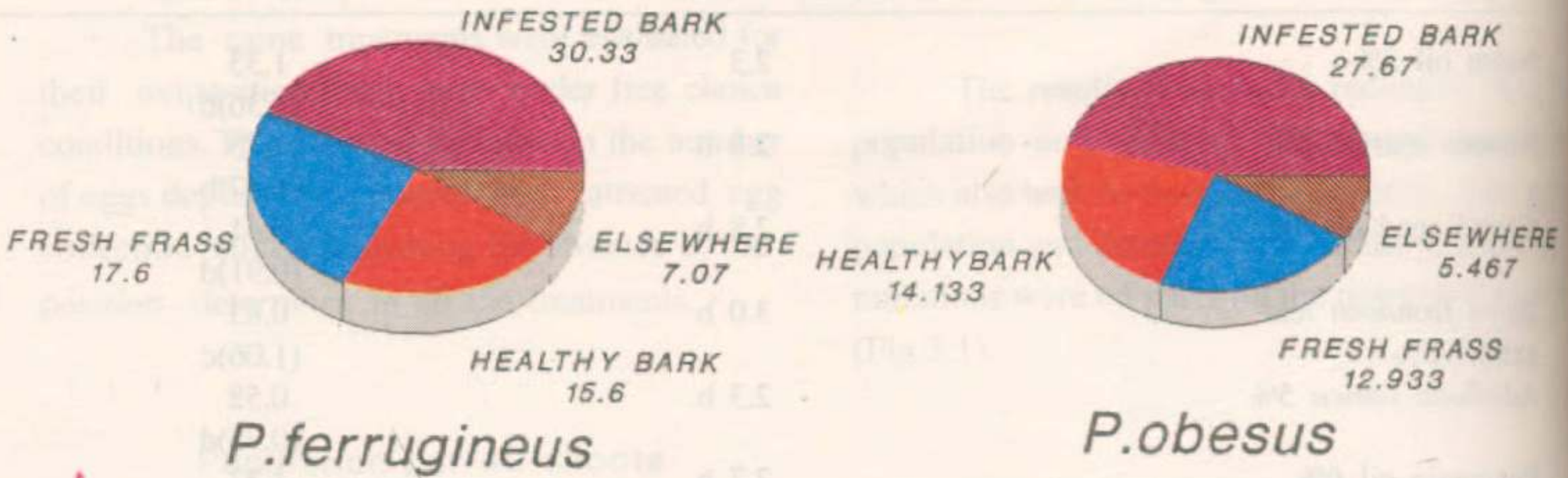


Fig. 3.2 Ovipositional preference of CSRB for different plant parts of cashew.

a large plot trial. For which, 21 grafts of Goa 11/6 were planted at 6m x 6m spacing during 1989 and since its planting, no insecticidal spray was given.

The extent of panicle damage and the yield data were recorded since 1993 onwards (Table 3.6). Panicle damage was severe on younger trees than matured trees. It was again observed that this accession is having mid season (December - February) flushing and flowering habit especially in matured trees and by this period the population of tea mosquito bug was also in downward trend. Because of this phenomenon, this accession was found to escape from valnerability of attack by tea mosquito bug and it also recorded higher mean yield of 7.2 kg/tree at its seventh year (fifth harvest).

Table 3.6 Panicle damage and yield of a moderately susceptible cashew accession (Goa 11/6)

Year	Total no of trees showing panicle damage grade				Yield (Kg/tree)		
					Mean	Range	
	VL	L	M	S			
1993	2	3	3	13	1.1	0.0	- 4.5
1994	3	7	7	4	0.8	0.0	- 4.0
1995	10	7	1	3	4.4	0.4	- 7.0
1996	6	12	3	-	3.5	1.9	- 5.8
1997	10	7	4	-	7.2	3.2	- 11.4
Mean Cumulative Yield Kg/tree	-	-	-	-	16.9	6.0	- 26.2

VL = Very low < 10.00 per cent
L = low 11 to 25 per cent
M = 26 to 50 per cent
S = > 50 per cent

Screening of G 11/6 for TMB infestation in net house

POST - HARVEST TECHNOLOGY

4 POST-HARVEST TECHNOLOGY

4.1 CAUSES FOR KERNEL REJECTS

Studies on investigations into the causes for kernel rejects during processing were continued. Storage period upto 16 months did not affect the processing quality in terms of shelling percentage (29 to 30%), peeling outturn (23 to 28%) and kernel rejects (2 to 4%). Thus results indicated that storage of nuts upto 16 months do not influence the kernel rejects.

In order to see whether floaters contribute to kernel rejects during processing, floaters obtained from nuts procured from Goa, Puttur, Shantigodu experimental farm and Mohinivilasa (M/s Achal Industry) were processed and assessed for processing quality (Table 4.1). Per cent kernel rejects among different samples varied from 6.18 to 50. Shelling percentage, peeling outturn and per cent wholes recovered also were less in these samples. Thus results presented clearly indicated that floaters are responsible for the rejects obtained during processing. Extent of kernel rejects could be reduced if these floaters are seperated before processing.

Effect of initial moisture content of raw nuts on processing quality during subsequent storage upto six months were studied and the results have indicated that pre-storage moisture content ranging between 5 and 14 per cent did not affect shelling percentage (25 to 30%), peeling outturn (21 to 25%), per cent wholes recovered (9 to 23%) and per cent kernel rejects (1 to 3%) during storage upto six months (Table 4.2).

Table 4.1 Processing quality of floaters of different origin.

Parameters	Mohinivilasa	Expt. station Shanthigodu	Goa	Puttur
Processing quality				
Shelling percentage	24.6	24.2	19.7	23.9
Peeling outturn (%)	10.5	17.2	15.9	18.5
Percent wholes recovered	06.1	15.5	15.9	14.7
Percent kernel rejects	50.0	06.2	07.7	11.4
Moisture content	03.0	06.4	06.7	05.0

Table 4.2 Effect of initial moisture on processing quality.

Moisture content (%)	Shelling percentage	Peeling outturn (%)	% wholes recovered	% kernel rejects
05.27	27.5-30.4	21.7-25.0	16.5-23.2	Nil-0.3
08.55	25.0-29.6	22.0-24.0	16.5-21.6	Nil-0.8
09.02	28.0-30.7	23.2-25.7	17.5-22.0	Nil
10.94	25.0-30.0	24.5-25.5	16.0-21.5	Nil-1.6
13.93	25.0-31.7	23.0-26.5	20.7-21.7	0.8-2.5
13.99	29.5-31.0	21.7-25.0	09.0-15.7	1.0-2.9

In an attempt to see whether size of the nuts influenced the kernel rejects during processing, raw nuts during storage upto 12 months were graded and processed separately. Grading before processing did not influence shelling percentage (28 to 30%), peeling outturn (23 to 27%), per cent wholes recovered (19 to 23%) and per cent kernel rejects (3 to 5%).

Influence of steam roasting time on the processing quality was assessed and results have indicated that roasting time varying from 5 to 20 min did not affect shelling percentage (29 to 30%), peeling outurn (23 to 25%), per cent wholes recovered (19 to 21%) and per cent kernel rejects (1 to 2%) (Table 4.3).

Thus, results obtained so far have clearly indicated that stoarge time upto 16 months, grading before processing and roasting time did not influence the kernel rejects. Higher kernel rejects was noticed when floaters were processed.

4.2 DATABASE ON PROCESSING ASPECTS OF CASHEW PROCESSING INDUSTRIES

About 133 cashew processing industries in India have responded for technical questionnaire Part-I (Administration) and Part-II (processing) after sending second reminder till date. Since the response was poor, an attempt was made to collect information on technical aspects from Dakshina Kannada district, Karnataka (59 industries). Information thus collected was fed to computer and a database has been developed. From the database the following inferences emerged.

Among the industries surveyed, 46 per cent were manufacturers and 48 per cent were engaged in both manufacturing and exporting processed kernels. Only 1.5 per cent were involved in value addition of cashew kernels (kernel roasting and salting).

Among the industries surveyed, 40 per cent were importing raw nuts for processing, procurement of which was done either partially of fully for the whole year.

Most of the cashew industries (49 industries) fell under the category of 50-500 MT of raw cashewnut procurement per year.

Table 4.3 Effect of roasting time on processing and biochemical quality

Roasting time (mm)	Origin	Processing quality				Biochemical quality					
		Shelling percentage	Peeling outturn (%)	% Wholes recovered	% Kernel rejects	Total Lipid	FFA	Sterols	Lipid peroxides	Starch	Sugar
5	G	30.6	24.9	21.5	0.6	48.4	0.48	13.58	1.47	33.6	5.5
	P	29.8	23.2	12.5	2.0	47.8	0.17	18.48	1.45	27.4	4.4
10	G	28.0	22.8	18.8	0.7	47.1	0.45	25.80	1.44	32.7	5.8
	P	29.3	23.5	11.2	0.3	44.7	0.23	10.48	1.47	28.0	6.3
20	G	30.2	24.3	21.0	1.0	48.2	0.27	26.41	1.51	26.9	4.6
	P	28.9	23.2	17.8	0.3	48.1	0.24	15.37	1.47	33.1	5.8

G - Goa ; P - Puttur

Total production of cashew kernel ranged from 20.0 to 23.5 per cent. The difference was due to various origin, preliminary processing methods, efficiency of labour and effective handling of cashew kernels.

At the time of procuring raw cashewnut, float test, counting or cutting test and visual test were conducted to verify the quality for fixing the price.

Among the industries surveyed, 96 per cent of the units had good storage facilities. Raw cashewnuts were sun dried for 2-3 days immediately after procurement.

Roasting was done by drum roasting method in Kerala and Andhra Pradesh and steam boiling method in Karnataka, Maharashtra and Goa. The duration and pressure of roasting in steam boiling method varied widely with origin of nuts and location of factory.

Shelling was done using peddle cum hand operated semi-automatic machine for steam boiled nuts and mallet hitting for drum roasted nuts. Desorption of moisture from cashew kernel was done in borma drier. The duration and temperature of flue gas treatment differed from place to place.

Peeling of testa layer was carried out using pellets manually. The percentage of wholes recovered ranged from 70-80 per cent and peeling capacity was 11-15 Kg/labour/day.

More than 20 grades were sorted out based on the size, shape, colour, broken nuts etc. and vita packing was followed with CO_2 as inert gas.

About 15 CNSL extraction units were operating and most of them were expellers. The quantity of CNSL extracted per kg of cashew shell was 200-250 ml.

4.3 RAW CASHEWNUT GRADER

Physical and Mechanical parameter of raw cashewnut have been determined for different origins (21) and varieties (15).

A gravity seperator model with aluminium as construction material has been designed considering the mechanical parameter, coefficient of internal friction and ease of fabrication. Mechanism to adjust end and side slope has been provided for maximum seperation efficiency.

Similarly sieve seperator has been designed with three trays. Considering the major axis dimension of raw cashewnuts, the first tray is designed with 30mm sieve diameter (round sieve) with a spacing of 15 mm between circumferences and sieves. Second tray has round sieves with 25 mm diameter and 15 mm spacing.

Third tray is a collection tray passed through second tray. An adjusting mechanism is provided to change the slope to optimise for maximum separation efficiency. The trays are moving to and fro on rails to increase the rate of separation. Fabrication of sieve separator and gravity separator model has been completed.

TRANSFER OF TECHNOLOGY

5 TRANSFER OF TECHNOLOGY

5.1 RESEARCH CUM DEMONSTRATION

Eight more demonstration were laid out in Puttur, Karkala and Buntwal taluks bringing the totalnumber of demonstration laid out so far to 69. At present, 28 plots are receiving input support from Directorate of Cashewnut Development, Kochi under Central Sector Scheme (CSS). The amount disbursed so far under this scheme is Rs 2,25,235.

Information collected from 60 neighbouring farmers (at the rate of two farmers around each demonstration plot) was analysed to know the extent and nature of impact of the demonstration on neighbouring farmers.

5.1.1 Profile of neighbouring farmers

Majority of neighbouring farmers were middle aged and literate. Except 12 percent of the neighbouring farmers, the remaining reported agriculture as their main occupation. Nearly 50 per cent of them were small farmers with cashew as one of the crops grown.

5.1.2 Knowledge of improved cashew cultivation

Nearly 55 percent of the neighbouring farmers knew that grafts were the ideal planting material of cashew. But only 40 percent could name some improved cashew varieties. While more than 90 per cent of the respondents had the knowledge of recommended spacing, only 32 per cent of them felt that cashew needs to be fertilized. However, none had the knowledge of recommended dosage of fertilizers. All the farmers opined that cashew needed to be planted across the slope, but only 32 per cent of them felt that terracing needs to be done in slopy lands.

It was disturbing to note that none of the farmers had the idea of how the initial damage symptoms of tea mosquito bug looked like. Only about 20 per cent knew that the burnt appearance in leaves was due to TMB. Similarly, only about 30 per cent of them knew the damage symptoms of cashew stem and root borers. While only 15 per cent of the sample had the knowledge of spray schedule for TMB about 17 percent of farmers knew that the grubs should be extracted from CSRB affected trees (Table 5.1).

Table 5.1 Knowledge of neighbouring farmers on improved cashew cultivation

Cultivation practice	No.	Per cent
Grafts as planting material	33	55.00
Names of varieties	24	40.00
Spacing	57	91.00
Planting across slope	60	100.00
Terracing on slopy land	25	42.00
Recommended fertilizer dosage	Nil	-
Initial symptoms of TMB damage	Nil	-
Spray schedulee for TMB control	09	15.00
Treatment of CSRB affected trees (extraction of grubs)	10	17.00

5.1.3 Adoption pattern

Nearly 42 percent of the sample had planted cashew grafts while the entire sample had adopted proper spacing. But, none had applied recommended dosage of fertilizers. However, 25 per cent did apply partial dose of fertilizer. Of the total sample, only six farmers (10%) took up regular spraying of three rounds and 12 had sprayed only once with endosulfan when they noticed severe damage.

Only four farmers (6.67%) had prepared terraces around each plant as a measure of soil and water conservation. Planting across the slope was, however, adopted by majority of farmers (65%) (Table 5.2).

Table 5.2 Adoption Pattern of neighbouring farmers

Cultivation Practice	Adopted	Not adopted
Grafts as planting material	25 (42.0)	35 (58.0)
Spacing	60 (100.00)	- (0.0)
Fertilizer application		
a. Recommended dose	-	-
b. Partial dose	15 (25.0)	45 (75.0)
Plant protection		
a. Three rounds	6 (10.0)	54 (90.0)
b. Once	12 (20.0)	44 (80.0)
Soil conservation		
a. Planting across the scope	39 (65.0)	21 (35.0)
b. Terracing	4 (7.0)	56.0 (93.0)

Figures within parentheses indicate percentage.

CONCLUDED PROJECT

6. HIGH DENSITY PLANTING OF CASHEW

Leaders : L.P.Misra, 1982-1985; N Yadukumar, 1986-1994
Associate : E Mohan, 1982-1990

6.1 INTRODUCTION

In recent years, there has been considerable interest in increasing plant density in monocropping to augment income. High density planting in temperate crops, specially in apple has been well documented. It is true that close planting offers immediate economic advantage owing to higher yield that can initially be obtained. Modern orchard management systems are all designed around the principle that orchard efficiency or increased production per labour input is improved by increasing planting density. This principle is based upon the increase in leaf area resulting from increased number of tree per unit of land provided and concomitant increase in light interception. Rapid establishment of productive potential from the land results in an earlier economic return. However, plant density should not be increased beyond optimum level.

Initially, going for high density and resorting to thinning out later on, to have optimum plant population to achieve its maximum productivity seems to be quite reasonable. In this direction no work has been reported so far in cashew. With the above points in view, an experiment on high density planting of cashew was laid out in Experimental Station of National Research Centre for Cashew at Shantigodu, Puttur, Karnataka in 1982. Following were the objectives of the experiment.

1. To study growth behaviour under high density planting.
2. To study root distribution pattern during the initial years.
3. To study photosynthesis and other physiological parameters in different stages of growth before thinning/after thinning and at different density situations.
4. To increase productivity of cashew per unit area.

6.2 MATERIALS AND METHODS

The experiment was laid out by adopting Randomised Block Design with five replications.

The details of experiment are given below.

Treatment	Spacing	No. of plants/plot		Net plot area (m^2)	Trees
		Gross*	Net		
T_1	8m x 8m	16	6	384	156
T_2	6m x 6m	24	8	288	278
T_3	4m x 4m	45	15	240	625
T_4	3m x 3m	88	28	252	1111
T_5	2m x 2m	192	77	308	2500

*Gross plot size : 32m x 24m

The planting material used was seedling progeny of the high yielding cashew variety H-4-7. This is a cross between Brazilian variety and BLA-139-1 (which is a released high yielding variety). All the recommended package of practices were adopted to raise plants. During the initial 3 years of growth, lower branches upto 1m height were removed uniformly for convenience of cultural/farm operations and also to give proper canopy shape.

Soil samples at two depths were collected just before monsoon (May 1982) and the same were analysed for nutrient contents. The mean values are given below.

Depth of soil collection	pH	Organic carbon (%)	Available P_2O_5(ppm)	Available K_2O(ppm)
0-25cm	4.99	1.55	3	66
26-50cm	5.01	1.11	Traces	52

Soils are slightly acidic, fairly rich in organic matter, moderately supplied with potash and highly deficient in phosphorus.

The following observations were recorded.

1. Growth parameters - Height, girth and spread (North South and East West).
2. Production or dry branches and weed in each treatment plot. Dry branches in each treatment plot were removed and weighed after complete drying. Weeds were collected after cutting at ground level and dried and weighed once seven years after planting and again at the end of 12th year. Weeds were also identified.
3. Root volume and distribution pattern studies, 7 years after planting by adopting soil block method as described for coffee and rubber. The procedure adopted were soil block method used by Franco and Inforzato (1951), Leon and Umana (1961) and Bhat and Leela (1969). The procedure adopted for studying distribution of cashew root system was soil block or quantitative method as described for coffee and rubber. This method consisted of digging a series of trenches between two trees starting from one tree to the other. Trenches of 60cm length, 30cm width and 30cm depth were dug starting from 30cm away from the trunk of the tree. Roots were seperated by sieving the soil obtained from each block of 60cm x 30cm x 30cm size. Roots were then washed, dried and weighed. Lateral and vertical distribution of roots was quantified by dry weight of roots. Roots collected were classifed as fine (< 1mm thick).
4. Biomass production seven years after planting. Two representative trees in each treatment were cut and weighed after drying.
5. Physiological parameters like photosynthesis, photon flux density, by using LCA3 model photosynthesis system equipment. Observations were taken between 9 to 11 am three different heights of the canopy. Third to fourth matured leaf of the current growth which were aligned at right angle to sunlight were used.

Soil moisture content at three different depths during the peak summer season by adopting oven dry method (gravimetric method).

Plotwise yield and conversion into hectare basis.

.3 RESULTS AND DISCUSSION

.3.1 Effect of plant density on growth

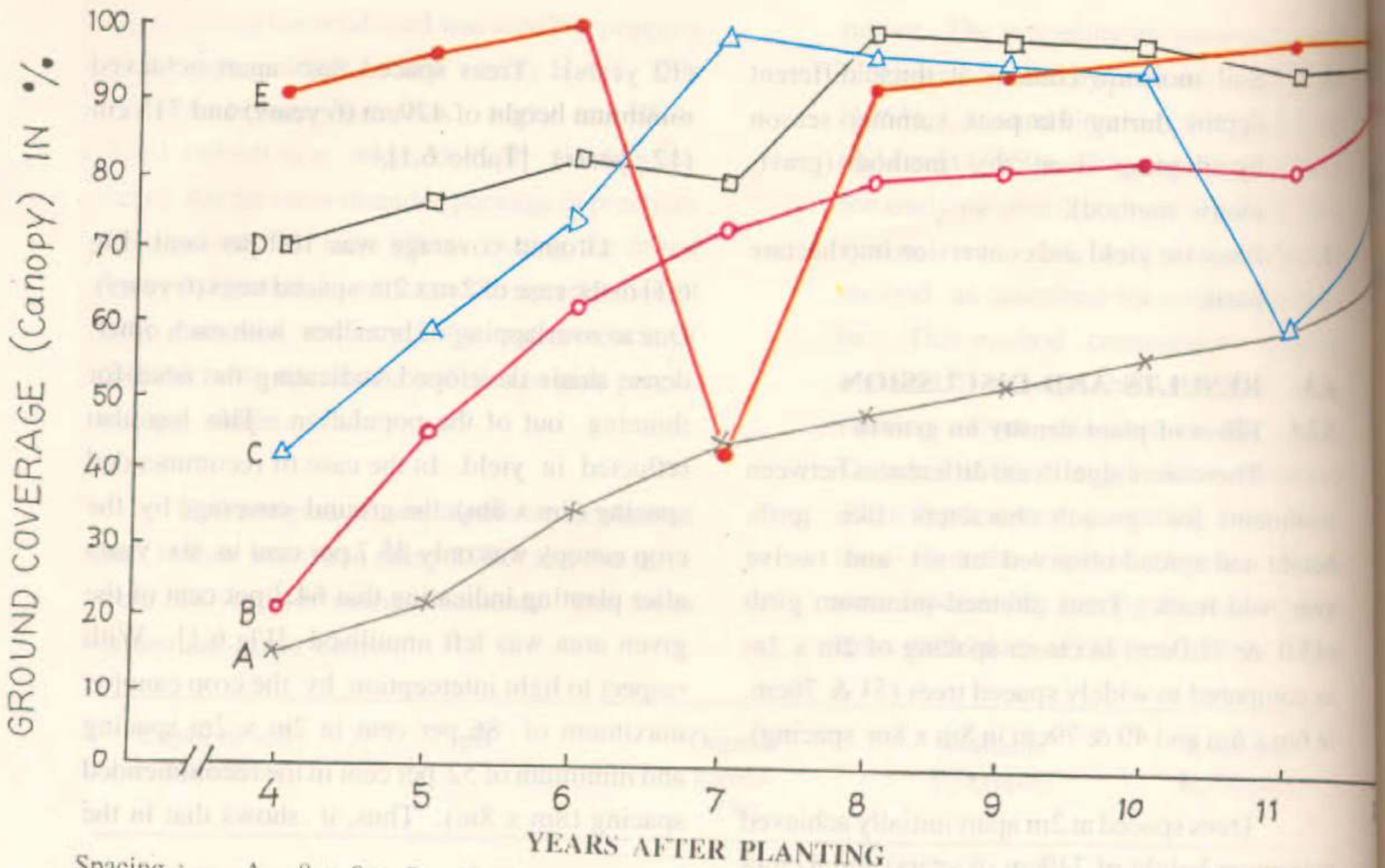
There were significant differences between reatments for growth characters like girth, eight and spread observed at six and twelve ear old trees. Trees attained minimum girth 43.0 & 71.0cm) in closer spacing of 2m x 2m s compared to widely spaced trees (51 & 76cm. n 6m x 6m and 49 & 79cm in 8m x 8m spacing).

Trees spaced at 2m apart initially achieved naximum height of 749cm (6 years) and 872cm (12 years). Trees spaced 8m apart achieved minimum height of 479cm (6 years) and 715 cm (12 years) [Table 6.1].

Ground coverage was 100 per cent [Fig 6.1] in the case of 2 m x 2m spaced trees (6 years). Due to overlapping of branches with each other, dense shade developed, indicating the need for thinning out of the population. This has also reflected in yield. In the case of recommended spacing (8m x 8m), the ground coverage by the crop canopy was only 35.7 per cent in six years after planting indicating that 64.3 per cent of the given area was left unutilised [Fig.6.1]. With respect to light interception by the crop canopy, maximum of 86 per cent in 2m x 2m spacing and minimum of 52 per cent in the recommended spacing (8m x 8m). Thus, it shows that in the

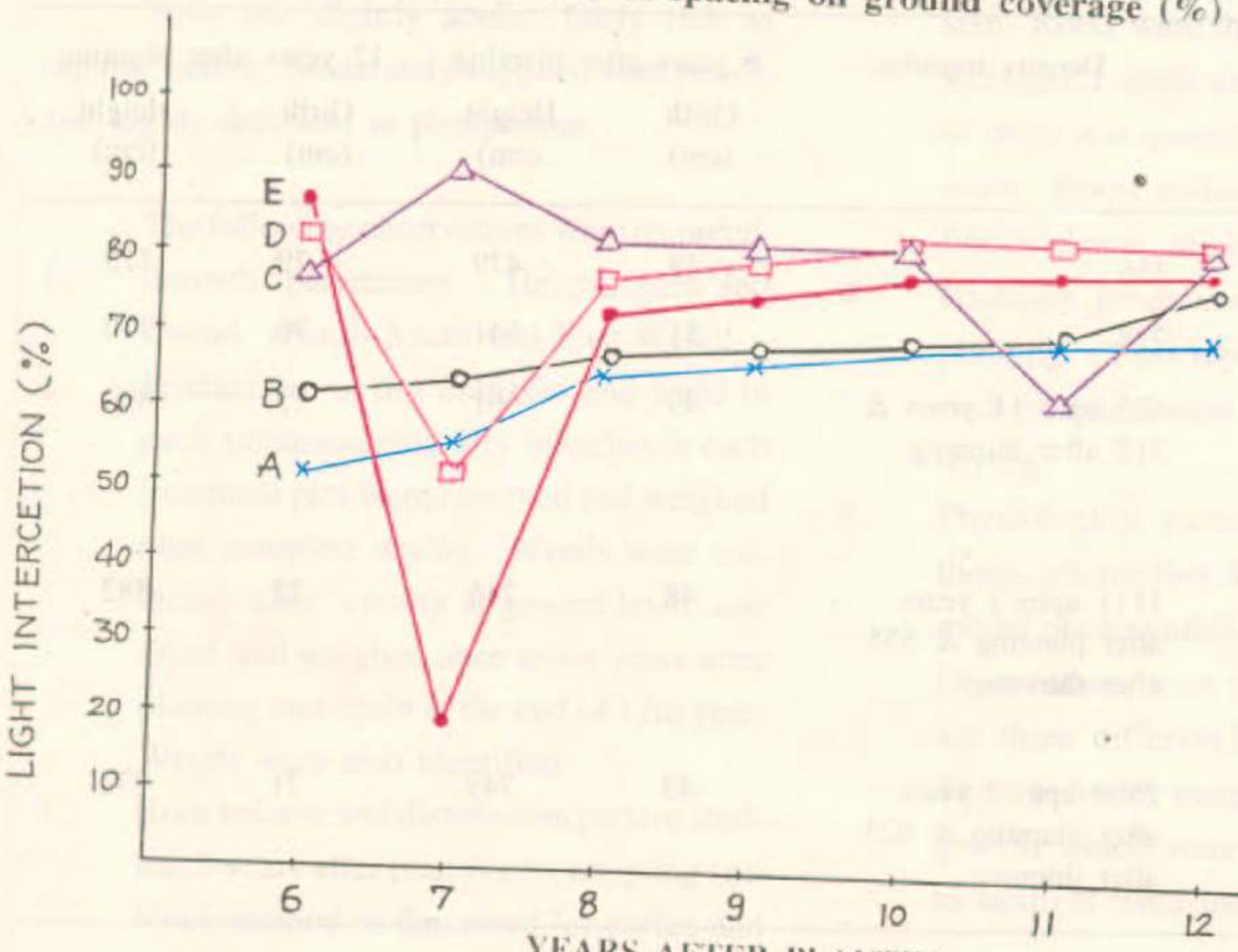
Table 6.1 Effect of spacing and density on growth

Treatment spacing (meters)	Density trees/ha.	6 years after planting		12 years after planting	
		Girth (cm)	Height (cm)	Girth (cm)	Height (cm)
8 x 8	156	49	479	79	715
6 x 6	278	51	541	76	710
4 x 4 upto 11 years after planting and 8 x 5.7 x 5.7 after thinning	625 upto 11 years & 312 after thinning	49	661	75	890
3 x 3 upto 7 years after planting and 6 x 4.25 x 4.25 after thinking	1111 upto 7 years after planting & 555 after thinning	48	745	72	882
2 x 2 7 years after planting and 4 x 4 after thinning	2500 upto 7 years after planting & 625 after thinning	43	749	71	872



Spacing : A - 8 x 8m, B - 6 x 6m, C - 4 x 4m upto 11 Yrs. and 8 x 5.7 x 5.7 after that D - 3 x 3m upto 7 Yrs. and 6 x 4.25 x 4.25m after that, E - 2 x 2m. upto 7 Yrs. and 4 x 4m after that.

Fig. 6.1 Effect of spacing on ground coverage (%)



Spacing : A - 8 x 8m, B - 6 x 6m, C - 4 x 4m upto 11 Yrs. and 8 x 5.7 x 5.7 after that D - 3 x 3m upto 7 Yrs. and 6 x 4.25 x 4.25m after that, E - 2 x 2m. upto 7 Yrs. and 4 x 4m after that.

Fig. 6.2 . Effect of spacing on light interception

normal spacing 48 per cent of the light was unutilised by the crop even six years after planting [Fig.6.2].

Ground coverage in treatments T5 (2m x 2m) and T4 (3m x 3m) was reduced by thinning down the plant density to 50 per cent (4m x 4m) and 25 per cent (6m x 4.25m x 4.25m) respectively seven years years after planting.

Ground coverage over the years (4 to 12 years after planting) showed steady increase in the case of treatments T1 (8m x 8m) and T2 (6m x 6m). But, it increased subsequently to achieve a ground coverage of 100 per cent in treatment T4 (3m x 3m) and 97.1 per cent in treatment T5 (2m x 2m) [Fig.6.1]. Similar trend was observed in the above treatment plots in the case of light interception also [Fig.6.2]. The ground coverage of 100 per cent observed in T3 (4m x 4m spacing) reduced to 65 percent at 11 years of age which was mainly due to diagonal thinning to 50 percent of the population during that year [Fig.6.1]. But , it increased to 82 per cent in the subsequent year. Similar trend was observed in the case of light interception also for the same treatment [Fig.6.2].

6.3.2 Effect of plant density on photosynthetic efficiency

Balasimha and Yadukumar[1993] reported that the studies conducted 6,7 and 8 years after planting in the same experiment revealed that closer planting resulted in minimum net photosynthesis (Pn). This was mainly due to minimum receipt of photosynthetically active radiation (PAR) as a result of over shading effect. Treatment differences were significant and there was no significant difference between three seasons (6, 7 and 8 years after planting). However, in T4 (3m x 3m) and T5 (2m x 2m), both PAR and Pn showed higher values seven years after planting which can be attributed to thinning undertaken during the year (7 years after planting). This is in conformity with the results obtained by Balasimha (1991) and Subbaiah (1983).

Subsequently, for three years (9, 10 and 11 years after planting) the photosynthesis increased in the case of trees in T4 and T5 (originally density was 1111/ha and later thinned down to 555/ha and originally 2500/ha and later thinned down to 625/ha) whereas, it reduced comparatively in the case of T3 (originally 625 trees/ha upto 11 years and 312 after thinning) depite the fact that every year overlapping branches were pruned to maintain 80% of light interception. Later, when total tree population was reduced from 625 trees/ha to 312 trees/ha, photosynthesis increased considerably (12 years after planting [Table 6.2]).

6.3.3 Effect of plant density on dry branches produced

Dry branches produced in different spacing treatments six years after planting ranged from 0.90 tonnes per ha in normal spacing (8m x 8m) to 9.5 tonnes per ha in 2m x 2m spacing (Table 6.3).

Owing to mutual shading of branches in plots where high density planting was adopted (3m x 2m and 2m x 2m spacing) maximum number of lower branches dried. This may be termed as physiological thinning due to minimum penetration of sunlight. Light interception in these high density planting plots was maximum (Fig.6.2) and as a result lower branches received minimum light, which in turn dried.

Dry branches produced in widely spaced trees (8m x 8m and 6m x 6m) were as minimum as 0.9 to 1.0 tonnes per ha which indicated that the leaves of the lower branches also received sufficient sunlight (Table 6.3). The light interception in 8m x 8m and 6m x 6m was minimum as compared to the plot where trees were much denser (Fig.6.2). Dry branches produced in closely spaced trees were almost 10 times more than widely spaced trees indicating shade effect and consequent drying of live branches in the lower portion of canopy. The weed biomass collected from the plots where trees widely spaced (8m x 8m x 6m) were maximum (11.80 & 10.71 tonnes/ha) and minimum in the plots (0.43 to 2.55 tonnes/ha) plots where trees were closely spaced (2m x 2m, 3m x 3m and 4m x 4m). This is mainly due to maximum light interception in high density plots and minimum light interception in low density plots. Weeds were also identified at the end of 12th year of plantation. The names of the weeds collected are given below.

Euphorbia hirta
Spermacoce ocymoides
Oxalis corniculata
Mikenia conedids
Commelina nodiflora
Desmodium polycarpon
Hepesteis charmonoides
Jussia repens
Emilia sonchifolia
Mimosa pudica
Solanum nigrum
Scoparia dulcis
Eleusine indica
Setaria glanca
Pennisetum polystachyon
Chromolaena odorata
Azaratum conizoides

Weed biomass collected (dry weight tonne/ha) 12 years after planting also showed similar trend as that of weed biomass collected 6 years after planting. But, total weed biomass collected 12 years after planting was almost 1/3rd to 1/5th in treatments (2.92 and 2.15 tonnes/ha T1 and T2 (8mx8m & 6mx6m) whereas in treatment 3 (4m x 4m) it was 1/3rd of the weight recorded 6 years after planting (0.83 tonnes/ha). Increase in weed biomass collected from 0.42 tonne/ha 6 years after planting to 1.4 tonne/ha 12 years after planting was noticed in T5. This was mainly due to thinning of population from 2500 trees/ha to 625 trees/ha seven years after planting which caused exposure of ground to sunlight thereby promoting weed growth.

6.3.4. Effect of plant density on the distribution of roots (seven years after planting)

a) **Lateral Spread** : Data on distribution of roots (expressed on dry weight basis in gram) at different distances from the base of the tree showed that 71 to 97 per cent of total roots concentrated within a radius of 90cm from the trunk in all the treatments. Maximum spread of 180cm radius was observed in 8m x 8m spacing and minimum of 120cm in 2m x 2m spacing (Fig.6.3).

b) **Vertical Spread** : In general, 63.73 to 97.0 percent of the roots were noticed from 0 to 60cm depth (Fig.6.4). The data on vertical spread of the roots showed that the roots had gone to a maximum depth in the case of 2m x 2m spacing as compared to wider spacing.

Table 6.2 Effect of spacing on photon flux density (PAR) and net photosynthesis.

Treatment spacing (meters)	Density trees/ha.	PFD (umol m^{-2} s^{-1}) years after planting			Pn (umol $C0^{2}$ m^{-2} s^{-1}) years after planting		
		6	7	8	6	7	8
8 x 8	156	1577	1387	1507	11.87	12.07	9.23
6 x 6	278	1032	1009	1020	11.42	10.15	9.78
4 x 4	625	763	360	561	8.58	6.01	6.27
3 x 3 upto 7 years after planting and 6 x 4.25 x 4.25 after thinning	111 upto 7 years after planting & 555 after thinning	303	1010	656	6.11	12.11	6.49
2 x 2 7 years after planting and 4 x 4 after thinning	2500 upto 7 years after planting & 625 after thinning	175	1161	668	5.88	10.27	5.71
Mean		770	985	882.4	8.77	10.12	7.49
LSD for treatment			308**				2.05**
LSD for year			240**				1.95*

Significant at P = 0.05 (*) or P = 0.1 (**)

Table 6.3 Effect of spacing on dry branches of cashew tree and weeds produced (7 years after planting).

Treatment spacings (m x m)	Dry branches collected (tons/ha)	Dry matter of weeds (tons/ha)
8 x 8	0.90	11.80
6 x 6	1.00	10.71
4 x 4	3.25	2.55
3 x 3	9.30	1.95
2 x 2	9.50	0.43

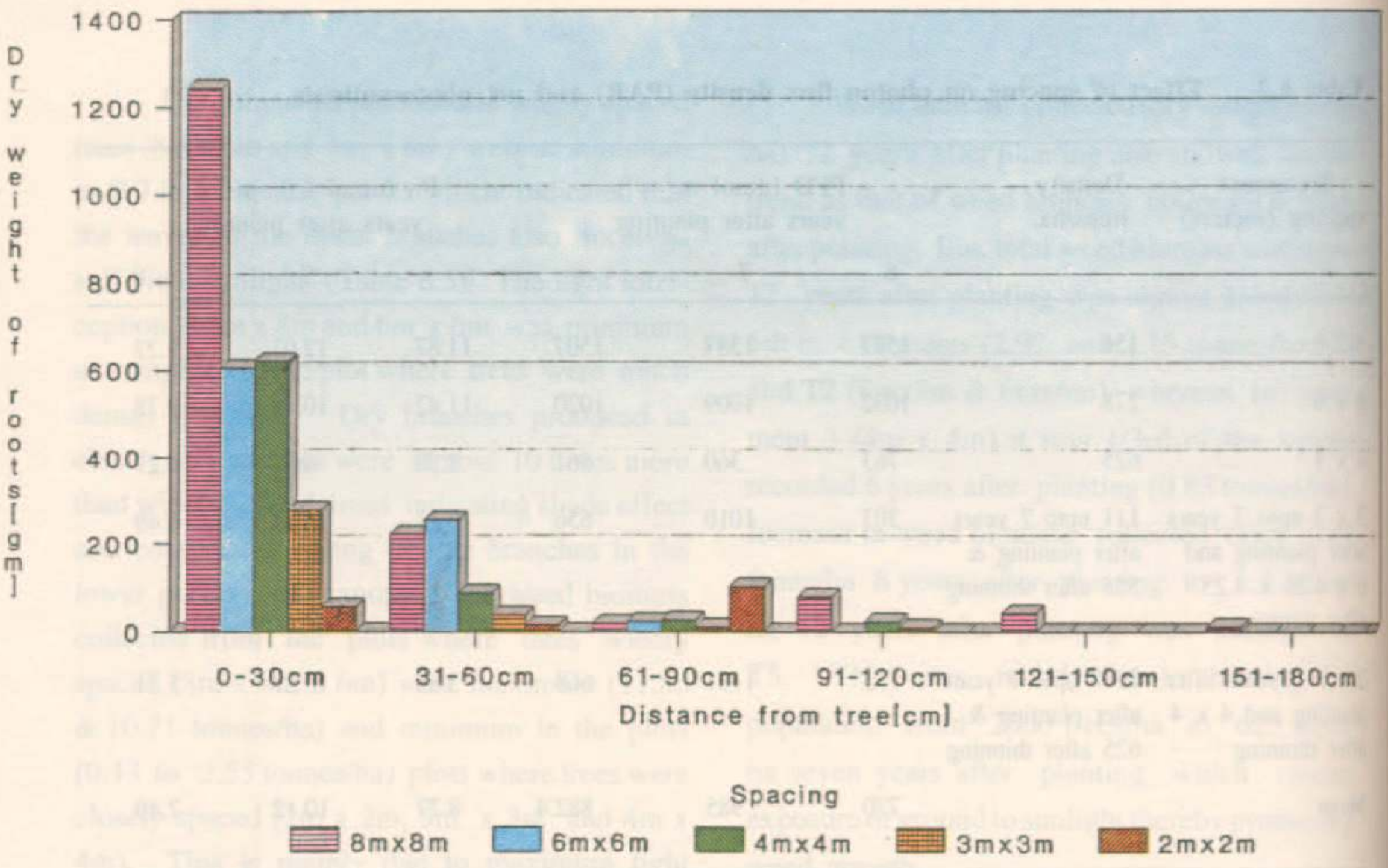


Fig. 6.3 Distribution of roots at different distances from the tree in relation to density of planting

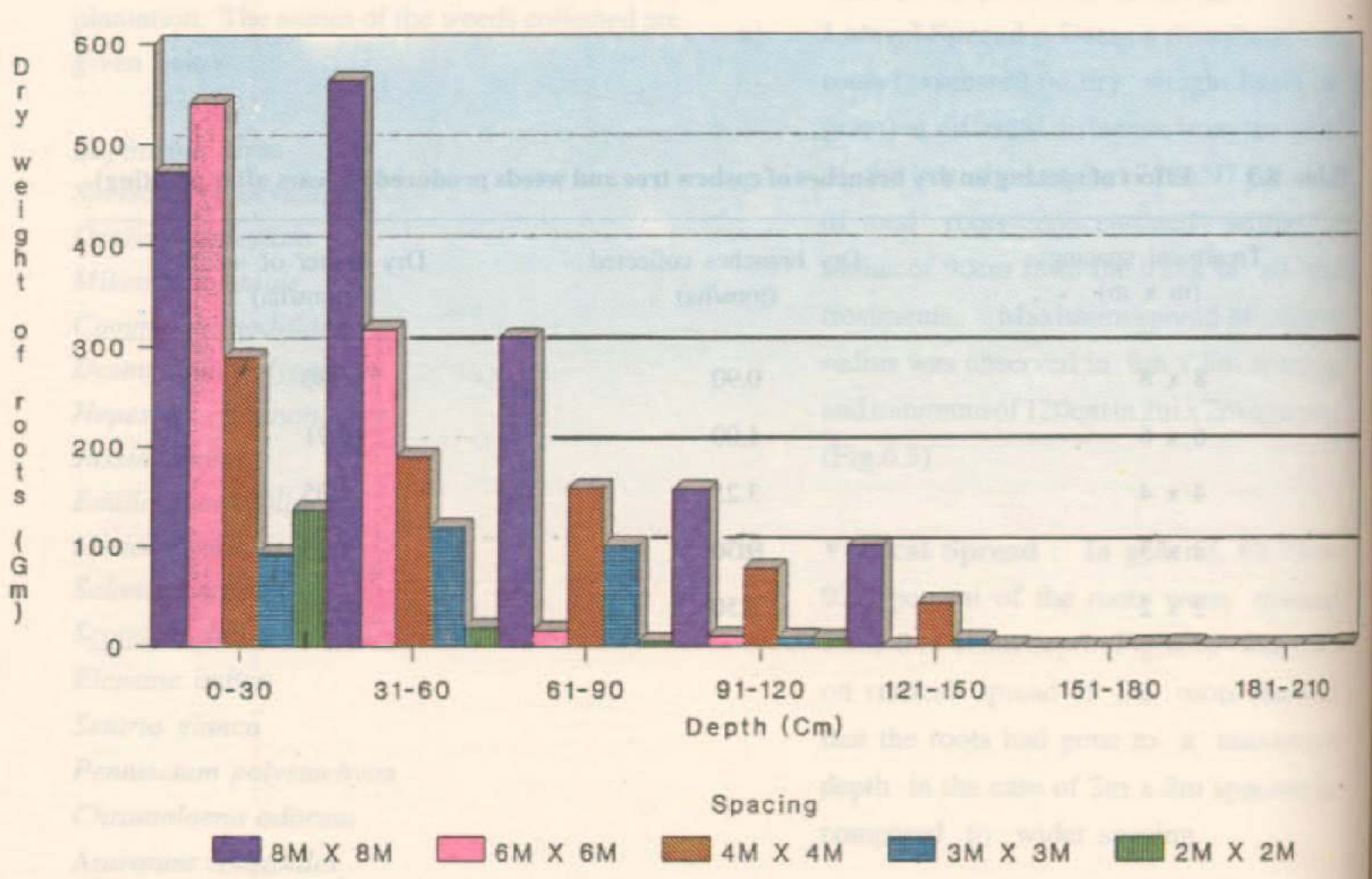


Fig. 6.4 Distribution of roots at different depths in relation to density of planting

Table 6.4 Dry weight of roots (seven years after planting).

Spacing (m)	Quantity of soil excavated (m3)	Wt. of roots in sample (kg)		Wt. of roots/ unit volume		Calculated gross wt. of roots in feeding zone (kg/tree)	
		Total	Fine	Total	Fine	Total	Fine
8 x 8	1.35	1.602	0.0048	1.187	0.036	18.04	0.54
6 x 6	1.08	0.884	0.028	1.037	0.027	10.91	0.29
4 x 4	1.08	0.759	0.033	0.703	0.030	7.45	0.32
3 x 3	1.08	0.270	0.039	0.248	0.035	3.23	0.28
2 x 2	1.13	0.174	0.010	0.154	0.008	1.46	0.08

c) **Weight of roots/unit volume of soil and calculated gross weight of roots** : The data given in Table 6.4 shows the relationship between the weight of roots and volume of soil they occupy. It was observed that as minimum as 0.15 kg of total roots in 2m x 2m spacing and as maximum as 1.197 kg of total roots in the 8m x 8m spacing were present per cubic meter of soil volume. The calculated gross weight of roots was found to be 1.46kg in 2m x 2m spacing and 18.04kg in 8m x 8m spacing per tree (Table 6.4).

Similar studies on root system in coffee and arecanut were conducted by Leon and Umana (1959) and Bhat and Leela (1969) respectively and reported that the root density varied according to spacing.

6.3.5 Thinning

Thinning was done to 25 percent of 2m x 2m spacing and 50 per cent in the case of 3m x 3m, 7 years after planting. Whereas in the case of 4m x 4m spacing, thinning was done to 50 percent 11 years after planting. The details re given below.

Original Spacing (m)	Population before thinning (trees/ha)	Spacing after thinning (m)	Population after thinning	Total wood recovered by thinning (tonnes/ha)
2 x 2	2500	4x4	625	39.53
3 x 3	1111	6x4.25x4.25	555	33.40
4 x 4	625	8x5.7x5.7	312	28.84

Table 6.5 Biomass produced at seven years after planting (dry weight).

Spacing (m)	Population	Shoot				Root	Total	
		Trunk	Side branches	Dried branches	Twigs and leaves		kg/tree	kg/ha
8 x 8	156	34.00	33.00	1.00	31.25	18.04	107.30	16938
6 X6	278	35.00	20.00	1.75	27.50	10.91	95.16	26454
4 x 4	625	25.50	12.96	5.00	12.50	8.69	64.70	40437
3 x 3	1111	20.36	8.00	2.91	8.11	3.23	42.60	47328
2 x 2	2500	12.15	1.25	1.50	3.25	1.46	19.60	49000

6.3.6 Biomass

Biomass production was calculated by randomly selecting two plants in each treatment. Root studies were also taken up during the same period and root weight is also included while presenting treatment-wise biomass production (Table 6.5). It was observed that total biomass produced per tree in 8mx8m spaced trees was five times more than that in 2m x 2m spaced trees seven years after planting when single tree was taken into consideration. Total biomass produced in 8m x 8m plots was 16938 and 26454 kg and in T4 (3m x 3m) and T5 plots (2m x 2m) it was 47328 and 49000 kg respectively, on per hectare basis. Total biomass produced in T3 plot (4m x 4m) was 40437kg.

6.3.7 Effect of soil moisture content on plant density

The results showed that in the case of closer spacing (2m x 3m and 3m x 3m) the moisture content was higher upto 60cm depth and decreased at lower depths of 60-90cm. Higher moisture content at the top depth of the soil is mainly due to heavy shading over the ground as well as due to thick mulch as a result of heavy leaf deposit. Weed occurrence was also minimum in these plots as reported earlier. At lower depths the soil moisture content reduced by 0.5 to 5 percent in the case of closer spacing of 2m x 2m, 3m x 3m and 4m x 4m indicating competition for moisture at lower depths by the neighbouring trees during the peak summer season (Fig.6.5).

The reasons for the drying of lower branches of the trees in plot where trees were spaced closely (2m x 2m and 3m x 3m) may also be due to water stress during peak summer season (March - Soil moisture at 61-90cm depth was 15.5 to 17.9 per cent.

6.3.8 Yield

Cumulative yield : The differences due to spaceings were also significant in yield/ha. Highest yield was obtained in treatments 2m x 2m, 3m x 3m and 4m x 4m spacings which were significantly superior to the treatment of wider spacings (6m x 6m and 8m x 8m). In the case of 2m x 2m and 3m x 3m spacing treatments the yield reduced considerably during the subsequent years (6 and 7 years after planting) indicating the need for thinning. Reduction in yield was due to overlapping of branches, less

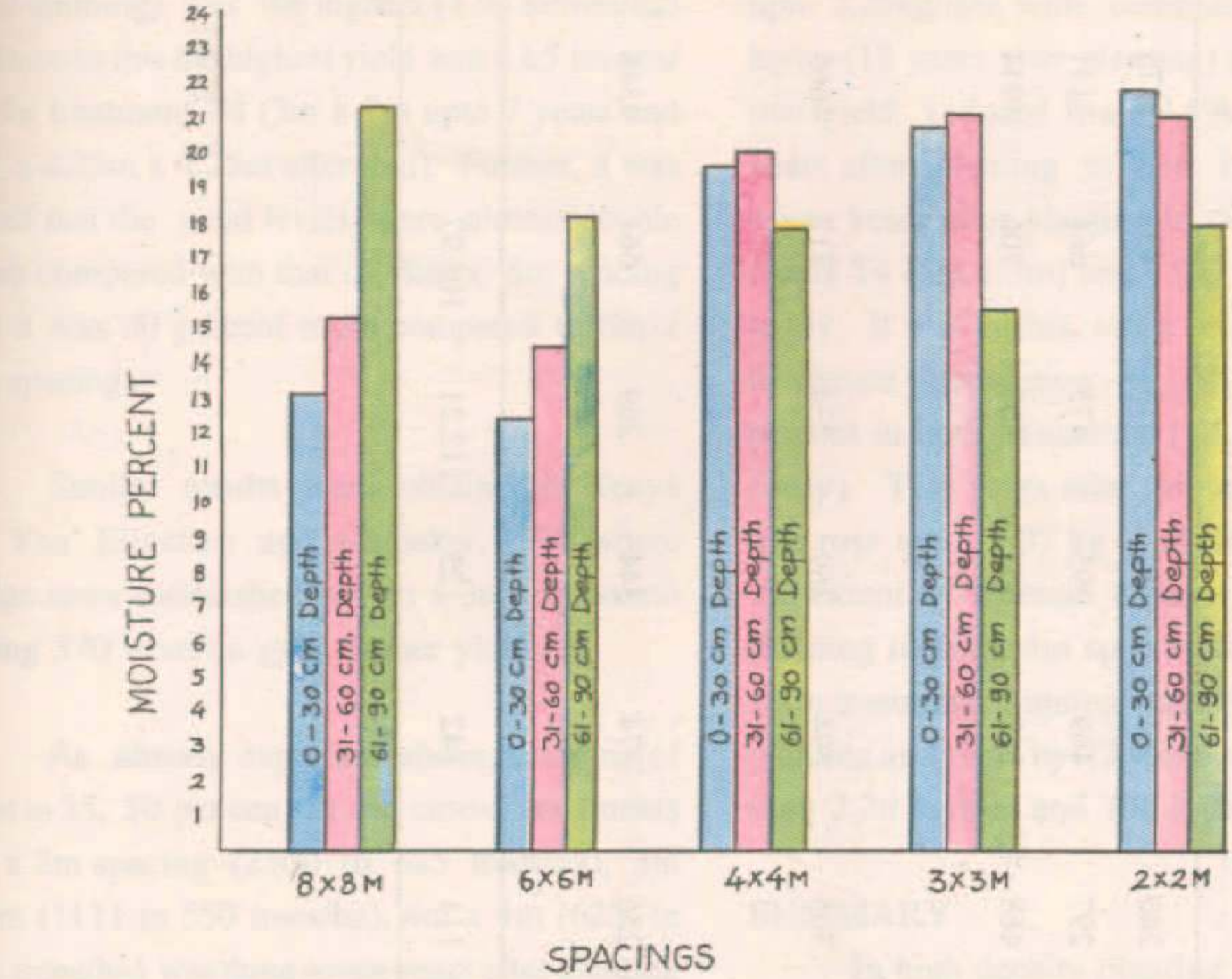


Fig. 6.5 Effect of spacing on soil moisture (at three depths)

availability of light, less photosynthesis (Table 6.6) as discussed earlier.

Reduction in yield was also due to intermingling of roots of neighbouring trees there by competing for nutrients and moisture. Hence, trees in 2m x 2m and 3m x 3m spacing were thinned down to 25 and 50 percent of the original population to reduce competition. In the very next year of thinning the yield reduced in both treatments. But subsequently, it picked up until the canopy covered the remaining ground area, upto 10 years after planting. In the subsequent year (11 years after planting), it further reduced. During this particular year the yield in general was minimum mainly due to heavy showers in December and January (during the flushing and flowering season) resulting in complete spoilage of flower panicles. But by 12 years after planting again there was increase in yield (Table 6.6).

In the case of treatment 4m x 4m spacing the yield per unit area was minimum during 10 and 11 years after planting. During this period yield reduced mainly because of over shading of branches and 100 per cent ground coverage. From 8th year onwards overlapping branches were removed every year to facilitate better flowering. When the yield suddenly dropped from 619 kg/ha 9 years after planting to 460 kg/ha 11 years after planting, it was felt that thinning was necessary and hence diagonal thinning was done by reducing the population to 50 percent. With this the density was reduced from 625 trees/ha to 312 tres/ha. Yield during the next year increased to 706 kg/ha 12 years after planting (Table 6.6). Cumulative yield for this treatment (4m x 4m upto 11 years and 8m x 5.7m x 5.7m

Table 6.6 Yield of cashew (kg/ha).

Treatments (m x m)	Density Nos/ha.	4 Yrs. After planting	5 Yrs. After planting	6 Yrs. After Planting	7 Yrs. After planting	8 Yrs. After planting	9 Yrs. After planting	10 Yrs. After planting	11 Yrs. After planting	12 Yrs. After planting	Total
8 x 8	156	157	181	186	173	240	311	281	313	433	2275
6 x 6	278	196	226	209	214	297	469	395	475	661	3141
4 x 4 upto 11 years after planting and 8 x 5.6 x 5.6 after thinning	625 upto 11 years & 312 after thinning	514	592	601	481	468	619	503	460	706	4944
3 x 3 upto 7 years after planting and 6 x 4.25 x 4.25 after thinning	1111 upto 7 years after planting & 555 after thinning	657	757	635	402	305	594	369	234	712	4665
2 x 2 7 years after planting and 4 x 4 after thinning	2500 upto 7 years after planting & 625 after thinning	677	780	603	384	256	374	344	269	661	4348
CD		--	318.5	325.9	160.85	111	142	123	112.21	108.97	

after thinning) was the highest (4.94 tonnes/ha) and next to this the highest yield was 4.65 tonnes/ ha for treatment T4 (3m x 3m upto 7 years and 6m x 4.25m x 4.25m after that). Further, it was found that the yield levels were almost double when compared with that of 8m x 8m spacing and it was 30 percent more compared to 6m x 6m spacing.

Similar results were obtained in Kenya by Van Eijnatten and Abubaker, 1983 where hedge rows established at 9 m x 3m accommo dating 370 trees/ha gave higher yields.

As already explained above, thinning of trees to 25, 50 per cent in the case of treatments 2m x 2m spacing (2500 to 625 trees/ha), 3m x 3m (1111 to 550 trees/ha), 4m x 4m (625 to 312 trees/ha) was done seven years after planting (T4 and T5) and 11 years after planting (T3). Here, primarily thinning was done to reduce competition between trees and also to avoid development of irregular canopy shapes.

Individual Tree Yield : It was observed that per tree yield increased steadily from 1.01 kg and 0.71 kg 4 years after planting to 2.78 kg and 2.38 kg 12 years after planting in the case of treatments T1 (8m x 8m) and T2 (6m x 6m) (Table 6.7). But in the case of treatment T3 (4m x 4m) the yield reduced from 0.95 kg/tree 5 years after planting to 0.75 kg/tree 8 years after planting. Since the ground coverage and light interception were more than required, by this stage, overlapping branches were removed to maintain the yield level upto 11 years after planting when decline in yield was noticed (0.74kg/tree) in spite of above corrective measures and at this stage thinning was done to 50 percent of the population. In the subsequent year, yield rose upto 2.26kg/tree with cumulative yield of 706 kg/ha (12 years after planting) [Table 6.7]. Per tree yield reduced from 0.59kg and 0.27kg 4 years after planting to 0.36 kg and 0.15 kg 7 seven years after planting in the case of treatments T4 (3m x 3m) and T5 (2m x 2m) respectively. It was at this stage thinning was done to reduce population to 50 percent and 25 percent in both treatments (T4 and T5 respectively). Two years after thinning the yield per tree rose upto 1.07 kg and 0.60 kg but not to the extent of increase noticed in the case of thinning in 4m x 4m spacing.treatment. In 4m x 4m treatment thinning was done 11 years after planting and yield by 12 years after planting rose upto 2.26 kg/tree and 706 kg/ha.

SUMMARY

In high density planting of cashew, optimum ground coverage can be obtained with simultaneous high yield per unit area upto 6 years after planting and beyond that either ground coverage can be manipulated by pruning overlapping branches and limit light interception to 80 percent every year or by thinning the plant population to 50 and 25 percent depending upon the original plant densities per unit area.

Significant higher photosynthesis in widely spaced trees parallel with higher irradiance was observed. Simultaneous increase in the Pn (Net Photosynthesis) values for the remaining trees after thinning was also observed. Decline in yield/ha was observed seven years after planting in the case of plant densities - 2500 trees/ha (2m x 2m) and 1111 trees/ha (3m x 3m) plots and 11 years after planting in the case of 625 trees/ ha (4m x 4m) plot. Steady increase in yield after thinning was also observed till the ground coverage and light interception reached peak.

Table 6.7 Individual tree yield of cashew (kg/ha).

Treatments (m x m)	Density Nos/ha.	4 Yrs. After planting	5 Yrs. After planting	6 Yrs. After Planting	7 Yrs. After planting	8 Yrs. After planting	9 Yrs. After planting	10 Yrs. After planting	11 Yrs. After planting	12 Yrs. After planting
8 x 8	156	1.01	1.16	1.19	1.11	1.54	1.99	1.80	2.01	2.78
6 x 6	278	0.71	0.81	0.75	0.77	1.07	1.69	1.42	1.71	2.38
4 x 4 upto 11 years after planting and 8 x 5.6 x 5.6 after thinning	625 upto 11 years & 312 after thinning	0.82	0.95	0.96	0.77	0.75	0.99	0.80	0.74	2.26
3 x 3 upto 7 years after planting and 6 x 4.25 x 4.25 after thinning	1111 upto 7 years after planting & 555 after thinning	0.59	0.68	0.57	0.36	0.55	1.07	0.66	0.42	1.28
2 x 2 7 years after planting and 4 x 4 after thinning	2500 upto 7 years after planting & 625 after thinning	0.27	0.31	0.24	0.15	0.41	0.60	0.55	0.43	1.06

Studies on root spread and depth indicated that the root of the closely spread trees reached deeper depth than widely spaced trees. Moisture content at deeper depths was minimum in plot when trees were closely spaced compared to widely spaced trees. Dry branches produced was maximum in high density plots compared to minimum plant density plots.

Cumulative yield data for the first 12 years after planting showed that maintaining a plant density of 625 trees/ha (4m x 4m) for the first 11 years and thinning after that to 50 percent (8m x 5.7m x 5.7m) resulted in maximum yield of nuts (4.94 tonnes/ha) and followed by 1111 trees/ha upto 7 years and 555 trees after thinning.

ADDITIONAL INFORMATION ON EXTENSION ACTIVITIES

7. ADDITIONAL INFORMATION ON EXTENSION ACTIVITIES

7.1 PRODUCTION AND DISTRIBUTION OF CASHEW GRAFTS

During the year, around 1,02,000 soft-wood grafts of cashew were distributed to development departments and farmers. Over 1,60,000 sellable grafts are ready for distribution during June 1997. Regional nursery established at NRCC was adjudged as one of the best Regional Cashew Nurseries in the country by the Directorate of Cashewnut Development, Cochin during 1995-96. During the National Seminar on Development of Cashew Industry in India held at Bhubaneswar on 14th and 15th December 1996, NRCC was awarded with a Merit Certificate and Memento for sustained supply of quality planting material of cashew and for the support extended towards development of cashew in India which were received by Dr.E.V.V.Bhaskara Rao, Director.

7.2 TECHNICAL ADVICE

During the year, 54 enquiries were received seeking technical advise. The major aspects on which technical advise was sought were,varieties, production technology, processing and pests (Table 7.1).

7.3 TRAINING

During the year two training courses, one each on Vegetative Propagation of Cashew and Cashew Production Technology were conducted. The former was for grafters and malies of development departments and the latter one was for middle level managers of development departments. In all a total of 43 persons were trained. State wise participation in training courses is given in Table 7.2

Dr. EVV Bhaskara Rao, Director, receiving memento.

Table 7.1 Technical enquiries from different states.

	Varieties	Production Technology	Processing	Pests	Literature	Misc.	Total
Andhra Pradesh	-	1	-	-	1	-	2
Assam	1	-	-	-	-	-	1
Bihar	-	3	-	-	-	-	3
Gujarat	-	-	-	-	-	1	1
Karnataka	2	4	1	2	4	2	15
Kerala	1	3	-	2	7	-	13
Madhya Pradesh	-	-	-	-	-	1	01
Orissa	1	-	1	-	1	-	03
Rajasthan	-	-	-	-	2	-	02
Tamilnadu	3	-	1	-	1	-	05
Uttar Pradesh	3	1	-	-	1	-	05
West Bengal	1	1	1	-	-	-	03
Total	12	13	04	04	17	4	54

Table. 7.2 Statewise participation in training courses (1996-97)

State	Vegetative Propagation of cashew (15-16 Oct.)	Cashew Production Technology (7-9 Jan.)	Total
Andhra Pradesh	5	4	9
Karnataka	11	5	16
Kerala	1	4	5
Goa	-	1	1
Meghalaya	-	3	3
Orisa	4	-	4
Tamil Nadu	-	5	5
	21	22	43

Farmers discussing with scientists on annual cashew day.

7.4 ANNUAL CASHEW DAY

Annual cashew day organised on 20th March 1997 was attended by over 160 farmers, extension workers and research workers from different parts of the State. The programme included visit to field experiments, discussions followed by question and answer session.

GENERAL INFORMATION

STAFF OF THE INSTITUTE

MANAGERIAL

Director — Dr. EVV Bhaskara Rao
(Acting Director till 28.02.97.
Assumed charge of Director from 1.3.97)

SCIENTIFIC

Discipline	Scientist	Sr. Scientist	Pr. Scientist	Total
Agricultural Engineering (ASPE)	D.Balasubramanian	-	-	1
Agricultural Entomology	P.Shivarama Bhat*	D.Sundararaju	-	
	TN Raviprasad	-		3
Agricultural Extension	Sreenath Dixit	-	-	1
Biochemistry (Pl. Science)	-	KV Nagaraja	-	1
Biotechnology	-	Thimmappaiah (Gen. & Cytogen.)	-	1
Computer Application	Vacant	-	-	1
Genetics and Cytogenetics	Shirly Raichal Anil	-	-	1
Horticulture	M.Gangadhara Nayak*	M.G. Bhat (Plant Breeding) KRM Swamy	Vacant	4
Plant Physiology	Vacant	-	-	1
Soil Science		N.Yadukumar (Agronomy)	-	1
Soil and Water Conservation Engineering	Vacant	-	-	1
TOTAL				16

* On study leave

TECHNICAL

Sri. B. Nagaraja	Sr. Farm Superintendent (T-8)	(promoted from 01-07-96)
Sri. K. Lakshminarayana	Farm Superintendent (T-6)	
Dr. Uma Raghunathan	Tech. Inf. Officer (T-6)	
Sri. R. Arulmony	Sr. Lib. Asst. (T-4)	
Sri. A. Padmanabha Hebbar	Elc. Cum. Pump. Operator (T-4)	
Sri. N. Manikandan	Tech. Asst. (T-4)	
Sri. R. Muthuraju	Computer (T-4)	(promoted from 14.11.96)
Sri. K. Seethrama	Farm Asst. (T-II-3)	
Sri. Prakash V Ambekar	Art. Cum. Photographer (T-II-3)	
Sri. Laskhmipathi	Tech. Asst. (T-II-3)	
Sri. R. Lakshmisha	Tech. Asst. (T-II-3)	
Sri. KV. Ramesh Babu	Tech. Asst. (T-II-3)	
Sri. Sardar Baig	Tech. Asst. (T-II-3)	(from 09-04-96)
Sri. R. Shekar Naik	Farm Asst. (T-II-3)	(from 23-09-96)
Sri. KR. Padmanabhan Nair	Jr. Tech. Asst. (T-I-3)	
Sri. A. Poovappa Gowda	Jr. Tech. Asst. (T-I-3)	
Sri. Ravishankar Prasad	Jr. Tech. Asst. (T-1)	
Sri. K. Baby Poojary	Jr. Tech. Asst. (T-1)	
Sri. Bejmi Veigus	Tractor Driver	
Sri. KK. Madhavan	Driver	
Sri. K. Umanath	Driver	

ADMINISTRATIVE

Sri. Ajit Kumar Bolur	Asst. Admn. Officer	(Retd. 31-12-96)
Sri. A. Keshava Shabaraya	Asst. Fin. & Accnts. Officer	
Sri. K. Sanjeevaa	Asst. Admn. Officer	(promoted from 01-01-97)
Sri. V. Ahamed Bava	Sr. Stenographer	
Sri. KM. Jayarama Naik	Superintendent	(promoted from 20-03-97)
Smt. B. Jayashree	Stenographer	
Sri. OG. Varghese	Stenographer	
Sri. MS. Sathyanarayana	Assistant	(promoted from 07-12-96)
Sri. KM. Lingaraju	Sr. Clerk	
Smt. M. Ratna Ranjani	Jr. Clerk	
Ms. Winnie Lobo	Jr. Clerk	
Sri. Rasario Mascarenhas	Jr. Clerk	
Ms. Leela	Jr. Clerk	
Sri. Uma Shankar	Jr. Clerk	
Sri. K. Balappa Gowda	Gestetner Operator	

SUPPORTING STAFF

Sri.D. Guruva Mera	Watchman (SS-GR-IV)
Sri.B. Devappa Naik	Watchman (SS-GR-IV)

Sri. K. Krishnappa Naik	Mali (SS-GR-IV)	
Sri. Krishnappa Gowda	(SS-GR-III)	promoted from 10-10-96
Sri. P. Vasantha Kumar	(SS-GR-III)	promoted from 10-10-96
Sri. P. Subraya Gowda	(SS-GR-III)	promoted from 10-10-96
Sri. Venkappa Naik	(SS-GR-III)	promoted from 10-10-96
Sri. S. Babu	(SS-GR-III)	promoted from 10-10-96
Sri. K. Narayana Naik	Mali (SS-GR-IV)	promoted from 26-10-96
Sri. K. Narnappa Gowda	(SS-GR-III)	promoted from 26-10-96
Sri. K. Monappa Poojary	(SS-GR-III)	promoted from 26-10-96
Sri. K. Shiva	(SS-GR-III)	promoted from 09-12-96
Sri. Deranna Gowda	(SS-GR-II)	
Sri. S. Ammu Gowda	(SS-GR-II)	
Sri. Krishnappa	(SS-GR-II)	
Sri. N. Narayana Naik	(SS-GR-II)	
Sri. B. Chennappa Poojary	(SS-GR-II)	
Sri. P. Krishnappa Poojary	(SS-GR-II)	
Sri. H. Veerappa Gowda	(SS-GR-II)	
Sri. Venkappa Gowda	(SS-GR-II)	
Sri. Rama	(SS-GR-II)	
Sri. P. Honappa Gowda	(SS-GR-II)	promoted from 26-10-96
Sri. S. Krishnappa	(SS-GR-II)	promoted from 26-10-96
Sri. PS. Shekara	(SS-GR-II)	promoted from 26-10-96
Smt. Janaki	(SS-GR-II)	promoted from 26-10-96
Sri. Lingappa Gowda	(SS-GR-II)	promoted from 09-12-96
Sri. P. Honappa Naik	(SS-GR-I)	
Sri. Vijaya Achary	(SS-GR-I)	
Sri. Veerappa	(SS-GR-I)	
Sri. Krishnappa Naik	(SR-GR-I)	
Sri. V. Sundara	(SS-GR-I)	
Sri. K. Annu	(SS-GR-I)	
Sri. Hariya Naik	(SS-GR-I)	
Sri. Umanath Shetty	(SS-GR-I) Messenger	
Sri. S. Pernu	(SS-GR-I)	from 09-04-96
Sri. K. Narayana	(SS-GR-I)	from 09-04-96
Sri. B. Narayana Poojary	(SS-GR-I)	from 09-04-96
Sri. K. Honappa	(SS-GR-I)	from 09-04-96
Sri. D. Krishnappa	(SS-GR-I)	from 09-04-96
Sri. D. Babu Gowda	(SS-GR-I)	from 09-04-96
Sri. T. Padmanabha	(SS-GR-I)	from 09-04-96
Sri. S. Monappa	(SS-GR-I)	from 09-04-96
Sri. B. Seetharama	(SS-GR-I)	from 09-04-96
Sri. K. Gopalakrishna	(SS-GR-I)	from 09-04-96
Sri. Surendra Kumar Indra	(Tea/Coffee Maker)	

INSTITUTE MANAGEMENT COMMITTEE (May 1994 - 97)

1.	Director NRCC Puttur	Chairman
2.	Director of Horticulture Govt. of Karnataka Bangalore, Karnataka	Member
3.	Additional Director Agriculture (Planning) Directorate of Agriculture Trivandrum, Kerala	Member
4.	Prof. M.M. Khan Professor of Horticulture Division of Horticulture University of Agricultural Sciences GKVK Campus, Bangalore	Member
5.	Shri Baldev Khosa Ex-MLA, Mumbai, Maharashtra	Non Official Member
6.	Shri Sudhir Jagtap Amroati, Maharashtra	Non Official Member
7.	Asstt. Director General (PC) ICAR, Krishi Bhavan New Delhi - 110 001	Member
8.	Dr. KRM Swamy Sr. Scientist, NRCC	Member
9.	Dr. M.G. Bhat Sr. Scientist, NRCC	Member
10.	Dr. D. Sundararaju Sr. Scientist NRCC	Member
11.	Sr. Finance & Accounts Officer CPCRI Kasaragod	Member
12.	Dr. K.V. Nagaraja Sr. Scientist, NRCC	Member-Secretary

The committee met twice during the year and deliberated on various aspects of institute management.

RESEARCH ADVISORY COMMITTEE
(July 1996 - 1999)

Dr.M.Aravindakshan Chairman, Coconut Development Board, Cochin, Kerala-682 011	Chairman
Dr.C.C.Abraham Associate Dean (Retd) College of Horticulture KAU, Vellanikkara-680 652	Member
Dr.A.G.Mathew Plant Lipids Ltd. Kadayiruppur Kolencherry-682 311	Member
Dr.R.T.Gunjate 6, Nutan Co-op. Housing Society Sabniswada, Sawanthwadi-416 510	Member
Dr.R.D.Iyer CP VIII/113, Indiranagar Kasaragod-671 541	Member
Shri Baldev Khosa C/o. Shri Sunil Dutt. Ex-MP 'Sunrise', 24th Road Bandhra, Mumbai-400 050	Member
Shri Sudhir Jagtap Gandhi Chowk, Dhamangaon Railway Dist. Amroati, Maharashtra	Member
Dr.R.N.Pal ADG (PC), ICAR, New Delhi	Member
Dr.E.V.V.Bhaskara Rao Director, NRCC, Puttur	Member
Dr.M.G.Bhat Sr.Scientist, NRCC, Puttur	Member-Secretary

INSTITUTE JOINT COUNIL (IJC)

OFFICIAL SIDE

Dr. EVV.Bhaskara Rao	Chairman
Dr. KRM.Swamy	Member
Sri.B.Nagaraja	Member
Sri.AK.Shabaraya	Member
Sri.AK.Bolur	Member (till 31-12-96)
Sri.K.Sanjeeva	Member (from 01-01-97)
Ms. Shirly Raichal Anil	Secretary

STAFF SIDE

Sri. Prakash V. Ambekar	Member, CJSC
Sri. R.Muthuraju	Member
Sri. MS.Sathyanarayana	Member
Sri. B.Chennappa Poojary	Member
Sri. H.Veerappa Gowda	Member
Sri. KM.Jayarama Naik	Secretary

The IJC met four times during the year to discuss staff welfare activities.

राजभाषा कार्यान्वयन समिति

1.	डा. ई.वी.वी. भास्कर राव	अध्यक्ष
2.	डा. श्रीनाथ दीक्षित	सदस्य
3.	डा. टी.एन. रविप्रसाद	सदस्य
4.	डा. उमा रघुनाथन	सदस्य
5.	श्री. प्रकाश व. आंबेकर	सदस्य
6.	श्री. उमानाथ शेट्टी	सदस्य
7.	श्री. अजितकुमार बोलूर	सचिव/संयोजक (दि. 21-12-96 तक)
8.	श्री. के. संजीवा	सचिव/संयोजक (दि. 1-1-97 से)

राजभाषा - गतिविधियाँ एवं प्रगति

केन्द्र में राजभाषा कार्यान्वयन समिति की इस वर्ष चार बैठकें आयोजित की गई । बैठकों मे राजभाषा हिन्दी के कार्यान्वयन संबधित निदेशक के दिशानिर्देशानुसार निर्णयों पर अमल किया गया । इसी तरह समय-समय पर परिषद और राजभाषा विभाग द्वारा सुझाए गये मंदो पर सभी संभव प्रयास केन्द्र द्वारा किए गये। केन्द्र द्वारा हर तिमाही के समाप्ति के बाद राजभाषा कार्यान्वयन के प्रगति संबंधि रिपोर्ट परिषद तथा क्षेत्रीय कार्यान्वयन कार्यालय, बेंगलूर को भेजे गये ।

दि. 7-9-96 से 13-9-96 तक केन्द्र में 'हिन्दी सप्ताह' का आयोजन किया गया । इस दौरान निबंध, तथा क्विज़ स्पर्धा, एवं हिन्दी कार्याशाला का आयोजन किया गया । इस कार्यक्रम मे वैज्ञानिक, तकनीकी एवं प्रशासनिक वर्गो ने स्वयंस्फूर्ति के साथ हिस्सा लिया ।

डा. सी.एम. तिवारी, सहायक निदेशक राजभाषा विभाग (प्रशिक्षण) मंगलूर के मार्गदर्शन में दि. 3 और 4 मार्च 97 को प्रशासनिक कर्मचरियों हेतु दो दिवसीय

'हिन्दी कार्यशाला' का आयोजन किया गया । इसी दौरान डा. सी.एम. तिवारी ने कर्मचारियों द्वारा इस वर्ष हिन्दी मे किए गये कार्यों का मुल्यांकण कर उन्हे पुरस्कृत भी किया ।

पुरस्कार पाने वाले कर्मचारी हैं

1.	श्री. प्रकाश व. आंबेकर (आर्टिस्ट कम् फोटोग्राफर)	प्रथम पुरस्कार रु. 250/-
2.	श्री. के.एम. लिंगराज (वरिष्ठ लिपिक)	द्वितीय पुरस्कार रु. 200/-
3.	श्री. अजितकुमार बोलूर (सहा. प्रशा. अधिकारी)	तृतीय पुरस्कार रु. 150/- प्रत्येक
4.	कु. एम. लीला (कनिष्ठ लिपिक)	

DEPUTATION ABROAD

1.	International Cashew and Coconut Conference - Dar-es-Salaam, Tanzania	EVV Bhaskara Rao	17-22 Feb. 1997

PARTICIPATION IN SYMPOSIA/SEMINAR/TRAINING

Meeting of Sub-Working Group on Diversification, Value addition and Export Orientation.	EVV Bhaskara Rao	2-3 Apr. 1996
Training on computer application in agricultural research	N Yadukumar	2-17 Apr. 1996
Training workshop on computer networking and information processing in agriculture. IASRI, New Delhi	D Balasubramanian	18 Apr. 2 May 1996
NATP Review Meeting, ICAR, New Delhi	EVV Bhaskara Rao	23-24 Apr. 1996
Staff Research Council Meeting of CPCRI, Kasaragod.	EVV Bhaskara Rao	28-30 May 1996
Meeting of Directors of Horticulture Division & 2nd Annual Conference of Project Coordinators. ICAR New Delhi.	EVV Bhaskara Rao	5-6 Aug. 1996

Meeting for finalization of Perspective Plan. ICAR, New Delhi.	EVV Bhaskara Rao	14-15 Sept. 1996
Mid-year review meeting of Directors of ICAR Institutes and Session on Intellectual Property Rights & Panel meeting on Plantation Crops. ICAR New Delhi.	EVV Bhaskara Rao	12-18 Oct. 1996
National Symposium on Horticultural Biotechnology, Bangalore	EVV Bhaskara Rao Thimmappaiah Shirly R. Anil	28-30 Oct. 1996
Second International Crop Science Congress, IARI., New Delhi.	EVV Bhaskara Rao	17-22 Nov. 1996
PLACROSYM XII, Kottayam, Kerala	KV Nagaraja	27-29 Nov. 1996
National Seminar on Development of Cashew industry in India, Bhubaneswar, Orissa	EVV Bhaskara Rao KV Nagaraja KRM Swamy	14-15 Dec. 1996
CASHEW DAY at Regional Fruit Research Station (KKV), Vengurla, Maharashtra.	EVV Bhaskara Rao	12th Feb. 1997
Directors and Project Coordinators meeting of Horticulture Division of ICAR., ICAR New Delhi.	EVV Bhaskara Rao	4-5 Mar. 1997
AGRI-TECH 1997 Seminar on Prosperity through Farm Productivity, Calcutta	EVV Bhaskara Rao	12th Mar. 1997

RESEARCH/POPULAR PUBLICATIONS

BHASKARA RAO, EVV. 1996. Cashew Research Infrastructure and Achievements. In: **Souvenir of National Seminar on Development of Cashew Industry in India.** 14-15 Dec. 1996, Bhubaneswar, India. pp. 19-23.

NAIR MK, KOSHY, PK, JACOB, PM, NAIR, RV, BHASKARA RAO, EVV, NAMPOOTHIRI KUK and IYER, RD. 1996. A root (wilt) disease resistant coconut hybrid and strategy for resistance breeding. **Indian Coconut J.** May 1996, pp.2-5

SWAMY, KRM and BHASKARA RAO, EVV. 1996. Recent advances in Propagation of Cashew. In : **Practical Guide on Advances in Fruit Propagation Techniques.** Agri-Horticultural Society, Hyderabad, India.

DIXIT, S. 1996. After care for cashew grafts. **Prajavani** (Kannada). 26 June, 1996.

SWAMY, KRM, 1997 Technology for planting materiel multiplication in cashew **The Cashew** 11 (1) : 23 - 32.

DIXIT, S. 1996. Farmer first - Why? How?. **Udayavani** (Kannada). 17 April, 1996.

DIXIT, S. 1996. Importance of grafts as planting material in cashew. **Prajavani** (Kannada). 29 May, 1996.

NAGARAJA, KV 1996. Biochemical changes during storage of cashew. *Plant Physiol* and *Biochem 23(2), 163-168.*

PAPERS PRESENTED IN SYMPOSIA / WORKSHOP / SEMINAR

BHASKARA RAO, EVV. 1996. Technological advances in Cashew Production and Strategical Approaches needed for Wider Adoption. **Pre-presentation papers:** National Seminar on Development of Cashew Industry in India. 14-15 December 1996, Bhubaneswar, India. pp.41-52

BHASKARA RAO, EVV. 1996. Emerging Trends in Cashew Improvement. 2nd International Crop Science Congress, November 17-24, 1996, New Delhi.

BHASKARA RAO, EVV. 1997. Cashewnut Industry in India. International Cashew & Coconut Conference, Dar es Salaam, Tanzania. 17-21 February 1997.

BHASKARA RAO, EVV. 1997. Cashew Crop Improvement Programmes in India. International Cashew & Coconut Conference, Dar es Salaam, Tanzania. 17-21 February 1997.

THIMMAPPAIAH AND SHIRLY R.S. 1996, Micropropagation studies in cashew (*Anacardium ccidentale L.*). Poster presentation. National Symposium on Horticultural Biotechnology, Bangalore 28-30 Oct, 1996

NAGARAJA, KV and PRABHU, GG. 1996. Investigations into factors influencing kernel rejects during processing - A preliminary study. National Seminar on Development of Cashew Industry in India. 14-15 Dec., 1996.

SWAMY, KRM 1996. Technology for planting material multiplication in cashew. National seminar on Development of cashew Industry in India. 14-15 Dec. 1996.

SWAMY, KRM, BHAT, MG and BHASKARA RAO, EVV. 1996. Characterization of Cashew germplasm. Poster presentation - 2nd International Crop Science Congress, November 17-24, 1996, New Delhi.

BOOK/CHAPTERS

BHASKARA RAO, EVV. 1996. **CASHEW. In:** 50 Years of Crop Sciences Research in India. (Eds. RS Paroda and KL Chadha). Indian Council of Agricultural Research, New Delhi. pp. 761-770.

BHASKARA RAO, EVV. 1996. **Advances in Production Technology for Cashew. In:** Strategies for Horticulture Development in India. (Eds. GL Kaul and NK Dadlani). Department of Agriculture & Cooperation, Government of India, Krishi Bhavan, New Delhi 110 001. pp. 45-50.

BHASKARA RAO, EVV, and SWAMY, KRM, 1996. **Cashew.** In : Issues in Horticultural and Plantation crops - Vol 2 Genetic resources.
(Ecl : KL Chadha) Malthotra Pub. House. New Delhi PP 273 - 290

TECHNICAL REPORTS / BULLETINS / COMPENDIA

National Research Centre for Cashew. 1996. **Annual Report 1995-96.** Puttur, Karnataka. 75 pp.

All India Coordinated Research Project on Cashew. 1996. **Annual Report 1995-96.** 100 pp.

National Research Centre for Cashew. 1996. **Research Highlights 1995-96.** Puttur, Karnataka. 10 pp.

National Research Centre for Cashew. 1996. **Research Highlights 1996-97.** Puttur, Karnataka. 10 pp.

National Research Centre for Cashew. 1996. **The Cashew News.** New Letter No.1 Vol.1., Puttur, Karnataka.

National Research Centre for Cashew. 1996. **The Cashew News.** New Letter No.2 Vol.1., Puttur, Karnataka.

RADIO TALKS/INTERVIEWS

(Broadcast from AIR, Mangalore)

Integrated nutrient management in cashew	MG Nayak	30 Jul. 1996
Cashew harvesting - care to be taken	KRM Swamy	11 Feb. 1997
Transfer of technology by NRCC	Sreenath Dixit	22 Feb. 1997
Pest management care to be taken in young cashew grafts	TN Raviprasad	15 Mar. 1997

IMPORTANT VISITORS

08-04-1996	Dr. MVR. Prasad International Specialist Cashew Rehabilitation Program Nampula CP177, Mozambique
02-06-1996	Sri. Ikramullah Joint Director of Horticulture Directorate of Horticulture Lal Bagh, Bangalore
13-11-1996	Sri. Arabinda Ghose Special Correspondent The Hitavada, Nagpur
05-12-1996	Dr. N. Mohanakumaran Director of Research KAU, Vellanikkara
	Dr. KR.Melanta Professor and Head Department of Horticulture UAS, GKVK, Bangalore
	Dr. MM.Khan Professor of Horticulture & Head of Division UAS, GKVK, Bangalore
20-12-1996	Dr. RN. Pal ADG (PC), ICAR, New Delhi
	Sri. Sudhir Jagtap Member, Management Committee of NRC-Cashew

WEATHER DATA - 1996-97

Month	Temperature °C		Humidity (%)		Rain fall (mm)	Rainy days	Sun Shine (hrs)	Evapo-ration (mm)
	Max	Min	FN	AN				
Apr.	*	23.8	90	60	81.0	5	9.8	5.6
May	*	23.4	89	58	62.0	6	9.1	5.9
Jun.	31.4	22.7	95	81	846.2	22	5.1	2.9
Jul.	31.6	22.5	97	90	1345.7	31	2.3	2.2
Aug.	29.5	23.1	97	86	624.9	27	2.1	2.4
Sep.	30.5	23.0	98	82	529.7	20	4.5	2.6
Oct.	31.6	22.2	95	71	385.2	17	7.4	3.2
Nov.	33.6	21.7	91	59	24.6	3	9.1	3.5
Dec.	32.6	19.2	89	57	24.4	4	6.8	3.2
Jan.	33.7	18.9	94	57	0.0	0	9.6	4.2
Feb.	36.0	18.0	92	42	0.0	0	9.8	5.2
Mar.	36.7	22.3	92	57	16.8	1	9.7	5.3

* Not recorded